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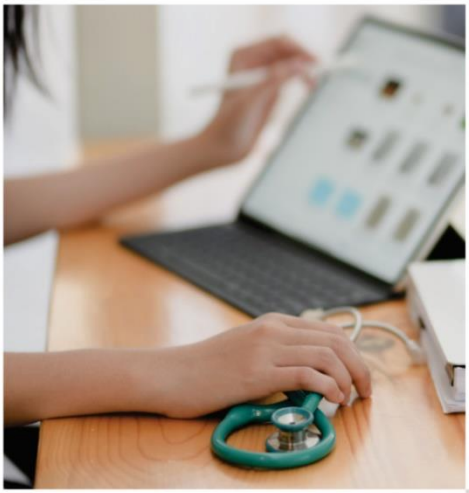
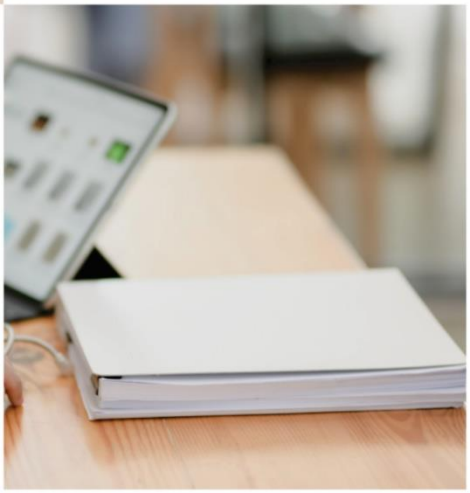
DIGITAL LITERACY IN ORAL HEALTH BEHAVIOR CHANGE





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Digital Literacy in Oral Health Behavior Change

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ISBN: 978-634-7188-74-8

August 2025

Publisher:
IPKESGIMI Publishing
&
PT. Pustaka Saga Jawadwipa
Jl. Kedinding Lor, Gang Delima No. 4A, Surabaya
Contact Number: +62 856-5539-6657

Member of IKAPI: No. 367/JTI/2023

Printed by: PT. Pustaka Saga Jawadwipa

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Dedication

This book is dedicated to the institutions and individuals who have persistently championed the advancement of public oral health in Indonesia. At the forefront are the Ministry of Health and the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia, whose strategic frameworks have enabled integration between science, education, and policy. Their support has laid the groundwork for collaborative action in health equity and literacy development. In an era where digital access defines health opportunity, such institutional foresight becomes indispensable. The values embedded in this work reflect national aspirations to build a more inclusive and resilient health system.

We extend our sincere dedication to the Rectors and Deans of the Faculty of Dentistry at Universitas Muslim Indonesia, Universitas Hasanuddin, Universitas Mahasaraswati, Universitas Sumatera Utara, Universitas Trisakti, and Universitas Airlangga. Their encouragement and commitment to interdisciplinary research have been vital in making this inter-university collaboration possible. These faculties have become intellectual homes where innovative ideas in oral health education have been nurtured. Their leadership illustrates how institutional vision can catalyze national impact. Through their support, this book has found both academic legitimacy and practical resonance.

This work is also a tribute to Ikatan Peminatan Kesehatan Gigi Masyarakat Indonesia (IPKESGIMI), which has taken bold steps to unify scholars and practitioners of community dentistry across the nation. As a professional association, IPKESGIMI has not only pioneered this collaborative writing initiative, but also redefined how knowledge co-creation can unfold within the field. By mobilizing experts across regions and institutions, it has created space for interdisciplinary reflection, ethical leadership, and shared authorship. This model should inspire other health disciplines to take similar steps. In this regard, IPKESGIMI's role is not only organizational but transformative.

This book also resonates with the broader global vision enshrined in the Sustainable Development Goals (SDGs), specifically Goal 3 (Good Health and Well-being) and Goal 10

(Reduced Inequalities). We recognize that oral health is inseparable from human dignity and health equity. Addressing the digital divide in oral health access, education, and care remains a moral and scientific imperative. Therefore, this book aligns with global and national mandates to reduce disparities and advance the right to health. Every chapter seeks to contribute substantively to these goals through evidence-based insights and inclusive practices.

Ultimately, this dedication is not only to institutions and frameworks, but also to the communities whose voices, needs, and resilience animate the field of public oral health. It is for the mothers educating their children about brushing, the elderly learning to use health apps, and the students who will one day become compassionate professionals. Their stories and challenges shaped the direction of this work. We hope this book becomes a meaningful tool, informing practice, guiding policy, and igniting critical conversations. May this contribution serve not only as a reference, but also as a catalyst for sustainable, ethical change in oral health promotion.

Preface

The emergence of digital health technologies presents both an opportunity and a challenge for oral health promotion in the 21st century. While innovation accelerates access to information, it also demands that individuals possess new competencies to navigate, interpret, and apply health knowledge effectively. This book emerged from the observation that digital literacy is no longer a technical skill alone, it is a public health necessity. For vulnerable populations, the absence of digital skills often means exclusion from preventive care and behavior change interventions. Thus, bridging this gap became the guiding motivation behind this publication.

The chapters in this volume are informed by the intersection of scientific theory, empirical evidence, and lived experiences from Indonesian contexts. We adopted a cross-disciplinary approach, integrating behavioral models, literacy frameworks, and digital inclusion strategies. Each section builds logically from foundational concepts to applied recommendations. This deductive structure ensures that the book is accessible to academics, clinicians, students, and policymakers alike. Through this design, we aim to make complex issues not only understandable, but actionable.

A defining feature of this book is its collaborative spirit, bringing together contributors from multiple faculties of dentistry across Indonesia. This spirit reflects a shared belief: that the future of oral health promotion lies in cooperation, not competition. The involvement of diverse institutions has enriched the narrative, contextualized the challenges, and strengthened the validity of recommendations. We are indebted to all contributors who brought their perspectives, data, and commitment into this scholarly endeavor. Their collaboration reaffirms the power of unity in advancing the nation's oral health agenda.

We also recognize the critical leadership of IPKESGIMI, whose coordination and vision turned this project from concept to reality. Through its support, we were able to synchronize perspectives, unify thematic priorities, and uphold academic rigor throughout the writing process. IPKESGIMI has shown that professional associations can go beyond advocacy, they can actively shape knowledge systems. This book is, therefore, not only an

academic output, but a symbol of collective stewardship in health development. We hope that this experience inspires further joint publications in the future.

Above all, this book is dedicated to the learners, educators, caregivers, and citizens who believe that digital tools should serve humanity, not widen inequity. The stories within these pages are drawn from communities in transition, from analog to digital, from exclusion to empowerment. We invite readers to engage with this work critically and reflectively. May this volume be read not only as a resource, but as a call to action. Together, let us build a more just, ethical, and health-literate digital future.

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Foreword

The publication of this book marks an important milestone in the national discourse on oral health promotion in the digital era. As Chair of IPKESGIMI, I have witnessed firsthand the growing need for scientific integration between behavioral theory, community practice, and digital innovation. This book addresses that intersection with commendable clarity and depth, grounded in empirical realities from Indonesia. It reflects a strategic shift from fragmented efforts to a harmonized knowledge platform for dentists, educators, and policymakers. In doing so, it helps reposition oral health literacy as a systemic and ethical concern, not merely a clinical one.

What distinguishes this book is its strong commitment to collaboration across institutions and regions. Authors from various Faculties of Dentistry have contributed not only their expertise but also their contextual understanding of communities often left behind in health transitions. Their collective insight bridges gaps between rural and urban practice, traditional and digital paradigms, and policy and pedagogy. This collaborative spirit is precisely what IPKESGIMI envisioned when advocating for national unity in academic contributions. It proves that shared goals in public health can transcend institutional boundaries.

In the realm of public health dentistry, the rapid emergence of digital platforms has raised important ethical, pedagogical, and operational questions. How can we ensure that innovation is inclusive? What safeguards must be in place to prevent misinformation and digital exclusion? This book provides a thoughtful, evidence-based response to such questions, using both global references and local best practices. Its relevance extends beyond the academic realm and into the lives of families, children, and elderly populations navigating the digital health space. In this sense, the book does not merely describe change, it actively supports it.

As someone deeply engaged in public health research and advocacy, I find this work both timely and necessary. It reflects the maturity of the Indonesian dental public health community in producing academic output that is forward-thinking, ethically

anchored, and grounded in scientific method. It also embodies a vision of dentistry that is socially responsive and globally aware. I am proud that IPKESGIMI has supported this groundbreaking initiative, and I am confident it will serve as a foundation for further innovations. Let this volume be not just a scholarly product, but a sustained commitment to oral health equity.

To all readers, students, professionals, educators, and policymakers, I extend my invitation to engage with this book not only with curiosity, but with critical purpose. Its chapters offer more than insight; they offer direction. They remind us that literacy, when coupled with empathy and ethics, can transform systems and empower communities. May this book fuel future research, inspire program development, and inform policy decisions at both local and national levels. I congratulate all contributors and encourage the continued momentum for collaborative progress.

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Acknowledgments

The development of this book would not have been possible without the collaborative engagement of many individuals and institutions who have contributed with intention, trust, and professionalism. We extend our profound appreciation to the Ministry of Health and the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia. Their national health strategies and emphasis on academic integration have enabled this book to be both conceptually relevant and policy-aligned. The intersection of digital innovation and public health requires enabling ecosystems, and these ministries have long invested in such strategic alignment. Their continued support affirms the government's vision for inclusive and participatory health development.

We are especially grateful to the Rectors and Deans of the Faculty of Dentistry at Universitas Muslim Indonesia, Universitas Hasanuddin, Universitas Mahasaraswati, Universitas Sumatera Utara, Universitas Trisakti, and Universitas Airlangga. Your academic leadership has provided the space and momentum necessary for this cross-institutional collaboration. The contributors from your faculties have brought not only disciplinary knowledge but also deep field insights that have enriched every chapter. Through your support, this book has become a model for collaborative academic productivity. We hope this spirit of partnership continues in future oral health scholarship.

We acknowledge with deep respect the pivotal role played by IPKESGIMI, which not only coordinated the effort but ensured the academic consistency, ethical focus, and strategic alignment of this publication. Your capacity to unite professionals from various academic ecosystems has demonstrated that scientific collaboration can be both rigorous and inclusive. IPKESGIMI's stewardship in facilitating this project signals a broader movement within public oral health to prioritize knowledge equity and system-wide transformation. We sincerely thank every board member, reviewer, and liaison who supported the manuscript process. Your dedication has elevated the quality and coherence of this work.

Special recognition is due to the many researchers, educators, community health practitioners, and students whose fieldwork and

lived experiences inform the content of this book. Their voices, challenges, and successes are reflected in the analysis, case studies, and recommendations offered herein. The integrity of this work owes much to their commitment to ethical health promotion in everyday settings. We are reminded that academic knowledge gains its value when it echoes the needs of communities. To those whose data and insights are documented within these chapters: thank you for your invaluable contributions.

Finally, this book aligns itself with the values and ambitions of the Sustainable Development Goals, particularly SDG 3 on health and well-being and SDG 10 on reducing inequalities. We believe that literacy, both digital and oral health-related are a social justice issue. It deserves investment, innovation, and inclusive frameworks for development. This book is one small step in that direction, and we thank everyone who walked alongside us in its realization. May this collective effort inspire future action toward more equitable oral health systems in Indonesia and beyond.

Denpasar, 1st of July, 2025

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Dr. Gilang Rasuna Sabdho Wening, drg., M.Kes., FISDPH., FISPD

Table of Contents

Chapter 1.
Introduction to Digital Literacy and Oral Health Behavior

1.1 Definition and Dimensions of Digital Literacy and eHealth Literacy

1.2. Relationship between Oral Health Literacy (OHL) and Digital Skills

1.3. Theoretical Background: Health Belief Model and Information-Motivation-Behavior Model

Abstract
Digital literacy and eHealth literacy are emerging as essential foundations for effective oral health behavior change in the digital era. This chapter explored the definitions and dimensions of digital and eHealth literacy, highlighting their critical roles in enhancing oral health outcomes. It examined the synergistic relationship between digital skills and oral health literacy (OHL), revealing how deficits in either domain hinder behavior adoption. Furthermore, theoretical frameworks such as the Health Belief Model (HBM) and the Information-Motivation-Behavior (IMB) Model were reviewed to explain how users perceive, process, and act on digital oral health interventions. By integrating national and international perspectives, this chapter established a conceptual basis for understanding how digital competencies and behavioral theories intersect in the design and dissemination of oral health promotion. These insights provide a strategic foundation for future chapters focused on educational and technological implementation.

Keywords: Digital health literacy; Oral health literacy; Behavior change; eHealth promotion; Health belief models

Prologue

In the evolving digital era, health behavior change is increasingly mediated by technological tools, reshaping how individuals access, process, and apply health-related information. Oral health, long challenged by behavioral determinants and access inequalities, now stands at the crossroads of digital innovation and public health literacy. As smartphones, messaging platforms, and mobile applications become embedded in daily routines, the urgency to understand digital literacy's role in influencing oral hygiene practices has grown. This chapter sets the foundation by defining digital and eHealth literacy, exploring their relationship with oral health behaviors, and discussing theoretical models that underpin this intersection. By unpacking the frameworks that guide behavior change, readers are equipped to critically analyze how digital platforms can enable better oral health outcomes. The discourse is grounded in current evidence and contextualized within both global insights and Indonesia's digital health transformation journey.

1.1 Definition and Dimensions of Digital Literacy and eHealth Literacy

Digital literacy refers to the ability to access, evaluate, and effectively use digital information and tools, particularly in health-related contexts. It encompasses a range of cognitive and technical competencies, including information retrieval, communication, and critical thinking in digital spaces. As technology becomes more integrated in healthcare systems, digital literacy has emerged as a critical social determinant of health. In dentistry, digital tools like mobile apps, videos, and online consultations demand that patients possess adequate digital literacy to navigate and apply oral health advice. Without these skills, vulnerable populations risk exclusion from essential preventive care. Thus, digital literacy is both a functional requirement and an equity challenge in modern health promotion (Wrona et al., 2025; Kim et al., 2025).

Closely related is the concept of eHealth literacy, which integrates six core literacies: traditional, media, information, health, computer, and scientific literacy. eHealth literacy enables individuals to locate, interpret, and apply online health information to maintain or improve health outcomes. This multidimensional construct is especially relevant in contexts where health promotion is delivered through digital media. As oral health interventions increasingly rely on digital delivery, such as through SMS reminders, gamified brushing routines, or teleconsultation platforms, eHealth literacy becomes indispensable. Evidence shows that individuals with higher eHealth literacy are more likely to adopt preventive behaviors and seek professional care proactively. These skills serve not only personal well-being but also shape community-level oral health standards (Cardoso et al., 2024; Verweel et al., 2023).

In the context of digital oral health, digital literacy expands beyond basic smartphone use to include health-specific decision-making competencies. For example, interpreting the severity of symptoms shown in educational infographics or navigating

treatment recommendations in dental apps are higher-order cognitive tasks. These require users to critically assess digital content for credibility, relevance, and bias, skills which are often lacking in underserved communities. Consequently, oral health educators must design interventions that are not only informative but also accessible and culturally appropriate to varying levels of digital and eHealth literacy. This requires a dual focus on content quality and user capability. The imbalance between digital innovation and literacy levels presents both an ethical and operational dilemma (Kim, Park, Park, & Chun, 2025; King et al., 2025).

Several frameworks have been proposed to classify digital health literacy levels across populations. For instance, the Digital Health Literacy Instrument (DHLI) and the eHEALS scale are commonly used to assess an individual's readiness to engage with digital health services. In dentistry, these instruments have been adapted to measure patients' ability to follow video tutorials on brushing techniques or use mobile apps for appointment reminders. In Indonesia, adaptation of such tools must account for variations in internet access, device ownership, and language proficiency. This reinforces the need for localized metrics and validation studies. Standardized assessment allows practitioners to tailor interventions more effectively, ensuring inclusivity (Kim et al., 2025; Wrona et al., 2025).

The dimensions of digital literacy can also be viewed through behavioral, cognitive, and socio-cultural lenses. Behavioral aspects pertain to technology usage patterns and digital habits, while cognitive components reflect critical thinking and comprehension. Socio-cultural dimensions involve access disparities and digital norms within specific communities. These layers influence how individuals perceive, trust, and engage with oral health content delivered online. For example, digital tools designed without accounting for local norms may experience poor adoption. Understanding these dimensions is essential for inclusive digital oral health programming (Liang et al., 2024; Yu et al., 2024).

Digital literacy cannot be separated from health promotion objectives, especially in low- and middle-income countries such as Indonesia. As smartphone penetration increases, the challenge shifts from access to effective utilization. Digital tools in oral health education often fail due to limited understanding of how to navigate health apps or evaluate credible sources. Hence, capacity-building efforts must be directed toward enhancing both access and comprehension. Digital literacy training programs tailored to demographic needs, such as age, education, or socio-cultural background, can bridge this competency gap. Evidence from Verweel et al. (2023) suggests that tailored interventions significantly improve digital engagement and oral health behaviors.

In contrast to general digital literacy, eHealth literacy specifically targets health information seeking, communication with providers, and decision-making. It acts as a mediator between information exposure and behavioral adoption. When users encounter conflicting online content, for example, regarding fluoride use, they rely on eHealth literacy to filter and apply accurate advice. Higher eHealth literacy has been linked to better oral hygiene, reduced caries incidence, and timely dental visits. Conversely, low eHealth literacy contributes to misinformation spread, delayed treatment, and poor preventive practices. Thus, digital and eHealth literacy should be addressed as critical predictors of oral health outcomes (Yu et al., 2024; Liang et al., 2024).

Within the educational domain, dental schools and public health institutions are beginning to integrate digital health literacy into their training modules. This approach equips future dental professionals to communicate effectively with digitally active patients. Additionally, it enhances their ability to evaluate and recommend reliable digital tools for behavior change. For example, professionals trained in digital health competencies are more likely to use secure messaging apps for patient reminders or employ digital storytelling for health education. The move toward digital-first dentistry requires alignment of technical literacy with pedagogical

objectives. This institutional shift can set the foundation for system-wide transformation (Cardoso et al., 2024; Ribeiro et al., 2022).

In practice, digital literacy also determines users' confidence in adopting oral health innovations. This includes comfort with installing applications, setting reminders for brushing, or navigating AI-based risk assessments. In communities with low digital literacy, these tasks are perceived as burdensome or intrusive. Therefore, human-centered design principles must be applied to ensure digital oral health solutions are intuitive, simple, and culturally sensitive. Interventions that ignore user literacy risk being underutilized or abandoned. Digital literacy, thus, plays a central role in sustaining user engagement (Kitsaras et al., 2023; King et al., 2025).

Elderly populations present unique challenges and opportunities in digital health integration. Age-related cognitive decline, unfamiliarity with digital interfaces, and distrust in online content hinder uptake among older adults. However, structured eHealth literacy programs have shown success in improving navigation, comprehension, and retention of health content. For instance, Kim et al. (2025) developed and validated a digital literacy scale tailored to older users, revealing significant correlations between literacy scores and behavioral adherence. These findings emphasize the importance of age-sensitive intervention design. Promoting autonomy among elderly users is key to enhancing their oral health resilience.

In underserved populations, digital literacy deficits are often compounded by language barriers and educational disparities. Oral health materials in national languages or academic terminology may be inaccessible to local users. Consequently, vernacular adaptation, voice-based applications, and visual storytelling become essential strategies. Community-based participatory approaches can inform design choices and ensure cultural alignment. These efforts not only enhance digital comprehension but also foster trust and relevance. Wrona et al. (2025) affirm that inclusive digital health models improve both uptake and long-term behavior change.

Digital literacy also intersects with gender, as women (especially mothers) are often the primary agents of oral health behavior within households. Enhancing mothers' digital competencies, particularly in child dental care, has been shown to influence family-level oral hygiene routines. For example, mobile apps providing brushing tutorials or dietary advice have led to improved plaque control among children. Yet, these benefits only materialize when digital literacy thresholds are met. Training mothers through local health centers or schools has proven effective in increasing both knowledge and usage. Hence, targeting female caregivers is both strategic and impactful (Ribeiro et al., 2022; Liang et al., 2024).

From a systemic perspective, national oral health programs must incorporate digital literacy components to ensure program effectiveness. Campaigns such as mobile-based counseling, SMS brushing alerts, and gamified education can only succeed if the target population possesses baseline digital competencies. Ministries of health and education can collaborate to embed digital literacy in curricula and public campaigns. This integrative strategy ensures alignment between health objectives and digital readiness. Moreover, monitoring and evaluation systems must include digital literacy metrics to inform adaptive programming. Institutional alignment enhances both accountability and effectiveness (Collet et al., 2024; Cardoso et al., 2024).

Despite growing evidence, digital literacy remains poorly measured in routine health surveys. Conventional health literacy tools often overlook digital dimensions, leading to underestimation of literacy gaps. Standardized instruments such as eHEALS and DHLI should be adapted and validated in diverse populations, especially in Southeast Asia. In Indonesia, limited research exists on population-level digital oral health literacy, making it difficult to benchmark or evaluate interventions. Addressing this gap requires interdisciplinary collaboration among health informaticians,

educators, and behavioral scientists. Measurement is the foundation of strategy (Kim et al., 2025; Wrona et al., 2025).

In summary, digital literacy and eHealth literacy are foundational enablers of digital oral health behavior change. They influence how individuals access, evaluate, and act upon online information, thereby determining the success of health promotion efforts. For digital health to be equitable, inclusive, and effective, literacy development must be prioritized alongside technological innovation. Policymakers, educators, and clinicians share a collective responsibility to close the literacy divide. Only then can digital oral health interventions deliver on their promise. The following section will explore how these literacies intersect with oral health literacy and behavior change mechanisms (Vivek et al., 2024; Liang et al., 2024).

1.2. Relationship between Oral Health Literacy (OHL) and Digital Skills

As health communication increasingly shifts to digital media, oral health literacy (OHL) must evolve in tandem with digital competencies. Traditionally defined as the ability to obtain, understand, and use oral health information, OHL now includes the capacity to interact with mobile apps, interpret visual media, and engage in remote consultations. In practice, digital skills serve as both a bridge and a barrier for individuals seeking to transform knowledge into healthy oral behaviors.

This subchapter explores how OHL and digital literacy are interlinked, mutually reinforcing, and essential for driving behavior change, particularly in low-resource settings. Drawing from both global frameworks and national initiatives in Indonesia, we examine how digital proficiency affects one's ability to process, internalize, and act upon oral health information. By understanding this relationship, stakeholders can better tailor digital strategies to enhance health equity and behavioral impact.

Oral health literacy (OHL) refers to a person's ability to access, understand, and apply oral health information for decision-making and behavior. With the rapid rise of digital platforms, this literacy must extend beyond traditional comprehension toward skills in navigating digital tools and content. A digitally competent individual with high OHL is more likely to assess health risks accurately and adopt effective oral hygiene practices. Conversely, low digital skills limit the functional potential of OHL, creating gaps between knowledge and behavior. In Indonesia, where digital health programs are growing, these two domains increasingly intersect. As noted by Anwar and Supiaty (2022), without baseline digital skills, even well-designed interventions may fail to influence behavior.

The synergy between digital literacy and OHL is bidirectional: high OHL enhances the uptake of digital health innovations, while strong digital skills facilitate better comprehension of oral health content. For example, apps or videos explaining caries prevention are only effective if the user can operate a smartphone, interpret audiovisual information, and apply recommendations. Studies such as those by Yu et al. (2024) show that patients with low digital skills often misunderstand online instructions, resulting in improper or no behavior change. This highlights that enhancing OHL alone is insufficient without concurrently developing users' digital capacities. Integrated strategies are thus required, especially among school-aged children and caregivers in rural or low-resource settings. In such contexts, localized and interactive approaches (such as gamification) prove more accessible and impactful (Aldilawati et al., 2023).

The evidence suggests that digital tools can effectively augment OHL when designed appropriately. In a randomized study by Ribeiro et al. (2022), mothers who received digital education through mobile media demonstrated improved knowledge and oral health behaviors in their children. Yet, such interventions depended on participants' baseline digital navigation abilities. This confirms that digital skills act as enablers of OHL-mediated behavioral

outcomes. In another study conducted by Wening et al. (2025), elderly individuals empowered with accessible media interfaces were more consistent in following up with dental care visits. These findings indicate that accessibility and interface design are as crucial as content accuracy in digital interventions targeting OHL.

One emerging model for connecting OHL and digital skills is the "interactive learning loop," where users first acquire health content and then reinforce it through digital practice. This is visible in the successful deployment of the Puzdent for Kids app, which enabled third-grade students in Makassar to recognize plaque development stages and proper brushing techniques (Aldilawati, Selviani, & Ardiningrum, 2023). The process of viewing, understanding, and reapplying knowledge digitally leads to deeper retention. However, without digital support such as tutorials or teacher mediation, users may abandon the application or misuse it. Thus, school-based digital interventions must also cultivate foundational OHL among both students and educators. This is critical in mainstreaming preventive oral health education in the digital age.

Digital literacy also influences how individuals seek, evaluate, and use oral health information online, which directly relates to the functional and critical dimensions of OHL. Users with high digital fluency are better equipped to identify trustworthy sources, understand terminology, and translate findings into daily habits. In contrast, individuals with low digital literacy may become overwhelmed, misled, or disengaged by contradictory information. According to King et al. (2025), interventions that pair digital engagement with guided literacy training result in significantly higher knowledge retention and brushing adherence. This calls for blended learning strategies that bridge personal interaction with digital autonomy. Such strategies are especially valuable for adolescent populations navigating complex digital environments.

In Indonesian public health contexts, community health workers (kader) are instrumental in supporting both OHL and digital

engagement. Training modules using flipcharts and videos have successfully raised OHL levels in rural villages, as shown in the study by Aldilawati, Wijaya, and Hasanuddin (2021). However, the effectiveness of these materials is strongly influenced by the digital fluency of the kader themselves. Without adequate support, community educators struggle to deliver structured messaging or utilize digital tools effectively. Therefore, upskilling educators becomes a prerequisite for equitable digital health dissemination. These cascading effects from educators to families, create multiplier outcomes in oral health behavior.

Another critical interface between OHL and digital skills is emotional engagement. Digital interventions that evoke empathy, such as storytelling or simulation, are more likely to induce behavioral change than purely informational content. A study by Wrona et al. (2025) on community-based digital interventions emphasized the need for affective and motivational dimensions in digital OHL strategies. This aligns with the notion that literacy is not just about reading or viewing but about interpreting and internalizing meaning. In the Indonesian context, game-based tools like Quizztooth (Aldilawati et al., 2026) illustrate how interactivity and reward-based design can engage young users in learning dental hygiene routines. However, sustained success requires reinforcement through both school curriculum and parental modeling. This reinforces the socio-ecological nature of digital OHL development.

Research also demonstrates that strong OHL and digital skills are associated with better oral health status, such as reduced plaque levels and caries incidence. For instance, in the study by Anwar et al. (2020), children who received animated educational interventions and possessed basic smartphone skills showed improved brushing performance and plaque control. The clarity and repetitiveness of audiovisual formats were critical to knowledge retention. Still, digital exposure without health literacy may not lead to the intended behavioral outcome. Hence, program designers must

anticipate and address both literacy dimensions concurrently. This duality should form the core design principle for all digital oral health interventions.

Within families, parental digital literacy plays a pivotal role in mediating children's oral health behaviors. When parents can access and interpret digital materials such as brushing guides or dietary warnings, they are more likely to enforce healthy routines at home. Research by Rahmayani et al. (2024) on motivational interviewing among pregnant women underscores that digital coaching tools are more impactful when users are digitally competent. Moreover, digitally literate parents act as role models and gatekeepers of children's information environments. This underscores the need to integrate family-based digital literacy modules within maternal and child health programs. Such integration offers a sustainable pathway for building intergenerational oral health habits.

The digital divide remains a barrier to equitable OHL advancement. In urban centers, exposure to digital content may be common, but comprehension varies widely based on socioeconomic status, education, and language. Rural communities often experience both access and skill deficits, compounding OHL challenges. To overcome this, programs such as community-based telehealth (Wening et al., 2025) must be paired with training sessions that build digital confidence. Without this infrastructure, digital tools risk becoming inaccessible artifacts rather than agents of change. Inclusive design and outreach remain essential components of digital OHL strategies.

Government policy and health education curricula also play a vital role in fostering the connection between OHL and digital proficiency. Programs that mandate digital oral health education within schools, such as Dokter Kecil training, can build foundational habits while improving both literacies. For instance, Failasufa et al. (2023) demonstrated that children who received audiovisual education through WhatsApp had significantly higher knowledge

scores compared to those who received printed leaflets. Such evidence highlights that both format and channel matter in shaping behavioral impact. Embedding these elements in standardized education ensures scalability and sustainability. The intersection of OHL and digital skill is therefore not only clinical, but also structural and pedagogical.

The relationship between OHL and digital skills also has implications for the design of culturally sensitive materials. In multi-ethnic regions like Indonesia, oral health messages must consider local languages, beliefs, and taboos. Tools that ignore these nuances (however advanced) are unlikely to foster behavior change. Digital storytelling, for example, enables contextualization of oral health messages within familiar social narratives. This method was employed by Alamsyah and Natassa (2018) to improve hygiene behaviors among visually impaired children using audio-based interventions. Tailoring content delivery to both cultural and cognitive profiles strengthens the dual pillars of OHL and digital literacy.

Digital health platforms also introduce new dynamics in patient-provider communication, which depend on both OHL and digital competence. Patients with higher literacies are more likely to articulate symptoms, ask questions, and adhere to follow-up care via online channels. For instance, apps that track brushing frequency or gingival status allow real-time feedback and early intervention, but only if users can input and interpret data. According to Liang et al. (2024), these interactions build self-efficacy and long-term adherence. Meanwhile, providers must also develop skills in digital counseling, ensuring that communication remains empathetic and comprehensible. Thus, bidirectional literacy becomes the foundation of successful digital oral care.

National data systems and research must evolve to capture the dual dimensions of OHL and digital skills, particularly in dental public health surveillance. Surveys that isolate OHL from digital access tend to underestimate barriers in real-world implementation.

Comprehensive indices are needed to inform both macro policy and micro intervention design. For example, integration of digital OHL metrics in school-based health reporting can reveal gaps in media usage and comprehension. This approach also helps in tracking the effectiveness of large-scale interventions, such as Indonesia's UKGS revitalization programs. Bridging this measurement gap is key to evidence-based policymaking and resource allocation.

In conclusion, oral health literacy and digital skills are interdependent constructs that shape how individuals engage with oral health promotion in a digital era. Strengthening one without the other limits the reach and sustainability of behavior change interventions. Effective programs must recognize this synergy and adopt integrative approaches that target both competencies simultaneously. From digital coaching apps to school-based gamification, success relies on the alignment of comprehension, access, and motivation. Policymakers, educators, and practitioners should collaborate to design systems that make oral health knowledge actionable through digital empowerment. The next section will explore the theoretical models that explain how these literacies influence behavior change trajectories.

1.3. Theoretical Background: Health Belief Model and Information-Motivation-Behavior Model

To effectively design and implement digital oral health promotion strategies, a theoretical understanding of behavior change is essential. The Health Belief Model (HBM) and the Information-Motivation-Behavior (IMB) model offer structured insights into how individuals interpret health risks, acquire motivation, and translate knowledge into preventive actions. Both frameworks have been applied extensively in oral health research and are especially relevant in the digital age, where behavior change must be mediated through screen-based interventions.

By mapping digital literacy and oral health literacy onto these theoretical constructs, health professionals can create

interventions that are not only informative but also behaviorally persuasive. These models also offer guidance for tailoring content to cognitive, emotional, and social readiness. This subchapter synthesizes the HBM and IMB frameworks as applied to digital oral health promotion and literacy development.

The Health Belief Model (HBM) posits that health-related action is influenced by perceived susceptibility, severity, benefits, and barriers, along with cues to action and self-efficacy. In oral health, HBM has been used to explain behaviors such as brushing frequency, dental visit compliance, and caries prevention. When applied in digital contexts, HBM dimensions help assess whether users perceive the oral health information presented through mobile apps or online videos as personally relevant. For instance, digital reminders are more effective when users already feel susceptible to dental diseases. Additionally, interactive tools that highlight consequences of neglect such as plaque visualizers, enhance perceived severity and urgency. Studies like those of Cardoso et al. (2024) show that mobile applications incorporating HBM dimensions are more effective in changing oral health behaviors.

Perceived barriers, such as lack of understanding or difficulty using technology, are particularly important in digital interventions. Users with low digital or health literacy often perceive digital content as confusing or untrustworthy, thus hindering behavioral uptake. Anwar et al. (2020) demonstrated that animated video interventions addressing these barriers significantly improved oral hygiene among school-aged children. Moreover, when HBM constructs are addressed explicitly such as reinforcing benefits of brushing or minimizing perceived effort, digital interventions are more successful. This is especially true in rural settings where access to traditional care is limited. Thus, barrier reduction and benefit reinforcement must be integral to digital oral health design.

Cues to action are digital prompts that trigger engagement or behavior. These may include SMS reminders, interactive quizzes, or gamified rewards that encourage brushing or dental check-ups.

Tools like the Quizztooth app developed by Aldilawati et al. (2026) exemplify this concept by embedding cues within educational games. Such cues serve not only as reminders but also as motivational nudges that help form consistent habits. In behavior change theory, repeated exposure to cues enhances habit formation and increases compliance. Therefore, integrating cues into digital content is a practical application of HBM principles in promoting oral health.

The concept of self-efficacy, the belief in one's ability to take action, is foundational in HBM and directly influenced by both oral health literacy and digital skills. Individuals who feel confident using an app or following online instructions are more likely to engage in preventive behaviors. In a study by Kim et al. (2025), digital health confidence was positively correlated with adherence to oral hygiene routines among elderly users. This indicates that literacy-building must include confidence-enhancing elements such as tutorials, support lines, or in-app guidance. Without self-efficacy, even the most informative interventions can fall short. Hence, self-efficacy is both a cognitive and technical outcome of integrated literacy development.

The Information-Motivation-Behavior (IMB) model, developed in the field of HIV prevention, is increasingly used in oral health to explain behavior change through three interconnected components. First, accurate and actionable information must be delivered in an accessible manner. Second, personal and social motivation must be cultivated through messages that align with users' values and contexts. Third, individuals require behavioral skills to execute the intended actions. In the digital realm, all three components must be embedded within platform design and content. Liang et al. (2024) highlight that IMB-based programs outperform traditional didactic methods in promoting daily flossing and brushing.

Information alone is insufficient to produce change unless it is motivationally relevant. Motivation is influenced by perceived

norms, personal beliefs, and emotional resonance with content. For example, an educational cartoon may be more impactful than a static poster because it engages both cognitive and emotional domains. In the Puzdent for Kids study (Aldilawati et al., 2023), game mechanics and rewards fostered positive emotions toward brushing, enhancing motivation. Moreover, digital social networks can serve as reinforcement mechanisms, allowing users to see peers modeling desired behaviors. These aspects confirm that motivation is not only internal but socially mediated.

Behavioral skills, the final IMB domain, refer to specific capabilities required to perform an action. In oral health, this includes knowledge of brushing techniques, flossing routines, or recognizing dental symptoms. Tools like animated tutorials or AR-based toothbrushing simulations help users visualize and imitate these skills. Anwar and Supiaty (2022) emphasize that when children can replicate modeled behavior through interactive media, adherence increases. These digital tools therefore function as behavioral rehearsal platforms. Embedding skills training into media transforms passive learning into active capability development.

Both HBM and IMB emphasize personalization and relevance, which can be facilitated through digital tailoring. Apps that adapt content based on age, prior behavior, or comprehension level provide better outcomes than generic formats. For instance, adaptive quizzes that reinforce weak points or avatar-based storytelling for special needs children are grounded in these theories. Yu et al. (2024) found that personalization improves comprehension and behavioral uptake among older adults. This confirms that theoretical grounding should be operationalized through user-centered digital design. Personalization is not a luxury but a theoretical imperative in modern health communication.

Another strength of IMB and HBM is their adaptability across life stages. For young children, motivation may be externally driven through gamified rewards, whereas for adults, risk perception and social norms may be more salient. Rahmayani et al. (2024)

showed that digital motivational interviewing adapted to HBM improved oral health behaviors among pregnant women. Meanwhile, for the elderly, content must emphasize functional relevance, ease of action, and confidence building. This life-course approach ensures that interventions remain effective across developmental and psychosocial stages. Theoretical flexibility is key to program longevity and inclusiveness.

In conclusion, both the Health Belief Model and Information-Motivation-Behavior Model offer robust frameworks for designing digital oral health interventions. They clarify the cognitive and motivational processes through which information becomes action. When aligned with oral health and digital literacy principles, these models enhance user engagement, learning retention, and behavior sustainability. They also provide diagnostic tools for assessing gaps in knowledge, motivation, or skill. As digital health becomes increasingly central in public oral health, theoretical rigor must guide both content and delivery strategies. The next chapter will explore specific applications of these models in digital educational interventions within schools, families, and communities.

Summary

In today's digital world, brushing teeth is no longer just about using the right toothbrush, it's also about knowing how to access and use online tools to maintain good oral health. This chapter explains how digital skills and oral health knowledge work together to help people make better decisions about their teeth. When someone understands dental advice and also knows how to use apps or watch videos for learning, they are more likely to follow healthy habits like brushing and visiting the dentist. We also talk about theories that explain why people choose to take care of their teeth and how digital platforms can help them do it. The chapter gives a solid foundation for understanding why literacy and technology matter so much in building healthy smiles. This is especially important for schools, families, and communities using mobile tools to teach children and adults about oral hygiene.

Key Messages

- *Digital skills and oral health literacy are deeply interlinked—neither alone is sufficient to drive long-term behavioral change in oral health.*
- *The Health Belief Model and IMB framework provide strong guidance for designing digital interventions that are informative, motivational, and behaviorally empowering.*
- *Inclusive, tailored, and theory-driven digital programs are essential to promote oral health equity across different age groups and socio-demographic settings.*

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Chapter 2.
Measuring Digital Health Literacy and Its Impact

2.1 Tools and instruments for assessing DHL and OHL (e.g., OHL-Ortho)
2.2 Digital health literacy among adults and older populations
2.3 Validation studies and methodological issues

Abstract
Accurate measurement of digital and oral health literacy (DHL and OHL) is pivotal for designing, implementing, and evaluating effective oral health promotion strategies in the digital era. This chapter reviewed a range of validated instruments, including eHEALS, DHLI, and OHL-Ortho, highlighting their strengths and contextual limitations. It explored how assessment tools must be adapted across demographic groups, particularly for older adults and underserved populations by incorporating user-friendly interfaces, behavioral metrics, and culturally sensitive content. Methodological considerations, such as content validity, construct coherence, internal reliability, and test-retest consistency, were discussed to underscore the importance of rigorous validation. Additionally, technological, ethical, and training factors were evaluated as integral to the success of digital tool deployment. These insights lay a scientific foundation for integrating validated literacy assessments into national and community-level oral health behavior change programs.

Keywords: *Digital health literacy; Oral health literacy; Assessment validation; Methodological integrity; Health behavior evaluation*

2.1 Tools and instruments for assessing DHL and OHL (e.g., OHL-Ortho)

The assessment of Digital Health Literacy (DHL) is fundamental for understanding an individual's ability to access, interpret, and use digital health resources effectively. Instruments such as the Digital Health Literacy Instrument (DHLI) and the eHealth Literacy Scale (eHEALS) have been widely used in public health studies to quantify these abilities. eHEALS, developed by Norman and Skinner, consists of eight items measuring users' perceived skills in using online health information. Although eHEALS remains one of the most cited tools, critiques highlight its reliance on self-report and limited adaptation to newer digital formats. In contrast, DHLI extends the framework by including operational skills and interactional capacities in online environments. Both tools serve as foundational benchmarks for measuring DHL but require contextual validation when applied to dental settings or specific populations (Wrona et al., 2025; Kim et al., 2025).

Oral Health Literacy (OHL), while traditionally assessed through print-based instruments, is increasingly measured using

hybrid or digital-compatible tools. The Rapid Estimate of Adult Literacy in Dentistry (REALD-30) and the Oral Health Literacy Instrument (OHLI) were among the earliest tools developed to measure basic word recognition and comprehension related to dental terms. These instruments, however, have limited scope in evaluating how patients interact with digital health content. Recent adaptations such as OHL-Ortho and REALMD-20 have emerged to assess specialized OHL in orthodontic and clinical settings, combining reading tasks with scenario-based questions. For example, OHL-Ortho includes items specific to digital orthodontic care instructions and app-based monitoring. These developments represent a shift toward more context-specific and digitally responsive assessment strategies (Yue et al., 2023; Cardoso et al., 2024).

Despite global advances in tool development, instruments specific to digital oral health literacy are still emerging. Tools like eHEALS or DHLI are often generalized and fail to account for domain-specific terminologies, decision-making challenges, or platform navigation issues in dentistry. Moreover, assessment tools for adolescents and elderly populations must consider cognitive, educational, and motivational factors that influence digital interaction. A promising development is the use of scenario-based questionnaires that simulate real-life decisions, such as interpreting app alerts for caries risk or navigating teleconsultation platforms. These instruments assess not only knowledge but also behavioral intention and confidence. Validation of such tools in Indonesia remains limited, emphasizing the need for localized development and psychometric testing (Kim et al., 2025; Liang et al., 2024).

In Indonesia, research by Anwar et al. (2022) demonstrated the utility of video-based behavioral assessments in measuring the impact of game-based education on dental hygiene knowledge. The interactive nature of the medium provided a more accurate reflection of comprehension and skill transfer, compared to paper-based tests. Likewise, Aldilawati et al. (2023) utilized digital quizzes embedded in the Puzdent app to gauge children's learning outcomes after a

brushing campaign. These approaches highlight how embedded assessment tools within digital platforms can serve dual functions—both educating and evaluating users. Importantly, these tools allow real-time data collection for continuous program improvement. The integration of such tools within mobile health interventions represents a shift toward adaptive learning systems in oral health.

The inclusion of health behavior theories in tool design enhances the predictive validity of DHL and OHL instruments. Instruments that integrate components from the Health Belief Model (HBM) or the Information-Motivation-Behavior (IMB) framework capture not only knowledge but also the motivational and behavioral aspects of literacy. For instance, users may understand brushing techniques yet lack motivation or confidence, which pure knowledge tests fail to detect. Tools embedding such frameworks, like those piloted by Liang et al. (2024), allow a more comprehensive view of readiness to change. This ensures that assessment informs not only classification but intervention design. Future instruments should consistently align their constructs with established theoretical models to enhance relevance and accuracy.

Assessment instruments should also consider language accessibility and cultural relevance, particularly in multilingual nations like Indonesia. A study by Aldilawati, Wijaya, and Hasanuddin (2021) emphasized the need to develop oral health education tools in local dialects to ensure comprehension among rural populations. When assessment tools are translated or adapted, cognitive debriefing and semantic validation are essential to preserve meaning. This is especially relevant when terms like “plaque,” “gingivitis,” or “fluoride” are unfamiliar in regional vernaculars. Without cultural tailoring, literacy assessments risk misrepresenting an individual's actual comprehension and competency. Localization is thus both a linguistic and public health imperative.

Digital assessment tools offer unique advantages over conventional paper-based formats, particularly in capturing real-time interaction and behavioral data. For example, app-based

quizzes can track response time, error patterns, and user engagement metrics—data which are inaccessible through static questionnaires. These digital footprints can be analyzed to identify cognitive difficulties, motivational lapses, or interface design flaws. Furthermore, adaptive testing formats adjust difficulty levels based on prior answers, improving measurement precision. Such features are particularly beneficial when evaluating OHL and DHL among users with varied educational backgrounds. These approaches support more responsive and learner-centered assessment strategies (King et al., 2025; Cardoso et al., 2024).

In school-based programs, teachers have also become instrumental in assessing digital oral health literacy. Studies by Failasufa et al. (2023) indicate that trained school personnel can deliver short surveys or observe children's digital tool usage during oral health campaigns. Teacher-facilitated assessments ensure that responses reflect actual comprehension rather than guessing or peer influence. Moreover, these instruments can be integrated into broader curricula and aligned with health education standards. This participatory approach not only builds assessment capacity but also enhances school engagement with digital health promotion. Teachers, therefore, serve as both assessors and literacy facilitators in digital oral health settings.

Some tools focus on specific behaviors, such as brushing frequency or flossing accuracy, which are assessed using self-reports or digital diaries. While self-reporting introduces subjectivity, integrating time-stamped photo uploads or video demonstrations enhances objectivity. For instance, the Hi BOGI application studied by Fadilah et al. (2024) enabled parents and children to upload brushing sessions, which were then rated by health professionals. These methods combine behavioral tracking with literacy assessment, offering a multi-dimensional understanding of health behavior. However, issues of privacy, data security, and technological equity must be considered in the tool design. Balanced

and ethical implementation strengthens public trust and participation.

An emerging trend is the development of composite indices that integrate DHL, OHL, and behavioral performance into a single scoring system. These indices allow program managers to segment populations, personalize interventions, and monitor longitudinal change. For example, the Digital Oral Health Readiness Index (proposed in pilot studies by Yu et al., 2024) assigns users a profile based on literacy, motivation, and usage history. Such profiles help tailor interventions to high-risk groups, such as digitally disengaged parents or elderly users with chronic disease. Composite tools also improve program efficiency by identifying who benefits most from additional support. However, widespread adoption requires rigorous validation across diverse populations.

Validation studies are crucial for determining whether an instrument accurately and consistently measures what it intends to assess. This involves assessing content validity, construct validity, internal consistency, and test–retest reliability. In Indonesia, few published validation studies exist on DHL or OHL tools tailored to digital contexts. The need for psychometric rigor was emphasized by Juliawati et al. (2022), who conducted a cross-cultural adaptation and validation of a safety attitude questionnaire for dental settings. Similar methodological diligence must be applied to oral health literacy instruments. Reliable tools are essential for both academic research and practical intervention design.

Usability testing is an often-overlooked component of assessment tool development, especially in digital formats. Even well-validated tools can be rendered ineffective if the interface is unintuitive, language is overly technical, or feedback is absent. For elderly users or individuals with disabilities, adjustments such as audio narration, simplified visuals, or larger fonts may be required. In their 2025 study, Wening et al. integrated elderly feedback into app refinement processes to enhance acceptability among hypertensive patients. These design iterations significantly improved

tool engagement and data accuracy. Human-centered design must therefore accompany scientific rigor in digital health assessment.

Another important dimension is assessing the literacy of caregivers or family members who act as intermediaries for pediatric or special-needs users. In a study involving children with type-1 diabetes, Nugroho et al. (2024) found that maternal oral health literacy directly influenced children's hygiene behaviors. Thus, measuring only the end-user's literacy may be insufficient in household or caregiving scenarios. Instruments should be designed to assess both the individual and their surrounding social support system. This multi-level approach improves predictive power and program effectiveness. It also aligns with socio-ecological models of health promotion.

Implementation science perspectives emphasize the integration of assessment tools into broader programmatic cycles. Rather than using tools solely at baseline or post-intervention, repeated short-form assessments can guide adaptive programming. These assessments help identify plateaus or regressions in learning, triggering corrective actions such as personalized coaching. As demonstrated in Balbeid et al. (2022), short digital check-ins during COVID-19 ensured continuity in oral health behavior education. Embedding such tools into program flow enhances both fidelity and responsiveness. It also facilitates real-time feedback loops for both users and educators.

In conclusion, tools and instruments for assessing digital and oral health literacy are rapidly evolving to match the complexities of digital health environments. Effective instruments must be valid, reliable, inclusive, and adaptable to various user groups and technological contexts. National efforts in Indonesia demonstrate creative local adaptations that integrate education, gamification, and real-time monitoring. However, broader institutional support is required to standardize, validate, and scale these tools across regions. Measurement is not merely evaluative; it is transformative when aligned with intervention goals and user experience. The next section

will explore how digital health literacy manifests in adult and elderly populations, where these tools must navigate generational, cognitive, and technological divides.

2.2 Digital health literacy among adults and older populations

Digital health literacy (DHL) among adults and older populations is increasingly recognized as a determinant of equitable health access and outcomes. With the shift of health services to digital platforms, individuals must be capable of searching, interpreting, and applying online health information effectively. However, older adults often experience difficulties due to age-related cognitive decline, limited prior exposure to technology, and low general literacy. These barriers place them at greater risk of misinformation, digital exclusion, and suboptimal health behavior. Research by Kim et al. (2025) found that elderly individuals with limited DHL were less likely to use teleconsultation services, even when available. Hence, promoting DHL among older populations requires both technological inclusion and supportive educational frameworks.

Cognitive decline and physical impairments such as reduced vision, hearing loss, and impaired fine motor skills, often affect the digital engagement of older adults. These challenges necessitate age-friendly designs that prioritize clarity, voice navigation, and simplified interaction flows. In a study by Snogren et al. (2024), a digital oral health training module tailored to older Swedish adults improved brushing adherence and preventive service uptake. The tool used large fonts, audio support, and interactive scenarios, showing significant improvements in self-efficacy and knowledge retention. This emphasizes the need to tailor digital interfaces to the specific sensory and cognitive characteristics of older users. Usability, rather than just content, is critical for uptake among this demographic.

Motivation plays a crucial role in older adults' engagement with digital oral health tools. Many older individuals lack intrinsic

or social incentives to learn and adopt new technologies unless linked to clear, personal health benefits. Programs that emphasize autonomy, dignity, and disease prevention have greater success in this cohort. For instance, Wening et al. (2025) showed that framing oral health content around hypertension management helped increase dental clinic visits among elderly Indonesians. Contextualizing DHL in terms of chronic disease co-management can therefore create emotional and functional relevance. This strategy enhances both the acceptability and sustainability of digital interventions.

Intergenerational support systems significantly influence digital health behaviors among older adults. Family members, especially younger relatives or caregivers, often serve as digital intermediaries, explaining content, managing apps, and encouraging usage. In this light, the DHL of the household becomes a shared responsibility, not an individual trait. Studies by Nugroho et al. (2024) highlight how maternal digital engagement shapes children's oral hygiene behaviors, suggesting that reciprocal effects may occur between generations. Thus, interventions targeting older populations must also consider family-based support models. Building household-level digital resilience can extend the impact of individual-focused interventions.

Health professionals play a pivotal role in bridging digital gaps among adult and older patients. Dentists, nurses, and health educators must not only deliver care but also support patients in navigating digital tools and interpreting online information. This dual function requires specific training in digital communication and adult learning techniques. In Indonesia, Failasufa et al. (2023) demonstrated that community health educators could effectively integrate WhatsApp-based oral health education for older audiences when supported by proper training. Provider-patient trust is crucial, especially when transitioning from traditional to digital systems. As such, digital empowerment should be integrated into continuous professional development programs.

Socioeconomic status and educational attainment remain strong predictors of DHL among older adults. Lower-income individuals, those with limited schooling, or residents of rural areas are less likely to have prior exposure to digital technologies. In studies conducted by Siripipatthanakul and Siripipattanakul (2024), digital health literacy was markedly lower in remote areas with infrastructural deficits. Even when devices are available, poor connectivity and lack of digital training limit engagement. These disparities reinforce the need for targeted policies and community-based capacity building. Equitable DHL promotion must begin with structural and infrastructural inclusion.

Trust in digital content is another determinant of DHL in older populations. Many adults, particularly those unfamiliar with digital environments, may distrust online sources or feel overwhelmed by conflicting information. This is exacerbated by the prevalence of unverified or commercial content online. Programs that curate and endorse credible health information (through government portals or validated apps) help mitigate this distrust. According to Koh et al. (2021), elderly participants were more willing to engage with content labeled by public health authorities. Establishing trusted digital ecosystems is thus critical to fostering long-term engagement.

Digital health interventions that incorporate community leaders or peer educators often achieve better uptake in older populations. Familiar faces and culturally resonant messengers can reduce intimidation and increase relatability. In Indonesian kampung settings, oral health cadres (kader kesehatan gigi) have been successfully mobilized to introduce mobile tools and offer hands-on demonstrations. This community-embedded approach not only delivers information but also builds confidence and accountability. It aligns with adult learning theories that emphasize relevance, social modeling, and experiential learning. Programs must therefore empower local champions to scale DHL among their peers.

Mobile phones remain the most accessible digital device for adults and older people in Indonesia, especially those in urban peripheries and rural areas. However, limited storage, outdated operating systems, and irregular internet access constrain the use of advanced apps. As such, SMS-based or offline-capable educational content may offer more feasible pathways. Studies by Anwar et al. (2022) recommend low-bandwidth, audio-visual formats for broader inclusion. This underscores the importance of designing interventions within the technological realities of target populations. Accessibility, in both technical and economic terms, must be prioritized.

Behavioral impact of DHL among older adults has been demonstrated in domains such as oral hygiene routines, appointment adherence, and emergency care seeking. For example, Mariño et al. (2016) found that a web-based oral health program improved flossing rates and reduced emergency dental visits among older adults in Australia. These gains were sustained for over six months, suggesting that digital literacy enhancements have durable outcomes. Importantly, behavior change was mediated by improvements in confidence, perceived control, and understanding of oral disease progression. These findings support the strategic importance of DHL development as a behavior change lever. Structured reinforcement mechanisms further extend these benefits.

Psychosocial factors, including digital anxiety, self-perception of aging, and emotional readiness, also influence DHL uptake. Older adults with negative self-concepts or anxiety around technology may resist digital interventions, even if functionally capable. Programs that normalize learning at later life stages and provide non-judgmental support structures are more effective. Emotional reassurance (through user-friendly messages, encouragement, and feedback) builds engagement and retention. A study by Wening et al. (2025) found that peer support groups for elderly hypertension patients enhanced confidence in using digital

oral health tools. Such findings highlight the value of integrating psychological safety into DHL promotion strategies.

Measurement of DHL in older populations presents unique methodological challenges. Standard tools like eHEALS or DHLI may not capture interactional nuances, cognitive load, or language complexity that affect elderly comprehension. Modified tools that include practical simulations or scenario-based assessments are more informative for this demographic. For example, tools that ask users to navigate a simulated dental appointment booking or identify signs of gingivitis from images are contextually richer. Liang et al. (2024) emphasized the need to triangulate self-report, behavioral observation, and usability testing to assess DHL reliably. Comprehensive validation ensures that tools are not only psychometrically sound but also practically meaningful.

Health systems and digital service providers must commit to inclusive design and outreach to close DHL gaps among aging populations. This involves more than just offering online services, it means embedding support in service delivery, such as assisted navigation kiosks, helplines, or guided enrollment sessions. In rural Indonesia, for instance, Wening et al. (2025) reported success with cadre-led digital education stalls during community events. These stations offered tutorials, assessments, and referrals, significantly increasing awareness and confidence among older participants. Infrastructure and human interface thus work in tandem to enhance reach. Institutionalizing such support systems is key to sustainable impact.

Policy-level interventions can institutionalize digital literacy as a right and requirement in health access for older adults. National digital health strategies should include mandates for age-friendly platform design, training programs for providers, and subsidies for device procurement. Public-private partnerships can drive innovation, especially in underserved regions. Programs like Indonesia's *Literasi Digital untuk Lansia Sehat* demonstrate potential when policy and community actors align. These efforts

must be continuously evaluated for impact, equity, and adaptability. A multisectoral approach ensures that no demographic is left behind in the digital transition.

In summary, digital health literacy among adults and older populations is shaped by intersecting factors including age, cognitive function, motivation, social support, and system-level enablers. While digital interventions hold immense potential for improving oral health, success depends on alignment with user capabilities and needs. Tailored content, age-friendly design, and supportive infrastructures are critical to overcoming barriers. Both local and global evidence show that DHL can be enhanced with strategic, inclusive, and empathetic approaches. As the population ages and digitalization accelerates, DHL must be integrated into broader health promotion agendas. The next subchapter will explore validation methodologies and practical challenges in assessing DHL and OHL across diverse settings.

2.3 Validation studies and methodological issues

Validation studies are critical in ensuring that tools designed to measure digital and oral health literacy are both reliable and contextually appropriate. A well-validated instrument must demonstrate psychometric robustness across different populations, languages, and digital environments. In the domain of oral health, early tools such as eHEALS and REALD-30 have been validated primarily in English-speaking countries, often with younger and digitally active participants. However, when applied in multilingual, rural, or elderly populations such as those in Indonesia, direct translation without cultural adaptation yields poor validity. Studies like Juliawati et al. (2022) have demonstrated the importance of cross-cultural validation procedures in adapting tools for Indonesian dental professionals. Without such rigor, measurement results may misrepresent actual comprehension or digital engagement.

Content validity must be established by ensuring that assessment items are representative of the theoretical constructs they

aim to measure. Expert panels including dental public health specialists, digital media designers, and linguists, are typically assembled to evaluate item relevance and clarity. For example, in adapting the DHLI to Bahasa Indonesia, each item must reflect the local terminology used in digital dental care, such as *aplikasi pemeriksa karies* or *reservasi online dokter gigi*. Misinterpretation due to lexical mismatch can reduce both reliability and user trust. Furthermore, cultural attitudes toward oral health may require nuanced adjustments to scenario-based questions. This process anchors tool validity in both technical accuracy and sociocultural appropriateness.

Construct validity is another essential dimension, typically assessed through factor analysis and correlation with external benchmarks. A validated DHL tool should positively correlate with measures of digital engagement, health-seeking behavior, and oral health knowledge. In the study by Liang et al. (2024), high DHL scores predicted consistent app usage and preventive oral hygiene practices. In contrast, weak construct validity results in poor prediction of behavior, reducing the instrument's utility in intervention design. Establishing such correlations often requires longitudinal or multi-modal datasets. As such, validation is not a one-time event but an iterative process grounded in evolving digital behaviors.

Internal consistency, often measured using Cronbach's alpha, indicates how well the items within a tool measure the same underlying construct. A score above 0.7 is generally accepted, although values closer to 0.9 are preferable for educational and behavioral tools. Tools like OHL-Ortho and the IMB-based DHL instruments often require testing of subscales, such as knowledge, motivation, and skills separately. Anwar et al. (2022) showed that in game-based oral health interventions, motivation-related items often demonstrated lower consistency due to varied emotional interpretations. This indicates that item wording, context, and even

visual presentation can affect internal coherence. Iterative testing and item revision enhance instrument fidelity.

Test-retest reliability assesses whether an instrument yields consistent results over time under similar conditions. This is particularly important in longitudinal digital health promotion programs, where repeated assessment is necessary to track change. Tools must show stability in the absence of intervention and sensitivity when actual change occurs. In a study by Cardoso et al. (2024), the oral health literacy score among digital orthodontic patients remained consistent over a two-week interval, validating the tool's reliability. However, in low-literacy populations, environmental factors like device availability or emotional states may introduce variability. Therefore, contextual stability must be monitored alongside psychometric stability.

One methodological issue in DHL assessment is the over-reliance on self-reported data, which is vulnerable to social desirability bias and overestimation. Many participants tend to report high confidence in using digital tools, even if actual interaction is limited or ineffective. Combining self-report with behavioral tracking, such as log data from app usage or observation of task performance provides a more accurate picture. For instance, Aldilawati et al. (2026) used dual-assessment through Quizztooth app scores and manual interview-based scoring. This triangulation approach enhances validity by accounting for performance-based realities. Integrating mixed-methods assessment is thus recommended for digital literacy evaluation.

Sample representativeness also poses a recurring challenge in validation studies. Studies often recruit participants from urban, educated, and digitally active populations, leaving rural, elderly, and disabled groups underrepresented. This undermines generalizability, especially when tools are applied in national health programs. Inclusive sampling strategies, stratified by age, education, income, and digital access, are essential. In the Indonesian context, Wening et al. (2025) incorporated diverse respondent profiles from coastal,

urban, and remote areas in tool validation. Expanding sample heterogeneity strengthens both credibility and utility in real-world application.

Response format and cognitive load should also be considered in tool design, particularly for older adults and those with limited education. Multiple-choice items may be challenging for users unfamiliar with digital interfaces or for those with reading difficulties. In these cases, image-based, audio-narrated, or touch-friendly formats offer greater accessibility. Tools developed by Anwar and Supiaty (2022) demonstrated that game-based interactive formats led to better comprehension and user satisfaction among children and caregivers alike. Simplifying user interface without diluting content ensures inclusivity. Validation must therefore extend beyond psychometric testing to human-centered design.

Technological factors such as device compatibility, app stability, and data privacy also influence the validity and acceptability of digital literacy tools. A well-constructed assessment tool may underperform due to technical bugs, slow loading, or incompatibility with common devices. Moreover, users may hesitate to engage with tools that collect personal data without adequate transparency or security. In their study on tool uptake, Yu et al. (2024) reported that elderly users were more responsive to platforms endorsed by trusted health institutions. Validity is thus intertwined with both function and perception. Ethical compliance and technical robustness are non-negotiable in tool development.

Finally, cultural validation remains a crucial, yet often overlooked, step in instrument adaptation. This involves not only language translation but also adjusting content to reflect local health beliefs, practices, and digital norms. For example, concepts like preventive care, dental insurance, or app-based booking may not resonate equally across regions. Rahmayani et al. (2024) emphasized that maternal beliefs about pregnancy and oral health significantly shaped tool responses. Validation must therefore assess whether

users interpret items as intended. Cultural congruence is a prerequisite for valid cross-contextual tool deployment.

Digital adaptation of validated tools must account for screen size, interactive features, and user fatigue. When tools originally designed for paper are converted to mobile formats, users may experience discomfort due to scrolling, font issues, or unfamiliar navigation gestures. Researchers must conduct usability pre-tests to ensure equivalence in comprehension and response accuracy. In a study conducted by Wening et al. (2025), adaptation of maternal oral health anxiety scales for mobile formats required interface simplification to avoid respondent dropout. This process involved user feedback and iterative UI/UX adjustments, which improved tool completion rates and response consistency. Without such adaptation, digital tools risk measurement error and reduced acceptance.

Cross-validation across diverse settings strengthens external validity and promotes broader tool applicability. A tool validated in one cultural or clinical setting may not perform equally in another without appropriate re-validation. For example, DHL instruments validated among pregnant women in Makassar may require recalibration for application among elderly populations in Bali or urban adolescents in Jakarta. Juliawati et al. (2022) emphasized this necessity by employing multistage validation for safety culture instruments across multiple clinics. Extending this model to oral health literacy tools would improve both policy relevance and clinical utility. Cross-site validation ensures tools support national-scale programs with diverse user bases.

Methodological integrity also depends on training evaluators and users in administering the tool consistently. In community health programs, tools may be used by dental health cadres, schoolteachers, or clinic staff, each with varying levels of understanding and engagement. Clear instruction manuals, demonstration modules, and fidelity checklists should accompany tool deployment. Anwar et al. (2020) integrated such training in multimedia-based school programs, ensuring that both administrators and respondents

understood the task expectations. This alignment minimizes inter-rater variability and response distortion. Standardization protocols are thus critical in applied public health measurement.

Evaluation of validation results should be transparently reported using international standards such as COSMIN or STARD. These frameworks specify statistical, procedural, and reporting guidelines that ensure replicability and credibility. Without such standardization, comparisons between tools or populations become difficult and risk misinterpretation. As emphasized by Collet et al. (2024), transparency in validation reporting improves the credibility of digital literacy studies in academic and policy circles. Applying these guidelines to OHL and DHL instruments will enhance academic rigor and implementation feasibility. Structured reporting also facilitates meta-analytic synthesis in the future.

In conclusion, validation studies are foundational to ensuring the reliability, accuracy, and cultural appropriateness of instruments assessing digital and oral health literacy. Methodological issues ranging from construct validity to user experience must be addressed through a multidisciplinary and iterative approach. In Indonesia and other low- to middle-income countries, contextual and technological realities demand rigorous adaptation strategies. Combining psychometric validation with inclusive, ethical, and design-conscious methodologies strengthens both tool quality and program success. As digital health interventions scale up, validated measurement tools will serve as the backbone for monitoring literacy gaps, tailoring strategies, and driving meaningful oral health outcomes. The next chapter will build on these foundations to explore how educational interventions leverage validated tools to transform digital literacy into tangible behavior change.

Summary
Understanding how well people can use digital tools to manage their oral health is the first step in helping them improve their behavior. This chapter explains the different ways researchers and public health professionals measure skills like using dental apps, reading online health information, or following digital instructions about brushing teeth. It shows how tools must be adapted for older people, children, or those living in rural areas so they are easy to understand and culturally appropriate. These measurement tools help identify who needs more support and what kind of education will work best. It also emphasizes the importance of testing tools carefully to make sure they are reliable and accurate. Good measurements lead to better programs, and better programs mean healthier smiles for everyone.

Key Messages

1. *Measurement is strategic, accurate assessment of DHL and OHL enables targeted interventions, equity in access, and meaningful behavior change outcomes.*
2. *Validation is contextual, tools must be psychometrically strong and culturally adapted to be useful across diverse age, education, and socio-geographic groups.*
3. *Multimodal assessment enhances accuracy, blending self-reports, observational methods, and digital interaction metrics improves the precision of literacy evaluation.*
4. *Inclusive design and ethical safeguards are essential, effective tools balance accessibility with data security and respect for user diversity.*
5. *Validated tools strengthen policy and practice, they provide the backbone for program monitoring, national surveys, and impact evaluations in digital oral health.*

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Chapter 3.
Digital Interventions in Oral Health Promotion

3.1 Mobile-based and web-based educational platforms (e.g., Know Your OQ™, TOOTH)
3.2 Effectiveness of WhatsApp, text-based messaging, and tutorials
3.3 Strategies for delivering tailored content digitally

Abstract
This chapter explores the impact and strategies of digital interventions in promoting oral health, focusing on mobile-based and web-based educational platforms, the effectiveness of text-based messaging services like WhatsApp, and tailored digital content delivery. Digital technologies offer a unique opportunity to bridge gaps in oral health education and behavior change, particularly in resource-limited settings. Mobile applications such as Know Your OQ™ and TOOTH have shown promise in increasing knowledge, improving attitudes, and changing oral health behaviors, especially among younger populations. The integration of gamification, multimedia, and personalized messaging through platforms like WhatsApp has proven to be effective in engaging users, enhancing learning experiences, and promoting sustained behavior changes. This chapter discusses how these technologies are being utilized to reach diverse populations, including children, pregnant women, and older adults, and addresses the challenges of digital health literacy. It highlights the importance of evidence-based strategies, community support, and continuous evaluation to maximize the effectiveness of digital health interventions. Ultimately, the chapter emphasizes that digital interventions, when properly tailored and implemented, have the potential to significantly improve oral health outcomes across populations.

Keywords: *Digital Health Interventions; Mobile-Based Education; Oral Health Behavior Change; Tailored Digital Content; Health Literacy*

Prologue

This chapter delves into the practical applications of digital interventions in oral health promotion. While digital health literacy serves as the foundation for understanding and navigating oral health information, digital interventions play a critical role in bridging the gap between knowledge acquisition and behavior change. The shift towards digital platforms in health promotion represents a significant opportunity to leverage technology in overcoming barriers to traditional health education, especially in remote and underserved communities.

There are three primary approaches: mobile-based and web-based educational platforms, text-based messaging services such as WhatsApp, and the personalization of digital content. These interventions have been increasingly recognized for their ability to engage diverse audiences, from school-aged children to the elderly, in promoting healthier oral habits. By integrating strategies such as gamification, multimedia, and personalized messaging, digital

platforms can effectively cater to individual needs and preferences, enhancing the likelihood of sustained behavior change. As we explore these digital solutions, we will also address the challenges and limitations of these interventions, including issues of digital health literacy and accessibility, and consider their potential to revolutionize oral health promotion on a global scale.

3.1 Mobile-based and web-based educational platforms (e.g., Know Your OQ™, TOOTH)

The integration of mobile and web-based platforms into oral health promotion has revolutionized the way healthcare professionals engage with communities. These digital tools offer a scalable and efficient means of delivering health education, particularly in the face of growing healthcare demands and resource limitations. Mobile-based and web-based platforms, such as Know Your OQ™ and TOOTH, provide users with interactive, personalized content that can be accessed at their convenience. As technology continues to advance, the potential for these platforms to address oral health literacy gaps has never been more promising. In particular, such platforms enhance accessibility, increase engagement, and offer real-time tracking of health behaviors, making them indispensable tools in oral health promotion strategies. This section will review key mobile-based and web-based platforms, discussing their effectiveness and challenges.

Mobile and web-based educational platforms have become pivotal in promoting oral health literacy, offering interactive tools that improve engagement, comprehension, and health outcomes. Platforms like Know Your OQ™ have been designed to assess oral health knowledge and provide targeted educational content. These platforms leverage the flexibility of digital technology to deliver a variety of materials, including videos, quizzes, and real-time feedback. Not only do these platforms serve as educational resources, but they also act as assessment tools, providing data on user engagement and knowledge retention. By integrating

personalized learning pathways, these platforms can adapt content to individual needs, ensuring more effective behavior change. According to Koh et al. (2021), such personalization is critical for improving the efficacy of digital health interventions, especially in diverse and underserved populations.

The TOOTH platform, for example, targets pediatric populations and provides a gamified experience for children to learn about proper oral hygiene techniques. Its integration of storytelling, rewards, and interactive challenges has proven effective in capturing the attention of young learners, ensuring that oral health education is both fun and memorable. Studies have shown that gamification enhances user motivation, leading to sustained engagement and better learning outcomes. As digital natives, children are more likely to embrace such platforms, which offer a safe, engaging, and accessible learning environment. The success of TOOTH in promoting oral health behaviors among children highlights the potential of mobile platforms to address the unique educational needs of younger populations (King et al., 2025).

Web-based platforms, on the other hand, offer broader accessibility and can cater to more diverse user groups, including adults and elderly populations. The flexibility of web-based platforms allows for the integration of multimedia content, such as videos, animations, and interactive features that can support varying learning preferences. In their 2024 study, Yu et al. emphasized that web platforms can increase engagement among adult populations by offering tailored content that aligns with users' health literacy levels. Furthermore, the capacity for real-time feedback allows for continuous monitoring and adaptive learning, enhancing user motivation and improving learning outcomes. Such feedback mechanisms also provide valuable data for evaluating the effectiveness of the intervention, a critical component in improving oral health behaviors (Cardoso et al., 2024).

The success of platforms like Know Your OQ™ lies in their ability to offer culturally relevant, context-sensitive content. The

adaptation of these platforms to local languages and cultural practices is essential for ensuring that the material resonates with target populations. In Indonesia, for example, oral health content needs to address local dietary habits, common oral health myths, and socioeconomic barriers to care. The adaptation process involves close collaboration with local health professionals and community leaders, ensuring that content is both relevant and accessible. As Wening et al. (2025) pointed out, understanding cultural nuances is essential for increasing trust and engagement with digital health interventions. This cultural alignment enhances the likelihood that users will not only engage with the platform but also integrate its teachings into their daily routines.

Digital platforms can also facilitate communication between patients and healthcare providers, which is a significant advantage over traditional educational methods. Tools like Know Your OQ™ offer users the opportunity to ask questions and receive personalized responses, thereby enhancing the educational experience. The ability to interact with health professionals via digital platforms helps build trust and encourage users to seek professional care when necessary. This interaction is particularly beneficial for individuals who may be hesitant to visit a healthcare facility due to geographical, financial, or social barriers. Tan et al. (2021) noted that digital health interventions that allow for two-way communication are more likely to result in improved health outcomes, as they foster continuous support and guidance.

While the benefits of mobile-based and web-based platforms are clear, there are challenges in ensuring equitable access to these technologies. In rural or low-income areas, issues such as limited internet access, lack of mobile devices, and digital illiteracy may hinder the widespread use of these tools. Strategies to overcome these barriers include offering offline functionality, simplifying user interfaces, and providing technical support. Additionally, public-private partnerships are essential for subsidizing technology costs and improving internet infrastructure in underserved regions.

Failasufa et al. (2023) argued that such collaborations are key to ensuring that digital health tools reach all members of society, regardless of socioeconomic status. Making these platforms universally accessible is fundamental to achieving health equity in oral health promotion.

Another challenge lies in the need for user motivation and sustained engagement. While the initial interaction with digital tools may be high, continued use is often a struggle. Gamification and personalized content are important motivators, but these platforms must also address external barriers such as device limitations, lack of time, or competing priorities. To enhance long-term engagement, platforms should incorporate reminders, rewards, and incentives that encourage consistent use. Research by Pacheco-Vergara and Cartes-Velásquez (2020) supports the idea that sustained user participation requires continuous reinforcement and the integration of behavior-change theories within the platform design. The ongoing refinement of digital platforms to incorporate such features is critical for improving the effectiveness of oral health promotion.

The integration of artificial intelligence (AI) into mobile and web-based platforms has further enhanced their ability to provide personalized education and care. AI algorithms can analyze user data and adapt content to match the learner's pace, preferences, and specific health needs. This adaptive learning approach ensures that users are always presented with relevant content that fits their current level of knowledge and understanding. AI-powered platforms like Know Your OQ™ can identify gaps in users' oral health knowledge and offer targeted interventions to address those gaps. In the future, AI may also enable real-time feedback on users' brushing techniques by analyzing images or videos uploaded by the user, providing a personalized learning experience that is immediate and actionable (Liang et al., 2024).

Furthermore, the success of these platforms hinges on the effectiveness of content delivery. The use of videos, animations, and interactive graphics can significantly enhance comprehension,

particularly in populations with low literacy levels or those unfamiliar with dental terminology. Anwar et al. (2022) found that animated videos significantly increased understanding of oral health concepts among schoolchildren, compared to text-based content. These multimedia formats appeal to diverse learning styles, making oral health education more accessible to a wider audience. By leveraging digital technologies to present information in engaging and understandable ways, platforms are able to break down barriers to learning and promote healthier behaviors.

3.2 Effectiveness of WhatsApp, text-based messaging, and tutorials

The integration of digital tools in oral health education has seen significant growth, with WhatsApp and text-based messaging platforms becoming central to delivering health messages across diverse populations. These platforms offer a unique opportunity to deliver oral health education efficiently, leveraging the widespread use of mobile devices. Text-based platforms are particularly effective in reaching underserved populations, especially in low-resource settings. In this subchapter, we examine the effectiveness of WhatsApp, text-based messaging, and tutorial-based platforms in improving oral health behaviors and outcomes. We analyze existing studies on these interventions, providing insight into their potential for driving behavior change, and how these digital interventions contribute to better oral health practices.

WhatsApp, as one of the most widely used mobile messaging platforms, offers a promising avenue for oral health education. Its widespread accessibility, coupled with the ability to share multimedia content, allows for diverse communication strategies. According to Yanti et al. (2017), WhatsApp has been used effectively in educational interventions, especially when the content is customized to the needs of specific audiences, such as deaf children. By incorporating images, videos, and voice messages, WhatsApp can overcome language barriers and enhance the

understanding of oral health concepts, demonstrating its utility as a multimedia educational tool.

The key advantage of WhatsApp and text-based messaging interventions lies in their ability to deliver tailored, personalized health messages. Research by Tan et al. (2021) highlighted that the effectiveness of health interventions increased when content was customized based on user demographics, such as age, educational level, and health status. By sending personalized messages, these platforms not only engage users but also cater to their specific needs, thus making health education more relevant and impactful. This personal touch fosters a sense of individual attention, making users more likely to follow through with the recommended behaviors, such as regular brushing and attending dental check-ups.

One of the critical elements of successful digital interventions is real-time feedback, which enhances engagement and reinforces learning. WhatsApp's capability to facilitate real-time communication between health professionals and users allows for immediate clarification of doubts and offers personalized guidance. For example, if a user inquires about the proper technique for brushing or flossing, health professionals can provide immediate responses. Research by Abdi et al. (2024) demonstrated that users who engaged in real-time conversations via WhatsApp had higher adherence rates to oral health behaviors compared to those who only received static educational materials. This real-time interaction helps to create a more supportive learning environment, crucial for maintaining sustained behavior change.

In addition to real-time interaction, WhatsApp-based interventions also benefit from the ability to send regular reminders, which have been shown to reinforce health behaviors. Studies such as those by Anwar et al. (2020) and Tan et al. (2021) underline the positive impact of reminders on oral health habits, particularly when delivered at optimal times, such as after meals or before bedtime. By receiving timely reminders, users are more likely to remember to engage in critical health behaviors, such as brushing their teeth twice

a day or scheduling a dental check-up. These reminders can act as cognitive prompts that strengthen the link between knowledge and action, thereby promoting positive oral hygiene habits.

One of the challenges in using WhatsApp and text-based platforms is avoiding information overload. Users may experience fatigue or disengagement if the content is too frequent or overwhelming. Research by Tan et al. (2021) emphasizes the importance of content pacing and message frequency in maintaining user engagement. Striking the right balance between informative messages and engaging content is crucial to avoid overwhelming users while ensuring they receive the necessary information. Tailoring the frequency and format of messages according to user preferences can mitigate the risk of message fatigue, maintaining the efficacy of the intervention over time.

Interactive features such as quizzes, polls, and feedback mechanisms enhance the educational value of WhatsApp-based interventions. King et al. (2025) suggest that incorporating quizzes or brief surveys following educational sessions can engage users more deeply and provide instant feedback on their knowledge. By evaluating user responses, health professionals can adjust content to address gaps in understanding, leading to more personalized and effective health education. These interactive elements not only make the learning process more engaging but also foster active participation, which is essential for reinforcing new behaviors.

Moreover, WhatsApp-based interventions can serve as a platform for social support, an essential factor in sustaining health behavior changes. By using group chats or support networks, users can share their progress, ask questions, and provide mutual encouragement. Abdi et al. (2024) highlighted the significance of peer support in health interventions, particularly in digital platforms. Social support mechanisms have been shown to enhance the likelihood of adherence to health behaviors, as users feel accountable to others within their community. This sense of shared responsibility can significantly increase the effectiveness of the intervention.

Furthermore, the accessibility of WhatsApp allows for scalability, making it an ideal tool for reaching large, diverse populations. Unlike traditional in-person interventions, which may be constrained by geographical or logistical barriers, WhatsApp-based interventions can be deployed to reach remote and underserved populations, thereby addressing health disparities. As noted by Tan et al. (2021), WhatsApp's scalability ensures that educational content can be disseminated widely at a minimal cost, making it a viable option for low-resource settings.

In addition to scalability, WhatsApp's ability to deliver culturally relevant content further strengthens its potential as an effective oral health education tool. Cultural sensitivity is crucial when designing health interventions to ensure that the content resonates with the target audience. Yanti et al. (2017) found that culturally tailored content increased engagement and knowledge retention, as the messages were aligned with the audience's values and beliefs. For example, WhatsApp messages can be customized to reflect local languages, customs, and oral health practices, making the content more relatable and actionable.

The inclusion of multimedia content, such as instructional videos and images, is essential in enhancing user comprehension, particularly for those with limited literacy. Anwar et al. (2020) emphasized that visual content aids in conveying complex oral health concepts more effectively than text alone. By demonstrating proper brushing techniques, flossing methods, and the use of mouthwash through video tutorials, WhatsApp interventions can cater to a wide range of learning styles. This is especially important for users who may struggle with reading or those with low literacy levels, making multimedia content an essential component of any digital health education program.

Inclusivity is a key consideration when designing WhatsApp-based interventions. Not all users have the same level of digital literacy or access to smartphones, and some may face challenges in navigating technology. As highlighted by Anwar et al.

(2020), accessibility must be a priority in digital health interventions. For users with limited literacy or digital skills, voice messages or audio instructions can provide an alternative way to access health information. Furthermore, offering content in multiple languages or dialects can help ensure that the intervention is accessible to diverse populations.

Long-term success in WhatsApp-based interventions depends on continuous engagement and follow-up. Providing regular check-ins and follow-up messages can help reinforce healthy behaviors over time. According to Tan et al. (2021), successful interventions are those that maintain user engagement over a long period, ensuring that health behaviors become ingrained as part of daily life. By offering periodic updates and reminders, WhatsApp interventions can ensure that users remain committed to improving their oral health behaviors in the long term.

The use of data analytics in WhatsApp-based interventions can further optimize the delivery of health messages. By analyzing user responses, behaviors, and engagement patterns, health professionals can gain valuable insights into which content works best for different individuals. As highlighted by Abdi et al. (2024), data analytics can help personalize health messages, ensuring that each user receives content that is most relevant to their health status and preferences. This level of personalization increases the likelihood of behavior change and improves the overall effectiveness of the intervention.

Future advancements in artificial intelligence (AI) and machine learning could further enhance WhatsApp-based interventions. AI could be used to predict which types of messages will resonate most with specific users, optimizing the timing and content of health messages. By using data from user interactions, AI could deliver highly personalized messages that meet individual needs. As noted by Tan et al. (2021), AI has the potential to revolutionize digital health interventions by offering a more tailored and efficient approach to health education.

In conclusion, WhatsApp and text-based messaging platforms are powerful tools for promoting oral health behaviors. By delivering personalized, interactive, and culturally relevant content, these platforms can engage diverse populations and facilitate long-term behavior change. However, to maximize their effectiveness, these interventions must be designed with inclusivity, interactivity, and continuous evaluation in mind. When combined with multimedia content and social support, WhatsApp-based interventions can significantly improve oral health outcomes, contributing to better public health on a global scale.

3.3 Strategies for delivering tailored content digitally

Delivering tailored content digitally is essential in addressing the diverse needs of individuals in oral health promotion. Personalized interventions enhance user engagement and ensure that health messages are relevant to each individual's unique circumstances. As digital platforms become more embedded in healthcare, the ability to provide targeted, individualized content through technology has grown substantially. This subchapter explores various strategies for delivering personalized content digitally, drawing on proven models and recent studies to illustrate their effectiveness in changing health behaviors. Special attention will be given to how personalization enhances outcomes and promotes long-term behavior change, particularly in oral health practices.

One of the most fundamental strategies for delivering tailored digital content is through segmentation. According to Yu et al. (2024), segmentation allows for the creation of content that is specifically designed for different groups based on demographics, health behaviors, and needs. For example, oral health education for children may focus on basic brushing techniques, while content for elderly populations might emphasize gum care and preventing periodontal disease. By segmenting audiences into meaningful groups, health messages can be better aligned with the specific

challenges and needs of each group, thereby increasing the likelihood of successful outcomes.

A key consideration when delivering tailored content is the use of user data to inform the personalization process. Platforms such as WhatsApp and other text-based messaging services allow for the collection of user data, which can be analyzed to tailor content based on individual health conditions, previous interactions, and behavioral patterns. Research by Abdi et al. (2024) demonstrated that personalized health interventions that incorporate user-specific data were more effective at influencing behavior change than generic messages. By continuously gathering feedback through user interactions and analyzing responses, these platforms can fine-tune the content to address evolving needs.

Gamification is another strategy that can be employed to personalize digital content. By incorporating game-like elements, such as points, rewards, and challenges, educational interventions become more engaging. Anwar et al. (2020) highlighted that game-based education increased knowledge retention and engagement, particularly among younger populations. In the context of oral health, a game could challenge users to complete daily brushing tasks, rewarding them for consistent engagement with interactive quizzes or badges. These elements not only make learning more enjoyable but also encourage users to adopt and maintain healthy behaviors by providing incentives and immediate feedback.

Multimedia content, including videos, infographics, and audio messages, is another powerful tool for delivering tailored content. According to King et al. (2025), combining various forms of media increases the accessibility and effectiveness of health education. For instance, instructional videos can demonstrate the correct brushing technique, while infographics provide easy-to-digest information on oral hygiene practices. Additionally, audio messages can reach those with low literacy levels or individuals who are more receptive to auditory learning. By offering content in multiple formats, digital health interventions can accommodate

diverse learning preferences, thereby enhancing the overall effectiveness of the intervention.

The inclusion of interactive features in digital health education platforms is essential for maintaining engagement. Interactive components, such as quizzes, polls, and real-time feedback, provide users with the opportunity to assess their understanding and receive immediate reinforcement of the information. Tan et al. (2021) noted that interactive elements increase user participation and help maintain attention, which is critical for long-term behavior change. For example, quizzes about oral health practices can assess what users have learned, while also encouraging them to apply this knowledge to their daily routines. This two-way interaction enhances the educational value and ensures that users are actively involved in their health education.

Personalized messaging through digital platforms is also crucial for addressing behavioral barriers, such as forgetfulness or lack of motivation. By sending timely reminders and follow-up messages, digital platforms can help users stay on track with their oral health routines. Research by Anwar et al. (2020) found that regular reminders significantly improved adherence to oral hygiene practices. These reminders can be tailored based on individual routines and health status, ensuring that users are prompted to take action at the most relevant times, such as after meals or before bedtime. Moreover, reminders can be combined with motivational messages that emphasize the benefits of good oral health, increasing users' intrinsic motivation.

Another strategy for delivering tailored content is the use of adaptive learning algorithms, which personalize the educational experience based on the user's progress. These algorithms track how users engage with the content and adjust the difficulty or complexity of the information accordingly. Kim et al. (2025) explained that adaptive learning can optimize content delivery, ensuring that users are not overwhelmed with information but are instead presented with the right level of content based on their current knowledge. By

dynamically adjusting to the user's learning pace, adaptive learning helps maintain engagement and improves knowledge retention, leading to more effective behavior change.

To enhance the relevance of digital health interventions, content should be designed with cultural sensitivity in mind. According to Yanti et al. (2017), tailoring content to the cultural norms, language, and values of the target population ensures that the messages resonate more deeply with users. In Indonesia, for instance, incorporating local languages and customs can help increase engagement and adherence to health recommendations. Content should not only be linguistically appropriate but also consider the community's social and cultural contexts, ensuring that oral health messages are received positively and are more likely to be acted upon.

Incorporating social support features within digital platforms is also an effective strategy for fostering behavior change. Group-based interventions on platforms like WhatsApp allow users to connect with peers facing similar health challenges, providing them with emotional support and motivation. As noted by Abdi et al. (2024), users who feel supported by a community are more likely to persist in their health behaviors. These social support systems help users share their experiences, ask questions, and encourage one another, creating a sense of accountability that further motivates adherence to health practices.

The integration of AI-powered personalization further enhances the impact of digital content. Artificial Intelligence can analyze vast amounts of user data to provide tailored health education based on specific patterns and preferences. For instance, AI can predict when a user is most likely to engage with a message and deliver content at that time, maximizing the chances of interaction. Tan et al. (2021) suggested that AI-powered interventions can optimize content delivery by ensuring that users receive relevant information at the most effective times, increasing the likelihood of behavior change.

Gamified approaches, as mentioned earlier, can be particularly beneficial for younger populations. Anwar et al. (2020) found that children who engaged with gamified content were more likely to retain oral health information and demonstrate improved oral hygiene behaviors. By incorporating elements of competition and achievement, such as earning points for each brushing session, users are motivated to maintain good oral health practices. This approach is not only engaging but also reinforces the message that oral health is important and rewarding.

A key factor in the success of digital interventions is the ability to provide continuous learning opportunities. Long-term engagement is essential for sustaining behavior change, and providing users with regular updates, new content, and follow-up messages ensures that they remain committed to improving their oral health. Research by Yanti et al. (2017) emphasized that ongoing education, combined with frequent check-ins and encouragement, significantly improved users' adherence to health recommendations. Continuous engagement ensures that oral health behaviors are reinforced and maintained over time, contributing to long-lasting improvements in health outcomes.

To evaluate the effectiveness of digital interventions, it is essential to collect data on user engagement, knowledge retention, and behavior change. Monitoring these outcomes allows health professionals to refine their approaches and ensure that interventions are having the desired impact. Tan et al. (2021) recommended incorporating data analytics tools into digital health platforms to track user progress and identify areas for improvement. This data-driven approach enables health professionals to optimize the content and delivery methods, ensuring that interventions are both effective and sustainable.

Digital content personalization can also be enhanced by incorporating user feedback into the design process. By collecting user feedback through surveys, polls, or direct communication, health professionals can gain valuable insights into user preferences,

knowledge gaps, and barriers to adherence. This feedback loop ensures that the content remains relevant and user-centered. As noted by Tan et al. (2021), involving users in the development and adaptation of health interventions enhances their engagement and commitment to the program.

In conclusion, delivering tailored digital content through platforms like WhatsApp, mobile apps, and text messaging has proven to be an effective strategy for improving oral health behaviors. By leveraging personalization, multimedia, social support, and AI-powered systems, digital interventions can meet the unique needs of different user groups and foster long-term behavior change. However, to maximize their effectiveness, these interventions must be continuously evaluated, culturally relevant, and responsive to user needs. As digital health interventions continue to evolve, the future holds great potential for expanding access to oral health education and promoting positive oral hygiene practices worldwide.

Summary

This chapter discusses how digital technologies like mobile apps, websites, and messaging platforms are being used to promote better dental and oral health. It explains how tools such as Know Your OQ™ and the TOOTH program can help people, especially children and adolescents, learn to take better care of their teeth and gums. The chapter highlights the benefits of using simple tools like WhatsApp and educational videos to share important health information, especially in places where people have limited access to dental care. These digital tools are effective because they are accessible, can be personalized to different groups, and are easy to use on a daily basis. With growing access to smartphones and the internet, using digital methods to teach and encourage good oral hygiene is becoming a practical and powerful approach. This chapter shows that with the right content and delivery methods, digital health education can help reduce tooth decay and promote better oral hygiene habits across all ages.

Key Messages

1. *Digital platforms such as mobile apps, websites, and messaging services offer scalable, low-cost solutions to promote oral health behavior change.*
2. *Text-based platforms like WhatsApp are effective in delivering health messages that are easy to access, understand, and apply in daily routines.*
3. *Tailoring digital content based on age, literacy level, and cultural context significantly enhances user engagement and the sustainability of oral health practices.*
4. *The success of digital interventions depends on a strategic blend of content quality, delivery methods, and digital literacy support among targeted populations.*

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Chapter 4.
Digital Literacy Among Special and Vulnerable Populations

4.1 Older adults, low-income groups, and people with disabilities
4.2 Barriers to adoption (cognition, education, readiness)
4.3 Solutions through community-engaged learning and family support

Abstract
This chapter explores the critical dimensions of digital oral health promotion among vulnerable populations, particularly older adults, low-income groups, and individuals with disabilities. Through a comprehensive synthesis of national and international literature, it identifies cognitive, socioeconomic, and technological barriers that impede digital intervention uptake. Particular emphasis is placed on the intersection of digital literacy and oral health behavior, revealing the layered challenges of access, trust, and readiness. Community-engaged learning and family involvement are presented as sustainable, culturally adaptive solutions that reinforce digital engagement and oral health awareness. Best practices highlight the utility of interactive tools, intergenerational learning models, and peer support systems in enhancing digital participation and behavior change. This chapter concludes with a call for inclusive, equity-driven approaches that empower communities through digital health ecosystems tailored to their specific needs.

Keywords: *Digital literacy; Oral health promotion; Vulnerable populations; Community-based education; Family engagement*

Prologue

The preceding chapter underscored the pivotal role of digital interventions such as mobile applications, web-based platforms, and tailored communication channels in enhancing oral health behavior across general populations. Previous chapter illuminated how behavioral change can be catalyzed through structured digital content, interactivity, and user-centric design, supported by national and global evidence. However, while digital transformation offers unprecedented opportunities, it also poses significant equity challenges. Disparities in access, comprehension, and usage of digital tools remain profound among those most at risk of poor oral health outcomes.

This chapter builds upon these insights by critically examining the unique barriers and facilitators of digital oral health promotion among special and vulnerable populations, including older adults, low-income groups, and individuals with disabilities. These communities frequently experience compounded disadvantages, not only in oral health access but also in their digital literacy and engagement capacity. As such, a more nuanced and empathetic approach is required to ensure that the momentum of digital innovation does not unintentionally widen health disparities.

Through interdisciplinary analysis, this chapter maps the intersection of digital exclusion and oral health inequity. It introduces strategic pathways, rooted in community engagement, family-centered education, and inclusive design that can elevate digital literacy in underserved populations. This inquiry is not merely about technology adoption; it is about reimagining digital health promotion as a vehicle for equity, resilience, and empowerment within Indonesia's evolving oral health ecosystem.

4.1 Older adults, low-income groups, and people with disabilities

Older adults often face multiple intersecting barriers to digital oral health literacy, including limited technological exposure and age-related cognitive decline. Studies indicate that digital exclusion in this group is compounded by health illiteracy and chronic disease burdens, which hinder their engagement with mobile health applications (Yu et al., 2024). In addition, physical impairments such as reduced vision and manual dexterity can affect their ability to use devices or interpret content. This underscores the need for simplified user interfaces and audio-visual aids that accommodate their functional limitations. Integrating gerontological design principles into digital health tools can substantially improve their usability and reach. Such design should prioritize clarity, accessibility, and interactivity tailored to the cognitive and sensory capabilities of older adults.

Digital literacy among low-income communities is constrained by limited internet access, low ownership of smart devices, and sporadic health education exposure. As observed in community-based studies in Indonesia, economic hardship correlates with lower oral health knowledge and fewer dental visits (Abdi et al., 2024). Moreover, individuals in this group may prioritize immediate economic needs over long-term health investments, including digital learning. Therefore, digital interventions must be designed to align with their daily routines and

resource availability. Free, offline-accessible educational apps with low data consumption can facilitate broader participation. Additionally, embedding oral health content within platforms already used by this population, such as WhatsApp, may increase engagement.

People with disabilities represent a highly heterogeneous group with distinct needs depending on physical, sensory, intellectual, or psychosocial conditions. Digital health education programs often fail to adapt content and platforms to accommodate these diverse impairments (Yanti et al., 2017). For instance, deaf users benefit more from captioned videos and sign language support, while blind users require screen reader compatibility and audio-based instruction (Alamsyah & Natassa, 2018). Tailoring content delivery methods to these specific requirements is critical to fostering inclusion. In this regard, collaboration with disability advocacy organizations and caregivers is essential during the content design and validation process. Participatory co-design ensures both accessibility and relevance, avoiding the common pitfall of ableist assumptions.

Several studies emphasize that the older population is not intrinsically resistant to digital technology but lacks structured and patient-centered guidance. A systematic review by Kim et al. (2025) reveals that when older adults are provided with hands-on training and consistent technical support, their uptake of digital health platforms improves significantly. The review also notes the importance of peer-led teaching models, which can build confidence and reduce technology-related anxiety. These insights highlight that improving digital literacy is not only about skill acquisition but also about fostering motivation and emotional security. Providing stepwise learning modules and safe spaces to fail can empower older users to gradually integrate digital health tools into their daily lives. Hence, capacity-building programs should extend beyond content delivery to encompass mentorship and emotional scaffolding.

The intersection of gender, poverty, and disability further complicates access to digital oral health information. Women with disabilities, for example, are more likely to face digital exclusion due to societal norms, caregiving responsibilities, and lower educational attainment (Wening et al., 2025). In such contexts, oral health promotion must adopt a holistic empowerment framework that addresses both digital and social marginalization. This includes leveraging community networks and peer educators who share similar lived experiences. Empowerment-oriented digital campaigns, particularly those co-produced with target users, have been shown to enhance both engagement and retention. Interventions that honor user dignity, autonomy, and agency are more likely to yield sustained behavioral improvements.

The role of local language and cultural context in digital oral health literacy cannot be overstated. Many low-income users are unfamiliar with formal biomedical terms or health system jargon, which hinders comprehension and trust (Anwar & Supiaty, 2022). Digital content that is localized (both linguistically and visually) has been found to improve knowledge retention and applicability. Moreover, culturally tailored storytelling or gamified modules enhance relatability, particularly among children and adolescents. Health education tools should thus undergo sociolinguistic validation to ensure resonance with intended audiences. Failure to adapt culturally can render even technologically sound programs ineffective or even counterproductive.

Research also shows that digital tools grounded in lived experience frameworks are more effective in driving behavior change. For instance, programs that include testimonies or role-modeling from peers within the same demographic group have greater impact on oral health knowledge and attitudes (Idaryati et al., 2024). This is particularly true among adolescents in underserved schools or low-income neighborhoods, where trust and identification are critical motivators. These findings suggest a move from generic mass messaging to hyper-local, community-curated digital

education. This paradigm emphasizes co-creation and dynamic feedback loops, aligning with participatory health promotion principles.

The digital divide in vulnerable populations is not merely about access to devices or internet but also about structural neglect in digital health policy frameworks. A review of Indonesian dental public health initiatives shows insufficient inclusion of persons with disabilities in digital health campaigns (Aldilawati et al., 2023). Even when content is accessible, the absence of engagement strategies tailored to their needs results in low uptake. Mainstreaming equity and inclusion into digital policy requires explicit mandates and measurable inclusion metrics. Collaboration with disability-rights experts and participatory audits can ensure accountability and responsiveness.

Digital health interventions often overlook the caregiver dynamic in special population settings. For older adults and individuals with disabilities, caregivers play a pivotal role in mediating access to information and digital interfaces. Yet few programs involve or train caregivers as digital intermediaries (Rahmayani et al., 2024). Integrating caregiver support modules or creating dual-user platforms can dramatically increase program effectiveness. Recognizing the caregiver's role not only enhances reach but also fosters shared learning and mutual accountability. Including caregivers in outcome evaluations also provides critical insight into implementation fidelity.

Schools and rehabilitation centers serve as strategic points of digital health engagement for children with disabilities. Research by Alamsyah and Pintauli (2018) underscores the importance of equipping teachers with digital health education tools to reach children with special needs. Furthermore, digital toolkits that complement existing curricula reduce friction in implementation and normalize preventive oral health messages. Adaptive learning platforms with built-in assessment modules help track progress and personalize content. Institutionalizing digital literacy in special

education requires systemic coordination between the health and education sectors. This also includes training non-health personnel to reinforce key oral health messages through digital media.

Limited availability of validated digital literacy assessment tools in non-Western contexts impedes targeted intervention design. The over-reliance on generic global instruments fails to capture contextual factors such as communal device sharing or informal digital learning pathways (Collet et al., 2024). Hence, developing locally relevant evaluation frameworks is crucial. These should account for the nuances of informal digital behavior and multi-generational device use. Incorporating qualitative insights into quantitative measurement enhances validity and responsiveness. The goal is not just to assess but to inform tailored interventions with actionable insights.

Multi-modal content delivery, that combining text, images, audio, and interactive elements, proves particularly effective for vulnerable populations. According to studies by Ilmianti et al. (2020), the combination of demonstration videos, animation, and simple instructions significantly enhances learning outcomes in school-aged children. For older adults and the visually impaired, audio formats and contrast-enhanced visuals offer accessibility and inclusivity. Multi-sensory engagement also increases message retention and emotional connection. When paired with timely reminders or nudges, such tools can support habit formation. Thus, content diversification is a non-negotiable element of inclusive digital design.

Cross-sector partnerships, including civil society and religious institutions, have shown promise in expanding digital health literacy in rural and low-income settings. These actors often enjoy higher trust and deeper community penetration than government agencies (Abdi et al., 2023). Collaborating with such networks can accelerate dissemination and contextual customization. Additionally, engaging local influencers in co-producing digital campaigns can build credibility and relevance.

Such alliances also offer logistical infrastructure for hybrid approaches that combine digital with face-to-face reinforcement. Multi-stakeholder approaches create sustainability and adaptability across contexts.

Policy integration remains a bottleneck in advancing digital oral health literacy for vulnerable populations. Despite growing evidence of its importance, digital inclusion is often treated as an afterthought in public health programs. Strategic policy alignment across health, education, and ICT sectors is essential to institutionalize inclusive digital literacy initiatives (Wening et al., 2025). This includes funding mandates, regulatory incentives, and implementation benchmarks. National strategies must also foster innovation from below, enabling local actors to adapt digital tools to community needs. Policy must move beyond pilot projects to scalable, rights-based programs.

In sum, addressing digital literacy in special and vulnerable populations requires a deliberate shift from one-size-fits-all approaches to responsive, equity-centered models. Success depends on inclusive design, culturally competent delivery, caregiver engagement, and institutional support. As digital health continues to evolve, its true measure lies in how well it serves those most likely to be left behind. Advancing oral health in these populations is not just a technical task but a moral imperative. The next subchapter will explore in greater depth the cognitive, educational, and behavioral barriers that hinder the adoption of digital oral health interventions. Through this, we aim to build a more holistic understanding of vulnerability in the digital health era.

4.2 Barriers to adoption (cognition, education, readiness)

Barriers to digital literacy adoption in oral health promotion are multifaceted, intersecting cognitive, educational, and psychosocial domains. Digital health interventions are often designed without full consideration of users' cognitive load, especially among older adults and individuals with low functional

literacy, resulting in reduced comprehension and engagement (Yu et al., 2024). Limited educational attainment often compounds the inability to access or interpret digital content effectively, thereby marginalizing vulnerable populations from the benefits of digital health education (Collet et al., 2024). Moreover, the dynamic nature of digital tools demands adaptive learning skills, which many low-income users lack due to systemic inequities. These factors contribute to a persistent digital divide that undermines the effectiveness of oral health behavior change strategies. Addressing this divide requires a comprehensive understanding of readiness beyond mere access to devices.

Cognitive barriers are particularly pronounced in older adults, who may struggle with abstract navigation processes or unfamiliar digital interfaces (Kim et al., 2025). Aging-related sensory and motor deficits, coupled with declining working memory, impede the learning and retention of digital tasks necessary for self-care (Yu et al., 2024). This cognitive vulnerability increases the risk of disengagement with mobile health applications or teledentistry platforms. In addition, fear of technology and a lack of perceived self-efficacy have been widely reported as deterrents among older demographics (Liang et al., 2024). Such psychological constraints must be recognized as legitimate factors in technology adoption frameworks. Effective design should therefore prioritize intuitive user experience and error-tolerant systems.

In populations with limited formal education, the challenges of digital adoption extend to basic health literacy deficits. Studies show that inadequate oral health knowledge correlates with reduced confidence in app-based educational tools, limiting the motivation to adopt new behaviors (Ueno et al., 2013; Thirasupa et al., 2023). Multimedia interventions, while promising, often assume a baseline of understanding that may not exist uniformly across user groups. For example, audiovisual modules without contextualization may fail to connect with local oral health practices or beliefs (Anwar et al., 2020). This mismatch between content complexity and user

comprehension calls for culturally sensitive instructional design. Tools must be co-created with the target population to ensure relevance and clarity.

The readiness dimension of digital adoption is shaped by infrastructure, cultural norms, and social support systems. For low-income families, digital readiness is often hindered by shared device access, unreliable connectivity, or insufficient digital skills training (de Oliveira Collet et al., 2024). Even where access exists, readiness can be constrained by competing life priorities such as work schedules, caregiving responsibilities, or chronic stress (Idaryati et al., 2024). Without holistic support, these constraints can nullify well-intentioned digital interventions. In such cases, readiness must be assessed contextually, rather than assumed universally. Bridging this readiness gap requires multisectoral collaboration, including schools, community health workers, and digital literacy champions.

Barriers to adoption are also deeply influenced by sociocultural beliefs and attitudes toward oral health. In some communities, traditional knowledge and oral health myths prevail over scientific information, affecting receptiveness to digital messages (Wening et al., 2025). Interventions perceived as externally imposed or culturally misaligned may be rejected outright, regardless of technological sophistication. Therefore, digital oral health tools must integrate behavioral change theories that account for motivation and belief systems (Liang et al., 2024). Techniques such as motivational interviewing and participatory content creation have shown promise in increasing acceptability. Respecting local knowledge systems is not a compromise to evidence-based practice but a prerequisite for sustained engagement.

Behavioral readiness further hinges on users' emotional and psychological states. Anxiety toward technology, often stemming from prior failures or lack of exposure, can paralyze adoption efforts (Verweel et al., 2023). Additionally, oral health itself is associated with stigma or trauma in certain populations, which may lead to avoidance behaviors even when digital help is available (Yu et al.,

2024). These affective barriers demand empathetic design and trauma-informed communication approaches. Interactive features that provide incremental feedback, gamification, or peer support can enhance emotional safety. Ultimately, emotional readiness is as crucial as cognitive readiness in navigating the digital health landscape.

Mothers of young children often experience unique adoption challenges due to time poverty and high caregiving burdens. In the Indonesian context, Wening et al. (2025) emphasized the importance of community facilitators in guiding mothers through digital platforms for early childhood oral health. Without localized outreach, even mobile apps tailored for maternal use remain underutilized. This insight underscores the value of embedded intermediaries (midwives, teachers, or volunteers) in enabling adoption. These human connectors enhance the credibility of the technology and personalize its use. Their presence mitigates both access and comprehension barriers simultaneously.

People with disabilities, particularly those with visual or hearing impairments, face profound barriers when platforms are not designed inclusively. Alamsyah and Natassa (2018) demonstrated the differential impact of braille and audio-based education among blind children in Indonesia, revealing that tailored formats drastically improve engagement and outcomes. The absence of such adaptations in mainstream applications risks excluding entire segments of the population. Therefore, digital inclusion must move beyond accessibility checklists to a paradigm of universal design. Government and institutions must mandate inclusive features as part of national digital health standards.

Another frequently overlooked barrier is the lack of digital role models or peer influencers within communities. Especially among youth in disadvantaged settings, there is minimal exposure to individuals who demonstrate constructive use of health technologies. Anwar and Supiaty (2022) highlighted the positive impact of gamified education when facilitated by trained peer educators. These

findings support the strategic cultivation of digital health ambassadors from within the target population. Role modeling helps demystify the technology and normalize its usage. Moreover, peer-led sessions tend to resonate better with group norms and language.

Infrastructural disparity also amplifies adoption challenges in geographically isolated or marginalized communities. In some coastal or mountainous regions of Indonesia, stable internet remains elusive, and electricity can be inconsistent (Anwar, 2020). This infrastructural deficit limits not only access to digital platforms but also continuity of engagement. Offline-capable apps, periodic community screenings, or hybrid learning models are thus necessary. Policymakers must align oral health digital strategies with infrastructure development plans. Ensuring hardware without guaranteeing connectivity undermines long-term efficacy.

Cultural language also serves as a key barrier when digital content is not localized. Standardized Bahasa Indonesia may not be fully intelligible to communities with strong ethnic dialects or minority language preferences. According to Aldilawati et al. (2023), integrating local idioms and storytelling into animation-based oral health education improved comprehension and retention. This reinforces the necessity for linguistic adaptation in app and video development. Moreover, such localization promotes cultural pride and trust in the intervention. Partnerships with regional educators and translators are critical to successful deployment.

Monitoring and evaluation barriers further constrain adoption improvement efforts. Without clear metrics on user engagement, dropout rates, or behavior change, digital programs risk becoming static tools without feedback loops. For example, the lack of user data segmentation by age, literacy level, or access modality hinders targeted refinements (Kitsaras et al., 2023). Therefore, digital oral health initiatives must incorporate real-time analytics and user feedback systems. Evaluation frameworks should be embedded from the planning stage. Iterative learning from implementation challenges enhances responsiveness and relevance.

Sustainability-related barriers also affect adoption, particularly when funding cycles are short-term. Community-based digital health programs often rely on temporary grants or academic pilots, leading to a lack of long-term commitment. As a result, promising tools are often discontinued or become outdated post-project (Cardoso et al., 2024). Governments and institutions must create policy mechanisms that integrate digital oral health into permanent public health infrastructure. Sustainable financing models, such as public–private partnerships or national insurance integration, are required. Adoption cannot be expected if continuity is not assured.

Privacy and data security concerns serve as deterrents to engagement, especially among users unfamiliar with consent frameworks. In low-literacy populations, terms and conditions are seldom read or understood, fostering mistrust in the platform (Collet et al., 2024). Transparent data handling protocols and user education on digital rights are essential. Additionally, digital tools should limit personal data collection to only what is necessary. Anonymity options and secure messaging can also bolster user trust. Ethical safeguards must match the pace of technological innovation.

A critical barrier to adoption lies within the provider system itself, limited digital competency among dental health workers. As shown by Juliawati et al. (2022), gaps in provider-side digital literacy can hinder implementation and training. When health workers are reluctant or unable to use digital tools, communities receive inconsistent messaging. Therefore, capacity building for providers is as vital as user education. Ongoing training, peer exchanges, and digital literacy credentialing can professionalize digital engagement. Investment in provider readiness ultimately reflects in patient adoption success.

In sum, adoption barriers stem not from user ignorance but from systemic mismatches between design assumptions and real-world conditions. Addressing these barriers requires deliberate planning, cultural humility, and iterative co-design with end users.

Moving forward, oral health promotion must operationalize inclusion, not only in content delivery but also in technological imagination. Communities must be seen not merely as recipients but as co-architects of digital futures. This human-centered vision of digital health is the foundation for equitable oral health behavior change.

4.3 Solutions through community-engaged learning and family support

Community-engaged learning is a pivotal strategy in addressing digital literacy gaps in oral health promotion, especially among vulnerable populations. This approach involves collaborative participation from local communities, educators, and health professionals to co-create knowledge and digital capabilities. In the context of oral health, such strategies empower community members to recognize the value of digital tools for disease prevention and behavior change. Studies show that interactive learning modules tailored to local contexts significantly enhance engagement and comprehension (King et al., 2025). Integrating cultural relevance into digital health education ensures that interventions are not only accessible but also meaningful. Community-based interventions thus offer sustainable models for promoting digital oral health literacy.

The role of family support cannot be understated in shaping oral health behavior through digital means. Families serve as the primary environment for behavior modeling, especially for children, adolescents, and older adults. Digital interventions that involve parents or caregivers have shown greater effectiveness in sustaining oral hygiene practices (Abdi, Ilmianti, & Pratiwi, 2024). Educating family units about using digital tools such as health apps, reminder platforms, and video tutorials creates an ecosystem of mutual accountability. These tools can bridge generational literacy gaps, especially when digital training is extended to older caregivers (Yu et al., 2024). Through structured involvement, family-centered programs amplify the impact of individual behavioral interventions.

A notable model of community learning was implemented by Wening et al. (2025), focusing on empowering women to lead oral health promotion activities for elderly hypertensive individuals. This model emphasized peer-based dissemination and culturally aligned communication, highlighting the importance of trust and shared experience in digital health advocacy. By enabling women to become health educators within their communities, the intervention fostered ownership and sustainability. This approach aligns with the Information-Motivation-Behavioral (IMB) Model, where information and motivation are co-generated through social dynamics. The digital tools used (ranging from WhatsApp groups to health logs) served as both educational and monitoring instruments. The success of such programs underscores the importance of aligning digital tools with community-based leadership.

Another example is the integration of the TOOTH™ text-based platform into family counseling sessions, which has demonstrated increased compliance in brushing frequency among children (King et al., 2025). Parents received daily motivational messages and educational tips, which indirectly influenced children's oral hygiene behavior. Such indirect learning pathways illustrate the effectiveness of passive digital engagement when reinforced within family structures. Moreover, the continuity of digital support facilitated habit formation, crucial for long-term oral health outcomes. Evaluative metrics showed significant improvements in both self-reported practices and clinical indices. These outcomes demonstrate the potential of combining digital messaging with familial reinforcement loops.

Community-engaged learning also necessitates adapting content to the literacy levels and learning styles of participants. This was evidenced in the work of Aldilawati et al. (2026), who developed the Quizztooth Games application aimed at school-age children and their caregivers. The gamified format increased user interaction, while family involvement in gameplay fostered shared learning experiences. Evaluation through pre- and post-intervention

knowledge scores indicated statistically significant improvement. Importantly, usability tests confirmed that even caregivers with limited formal education could operate the platform with minimal guidance. Such outcomes validate the application of universal design principles in digital health education.

Barriers related to technological readiness, as discussed in previous subchapters, can be overcome through phased learning facilitated by community health workers. In a study by Anwar and Zulkifli (2020), cartoon-based audiovisual tools were employed by trained educators to increase brushing knowledge among school children. The materials were shared during community gatherings and revisited through WhatsApp broadcasts. Parents and teachers reported increased motivation to reinforce hygiene behaviors at home. Community health workers played a vital role in explaining the content and moderating discussion. This layered dissemination model has proven effective in resource-limited settings.

Family support in digital oral health is particularly impactful among populations with limited mobility or disability. Alamsyah and Natassa (2018) demonstrated how audio-visual education materials were effectively used with blind children and their families, utilizing sound-based cues and tactile reinforcement. The program also involved caregivers in daily oral care routines, using WhatsApp voice notes for reminders and updates. The multisensory learning strategy resulted in improved Oral Hygiene Index Scores (OHIS). Moreover, qualitative feedback showed enhanced confidence among parents in managing their children's oral care needs. This reinforces the importance of inclusive, assistive technologies in digital health strategies.

Community support can also aid in overcoming cultural taboos surrounding oral health, which are prevalent in some marginalized groups. Wening et al. (2025) highlighted the value of involving respected community figures in digital oral health campaigns to address misconceptions and increase program uptake. These leaders facilitated workshops and shared educational content

through familiar digital channels. As trust increased, community participation in digital monitoring systems and preventive screenings also rose. Such culturally anchored digital engagement ensures that health promotion is not perceived as intrusive but rather as a community-driven endeavor. Evidence suggests that such trust-based approaches enhance adherence to digital interventions.

Digital storytelling has emerged as a powerful method for engaging families and communities in oral health education. Through the use of short videos and narratives shared via YouTube and TikTok, programs led by Juliawati and Damayanti (2025) encouraged adolescents and their parents to reflect on personal hygiene routines. These stories were designed around relatable characters and local scenarios, thereby increasing viewer resonance and message retention. Parental feedback indicated improved understanding and motivation to supervise children's oral hygiene. These emotionally engaging narratives, delivered via accessible platforms, effectively bridge informational and behavioral gaps. Digital storytelling, therefore, complements traditional education by fostering empathy and identity alignment.

Digital literacy development also benefits from intergenerational learning, where children often become digital facilitators for older family members. In many Indonesian households, this dynamic has been harnessed through structured interventions involving both youth and elderly (Wening et al., 2025). Children were trained to use oral health apps, which they then introduced to grandparents, thereby facilitating two-way knowledge transfer. This method not only increased digital exposure among older adults but also strengthened familial bonds. Evaluation showed improvement in both digital competence and oral hygiene behaviors across generations. Intergenerational learning thus holds promise as a culturally appropriate, cost-effective strategy.

The design of community-based digital programs must consider sustainability and scalability. Partnerships with local schools, religious organizations, and public health offices are

essential to embed programs within existing structures. For example, in the Little Doctor initiative (Balbeid et al., 2022), students became health ambassadors, using mobile apps to disseminate educational content within their families. Community volunteers monitored progress using simple digital tools, ensuring accountability and continuous feedback. This model illustrates how structured, low-cost digital engagement can be scaled through institutional collaboration. Moreover, it enhances local capacity and program ownership.

To maintain engagement, community programs must employ regular feedback mechanisms and performance tracking. Platforms like Google Forms, WhatsApp surveys, and app-based quizzes have been successfully used to monitor oral health behaviors and identify areas for improvement (Aldilawati et al., 2026). These tools offer real-time data that can inform program refinement and policy advocacy. Community members are more likely to remain engaged when they see tangible benefits and recognition of their contributions. Periodic rewards or acknowledgment can further reinforce participation. Digital feedback loops thus serve both educational and motivational functions.

Successful implementation of these strategies requires capacity-building among community stakeholders. This includes digital skills training for community health workers, parents, and educators. Workshops must be designed with context-sensitive pedagogy, combining hands-on activities with digital simulations (Ilmianti et al., 2020). Resource kits can include preloaded mobile apps, digital content guides, and simple troubleshooting manuals. Ensuring that stakeholders feel competent in using digital tools is key to program fidelity and effectiveness. Training must also be ongoing to adapt to evolving technologies and user needs.

A key component of sustainable engagement is establishing peer support groups facilitated by digital platforms. WhatsApp or Telegram groups, managed by community health workers or trained volunteers, can serve as hubs for discussion, reminders, and problem-solving. These groups provide a safe space for sharing

challenges and exchanging practical tips. They also function as decentralized information networks, reducing reliance on formal infrastructure. Empirical evidence supports the role of peer learning in enhancing health behaviors and digital confidence. Community cohesion, fostered through such platforms, amplifies the reach and resilience of oral health interventions.

Finally, the integration of digital oral health literacy into school curricula and family welfare programs can institutionalize its value. Policy advocacy is needed to support the inclusion of digital health competencies within national education and health promotion standards. Collaborative initiatives between ministries of health and education can create standardized modules and teacher training programs. Long-term planning should also involve public-private partnerships to support infrastructure and content development. Embedding digital health promotion in mainstream institutions ensures continuity and scalability. This transition from innovation to normalization marks the maturation of community-engaged digital oral health strategies.

Summary

Many people in Indonesia (especially the elderly, low-income families, and those with disabilities) still face difficulty accessing dental health services and using digital tools for health education. This chapter explains how we can support these groups through digital learning programs that are easy to understand and include the whole community. When families are involved and local health workers are trained to use digital tools, it becomes easier for everyone to learn how to take care of their teeth. Simple platforms like WhatsApp, games, and short videos can help improve how people brush their teeth and visit the dentist regularly. Programs that encourage parents, children, and even grandparents to learn together also make dental education more fun and effective. These efforts are most successful when supported by schools, community centers, and health policies that make digital learning part of daily life.

Key Messages

1. *Digital health promotion must be inclusive: Strategies should specifically address the needs of older adults, low-income families, and people with disabilities, ensuring accessibility and cultural relevance.*
2. *Family engagement multiplies impact: Involving parents, children, and caregivers in digital oral health education fosters collective behavior change and long-term sustainability.*
3. *Community-led digital learning is effective: Peer-based training, intergenerational learning, and participatory media (e.g., WhatsApp, games, videos) are powerful tools in bridging digital health literacy gaps.*

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Chapter 5.
Designing and Evaluating Behavior Change Through Digital Tools

5.1 Case examples: mother-child interventions, elderly tutorials
5.2 Evaluation metrics: behavioral outcomes, health indicators
5.3 Qualitative and quantitative impact assessments

Abstract
This chapter explores innovative methodologies for implementing and evaluating behavioral change interventions in digital oral health promotion. It presents case-based evidence involving vulnerable populations, such as mother-child dyads and elderly users, demonstrating the effectiveness of personalized, technology-mediated approaches. The chapter details key evaluation metrics, including behavioral and clinical indicators, while emphasizing the critical role of both qualitative and quantitative assessments in capturing holistic program outcomes. It further discusses challenges in tool validation, sustainability of behavior change, and digital equity considerations, which are essential in policy formation and program scaling. By integrating case-driven narratives, impact metrics, and analytical frameworks, this chapter provides a roadmap for designing effective and ethically grounded digital oral health promotion interventions.

Keywords: *Digital oral health promotion; Behavior change evaluation; Mixed-methods assessment; mHealth interventions; Community-based digital tools*

5.1 Case examples: mother-child interventions, elderly tutorials

Digital innovations have increasingly supported the development of targeted oral health behavior change strategies among specific populations, notably mothers with young children and the elderly. In mother-child interventions, behavioral shaping often begins with the caregiver's knowledge and motivation, supported by tools that translate dental literacy into daily practices. Interventions employing audiovisual counseling or interactive applications have shown significant gains in maternal understanding and preventive routines (Anwar, Zulkifli, Syafar, & Jafar, 2020).

For example, structured educational videos integrated into mobile platforms allowed for improved toothbrushing supervision, reduced early childhood caries, and increased maternal confidence. This aligns with findings by Abdi et al. (2022), who demonstrated that prenatal health education using the CPITN index for periodontal health significantly impacted maternal oral health awareness. These strategies underscore how digital interventions serve as accelerators in health behavior adoption among maternal populations.

The mother-child dyad benefits from interventions that are culturally aligned and emotionally engaging, especially in rural or underserved areas. The deployment of cartoon-based animations and

gamified modules has enhanced children's compliance with brushing practices, while indirectly improving maternal monitoring (Aldilawati, Selviani, & Ardiningrum, 2023). This approach aligns with Anwar & Supiaty's (2022) systematic review that underlined the impact of game-based education on behavior, particularly when reinforced by consistent parental involvement.

Through tools like Quizztooth and Puzdent, which offer interactive content aligned with national oral health goals, facilitators could assess comprehension and engagement across various literacy levels. Such gamification also assists in knowledge retention by stimulating positive emotions and reinforcing self-efficacy. The embedding of behavioral science within digital modules ensures that motivational cues and decision triggers are reinforced across multiple sessions. As noted in the work of King et al. (2025), consistency and frequency of exposure are vital for sustaining habit formation in home-based interventions.

In more complex mother-child contexts, socioeconomic constraints often inhibit regular dental visits, creating a digital divide in health access. However, efforts by Wening et al. (2025) demonstrated that mothers in hypertensive households were more likely to adopt oral hygiene practices when provided with customized digital materials and supported through community cadre involvement. These cadres acted as facilitators between the health system and household, enhancing the community's ownership of behavioral change.

Such localized adaptation reflects the strength of participatory digital health designs, especially in Indonesia's diverse demographic terrain. Furthermore, Abdi, Ilmianti, & Pratiwi (2024) indicated that knowledge about oral hygiene significantly correlated with behavioral outcomes among ojek drivers, with implications for families where mothers or fathers function as informal workers. These findings amplify the role of digital inclusivity in oral health education for working-class populations. They also highlight the

importance of integrating oral health promotion into non-health digital touchpoints.

Case examples from Makassar and Surabaya show that elderly populations also respond positively to digital tutorials when content is adapted for sensory and cognitive accessibility. Tutorials delivered via smartphones or community displays in posyandu lansia have enhanced brushing frequency, denture hygiene, and reduced periodontal risk (Wening et al., 2025). By incorporating family members into the education process, these interventions reinforced collective accountability, especially among elderly with comorbidities.

The use of flipcharts and short videos as used in Abdi et al.'s community education (2023) further demonstrated scalability across low-tech environments. This multimodal content strategy not only improved recall but also addressed emotional barriers to behavior adoption. Digital oral health promotion for the elderly must also consider comorbid chronic conditions, such as diabetes or hypertension, which affect oral hygiene routines. Here, user-centered design becomes essential to optimize tutorials for age-related cognitive and motor limitations.

Cross-generational learning initiatives, such as "Dokter Kecil Goes Virtual" in Malang (Balbeid et al., 2022), have expanded mother-child and elderly tutorials into community-based learning ecosystems. These programs used snowball techniques to transfer oral health messages across networks of children and parents, facilitated by trained health educators via Zoom and WhatsApp. Evaluation showed increased knowledge retention in children and increased maternal assistance during morning and night brushing.

Notably, these outcomes were not only sustained for weeks after the intervention but also inspired new cadres to initiate similar modules in other schools. The community-driven expansion demonstrates how decentralized digital efforts can scale through social replication and local leadership. It also supports Juliawati & Damayanti's (2025) finding that youth-based YouTube education

could influence parental behavior indirectly through child-to-parent information flow. Therefore, digital health promotion becomes not only a communication tool but also a mechanism for horizontal community engagement.

Elderly tutorials in rural regions, such as those documented in the Kaluku Bo'doa program (Sufyaningsi et al., 2024), have effectively integrated nutritional education with dental hygiene messages. Interventions emphasized the importance of brushing after meals and before sleep, supported by animated instructions on proper technique and denture care. These tutorials were distributed via WhatsApp groups for community elders, coordinated by local health cadres and PKK.

Feedback loops were embedded through post-intervention quizzes and biweekly reinforcement messages. Participants reported enhanced understanding and routine adherence after three months, with follow-up data indicating improved gingival health. Moreover, such initiatives reduced caregiver burden by empowering older adults with autonomy over their hygiene behaviors. As with the TOOTH program in the UK (King et al., 2025), digitally guided autonomy appears to be a key determinant in sustaining elderly engagement.

Interventions targeting elderly populations have also addressed the psychosocial dimensions of oral health neglect, often rooted in generational health beliefs and low health-seeking behavior. In studies by Yu et al. (2024), older adults with limited oral health literacy demonstrated significantly poorer oral hygiene status and higher prevalence of periodontal disease. Tutorials that incorporated motivational components, such as peer support and testimonial-based storytelling, have proven to be effective in reframing fatalistic beliefs toward aging and tooth loss.

In Indonesia, Wening et al. (2025) successfully introduced digital leaflets and WhatsApp videos explaining the relationship between hypertension and oral infections, helping elders recognize the systemic implications of poor oral health. These behavioral

triggers, reinforced through weekly community calls, stimulated higher participation in dental visits within two months. Furthermore, family support was found essential to reinforce behavioral shifts, especially in households with multigenerational caregiving dynamics.

Mobile-based tutorials for the elderly must also address digital hesitancy and low self-efficacy in navigating applications or text interfaces. Aldilawati et al. (2026) illustrated how gamified learning platforms, even when simple in design, could engage senior cadres when integrated with direct mentorship and short video simulations. Their findings showed that local champions or peer facilitators improved tutorial completion rates and encouraged repeated engagement. Such peer-facilitated digital interventions mirror the success of the "Empowering Women" program (Wening et al., 2025), which tailored health education modules to community strengths rather than technical proficiency. In this way, behavioral change is anchored in contextual adaptation and relational reinforcement. Tutorials are no longer just repositories of information but embedded systems for interactive community learning.

Anwar et al. (2020) emphasized the importance of multimedia-based training for teachers and cadres who serve as oral health agents within elementary and community settings. Their doctoral study demonstrated how structured digital mentorship significantly impacted student oral hygiene behaviors across geographic settings (mountainous, coastal, and urban).

Teachers trained through interactive modules displayed higher fidelity in message delivery and created ripple effects in student knowledge gains. Such approaches underscore the role of digital literacy not just at the end-user level but also at the level of the educators and health promoters. When educators are empowered through digital literacy, their instructional delivery becomes more adaptive, engaging, and sustainable. Tutorials for elderly learners

thus benefit from intergenerational facilitators who are digitally competent and emotionally responsive.

The incorporation of behavior change models within digital interventions has further elevated their effectiveness. Tools like TOOTH (King et al., 2025) explicitly embed the Information–Motivation–Behavior (IMB) framework to guide user progress through knowledge acquisition, motivation building, and behavioral rehearsal. Similarly, digital tools in Indonesia, such as Quizztooth and cartoon video education, integrate stages from the Health Belief Model to address perceived barriers and cues to action (Anwar & Supiaty, 2022; Abdi et al., 2024).

These behaviorally informed structures increase the likelihood that users will complete tutorials and integrate new behaviors into their routines. Furthermore, when digital tools are combined with periodic feedback and social incentives, their impact becomes more resilient to contextual disruptions. The application of theory-driven design in tutorial content ensures that the interventions are not only informative but transformative. Such integration of theory and technology forms the backbone of sustainable digital oral health education.

Importantly, tutorial content must be sensitive to language, cultural metaphors, and the cognitive load of users across life stages. In programs evaluated by Alamsyah & Natassa (2018), blind and deaf students achieved significant gains when educational content was delivered in modes aligned with their sensory strengths, braille for text, and high-contrast animation for video. Translated into elderly care, this principle affirms the need for high-contrast visuals, audio narration, and repetition to accommodate age-related impairments. Simplified navigation and touch-based interactions, rather than text-heavy menus, improve usability for older adults. Furthermore, caregivers and family members should be included in training to support the uptake and retention of tutorials. This aligns with findings by Ribeiro et al. (2022), who stress that oral health learning is optimized when it occurs within supportive ecosystems.

Another Indonesian case in Tabanan Bali (Idaryati et al., 2025) illustrated how digital education was used to train cadres on managing periodontitis among the elderly through retrospective data dashboards and tutorial simulations. This pilot effort found improved patient-provider communication and increased early detection behaviors among cadres. Importantly, the digital tools enabled localized tracking of treatment adherence and symptom monitoring over three months. These findings align with global reviews (Yu et al., 2024; Liang et al., 2024), indicating that community-based tutorials not only influence individual behavior but also strengthen health system responsiveness. Case-based learning embedded within tutorials fosters problem-solving and clinical reasoning among community agents. Thus, digital tutorials can act as both educational and operational infrastructure.

Tutorials focused on vulnerable populations, including the elderly and caregivers, must also integrate self-reflective elements to foster deeper behavior internalization. Feedback modules such as quizzes, self-assessment forms, and oral hygiene logs serve not only as evaluation tools but as behavioral nudges. In studies conducted by Setiawati et al. (2025), participants reported that reflective tasks helped them recognize personal gaps and encouraged routine correction. Such features transform tutorials from didactic content into dialogic learning environments, reinforcing agency and personalized goal-setting. The incorporation of real-life stories and culturally relevant scenarios enhances emotional connection and message resonance. This strengthens the perceived relevance of digital interventions, increasing their sustainability in low-resource contexts.

In conclusion, mother-child interventions and elderly tutorials exemplify the practical application of digital tools to promote oral health behaviors across life stages. They demonstrate how multimedia formats, community involvement, and behavior-based design principles contribute to the success of health education programs. The dual benefit of enhancing knowledge and fostering

social support has been consistently highlighted across both global (King et al., 2025; Kitsaras et al., 2023) and Indonesian sources (Abdi et al., 2022; Wening et al., 2025). Ultimately, the impact of these digital tutorials depends not only on content quality but on contextual adaptability and stakeholder participation. Future interventions should consider scaling such models through national platforms and integrating them into school curricula, posyandu routines, and elderly care services. This will ensure that digital oral health education becomes a mainstream component of preventive health systems.

5.2 Evaluation metrics: behavioral outcomes, health indicators

Evaluation in digital oral health promotion is central to verifying both individual behavior change and broader public health impacts. Measurement strategies must reflect both short-term changes in knowledge and long-term modifications in oral health practices. Quantifiable behavioral outcomes such as improved toothbrushing frequency, reduced sugar intake, or enhanced appointment adherence are often employed as proxies. Health indicators, including plaque scores, DMFT (Decayed, Missing, and Filled Teeth), and periodontal status, complement behavioral metrics by demonstrating physical health changes. Integration of both categories allows practitioners and policymakers to appraise interventions holistically. This balance is vital in digital contexts where behavior may change without immediate observable health effects.

The use of standardized tools ensures reliability and comparability of behavioral outcomes across populations and programs. The OHL-Ortho instrument, for instance, has been validated for measuring oral health literacy and its predictive value toward preventive behaviors in orthodontic patients (Thirasupa et al., 2023). Likewise, the Digital Oral Health Literacy (DOHL) Scale allows researchers to gauge digital navigation skills that underlie technology-assisted behavior change (Kim et al., 2025). These

instruments are not merely diagnostic but also formative, informing the design of tailored interventions. Programs that begin with a diagnostic assessment are better equipped to target the specific educational and technological needs of their audience. Thus, the adoption of standardized instruments should be seen as a prerequisite rather than a complement.

Recent research affirms the importance of triangulating self-reported behaviors with clinical observations for validity. For example, Abdi et al. (2024) employed both self-assessment surveys and CPITN indexes to evaluate the impact of digital counseling on pregnant women's periodontal awareness. This dual-method evaluation strengthened the credibility of reported outcomes and captured both perceived and actual changes. In settings with limited clinical capacity, visual validation through intraoral photo-based assessments has also proven effective (Fadilah et al., 2024). Such innovations ensure that behavioral claims are substantiated with tangible health metrics. Consequently, evaluation strategies should not rely exclusively on digital data or self-reporting but consider integrated verification methods.

Behavioral metrics in digital interventions must also consider cognitive and affective dimensions of change. Juliawati et al. (2022) emphasized how patient safety culture and trust in digital information sources influence compliance with oral health recommendations. This suggests that behavior change cannot be measured solely by frequency-based actions but must include underlying attitudes and beliefs. Tools like the Safety Attitude Questionnaire (SAQ) adapted for dentistry can capture such dimensions in a structured way. Additionally, digital storytelling or tutorial engagement levels may serve as proxies for affective commitment. Evaluators must, therefore, broaden their conceptualization of "behavior" to encompass psychosocial components.

Longitudinal designs provide critical insights into sustainability and relapse patterns in oral health behavior. Studies

such as that of King et al. (2025) on the TOOTH intervention tracked brushing behavior and plaque accumulation over several months, showing gradual consolidation of habits. These findings underscore that single-point evaluations are inadequate for capturing the temporal dynamics of digital behavior change. Researchers should employ repeated-measure frameworks, pre- and post-intervention comparisons, or delayed follow-up to assess long-term adherence. Attrition rates in mobile-based programs, however, pose a challenge for consistent data capture. To address this, flexible engagement models with digital reminders or gamified check-ins are recommended.

Qualitative metrics remain essential in interpreting behavioral shifts that are complex or context-specific. Interviews and focus groups allow researchers to decode the meaning participants assign to their oral health behavior changes. In the case of Wening et al. (2025), narrative inquiries were used to explore elderly patients' motivation to continue digital learning after tutorial sessions. Such insights revealed that behavior change was often driven by a sense of regained autonomy or family appreciation. Therefore, qualitative analysis complements quantitative indicators by explaining not just "what changed," but "why" and "how." Mixed-method evaluations are thus not optional but essential for comprehensive digital program assessment.

Cultural and contextual adaptations significantly influence behavioral evaluation in diverse Indonesian populations. Anwar et al. (2020) demonstrated that digital education delivered in local dialects enhanced behavioral uptake in highland and coastal primary schools. The same intervention, when translated directly without cultural tuning, yielded less effective results in urban contexts. Evaluation tools should, therefore, be linguistically and culturally validated to avoid misinterpretation or bias. This includes adjusting question phrasing, visual symbols, and feedback language to suit user profiles. By accounting for cultural contexts, evaluations become not only more accurate but also more ethically responsive.

Technology-mediated data collection introduces both opportunities and risks in behavioral evaluation. On one hand, mobile apps like Puzdent for Kids allow real-time behavior tracking, such as brushing frequency or quiz participation (Aldilawati et al., 2023). On the other, reliance on device usage data can exclude digitally illiterate populations, introducing sampling bias. Therefore, evaluation protocols must employ hybrid models, digital where feasible, and offline or assisted methods where necessary. Ethical considerations surrounding data privacy and informed consent must also be emphasized. Only through responsible digital governance can behavioral evaluation uphold both rigor and equity.

Health indicators provide the biological validation of claimed behavioral improvements. Indicators such as plaque scores, bleeding indices, and caries progression are widely used in school-based and maternal interventions. For example, Fadilah et al. (2024) observed significant plaque reduction in students who participated in AI-supported brushing education. Similarly, CPITN improvements were recorded in pregnant women following multimedia-based motivational counseling (Abdi et al., 2022). Such metrics help bridge the gap between knowledge acquisition and health impact. Evaluators should, therefore, systematically collect and analyze biological data in parallel with behavioral ones.

Program fidelity is another crucial aspect influencing the interpretation of evaluation metrics. Without consistent implementation, variations in digital exposure can distort behavioral and health outcomes. Juliawati et al. (2025) highlighted how inconsistent tutorial delivery in community programs led to differential impacts on elderly oral hygiene behaviors. Standard operating procedures and digital usage logs can help monitor fidelity in intervention delivery. Moreover, training facilitators to adhere to digital scripts or modules ensures consistent message framing. Therefore, fidelity checks are indispensable in the evaluation design phase.

Program impact must also be analyzed through the lens of equity. Are behavioral gains equitably distributed among genders, regions, and literacy levels? Studies like those of Alamsyah & Natassa (2018) on visually impaired children revealed that alternative formats such as Braille and audio significantly improved knowledge retention and brushing routines. If interventions are only effective for tech-savvy populations, their impact is inherently limited. Thus, evaluators must stratify behavioral and health outcomes by demographic variables. In doing so, equity-based impact evaluation supports ethical scaling of digital oral health programs.

In multi-setting evaluations, the environment plays a mediating role in behavior change. School-based programs, such as those conducted by Ilmianti et al. (2020), reported higher adherence due to peer influence and structured routines. Meanwhile, community interventions like those by Abdi et al. (2023) in rural settings noted fluctuating behaviors based on seasonal labor demands. Evaluators must, therefore, incorporate environmental variables into behavior models. Context-aware evaluation leads to more nuanced conclusions and actionable recommendations. Ignoring environmental mediators risks oversimplifying the dynamics of digital health behavior.

Advanced statistical analysis supports deeper insights into behavioral patterns. Multivariate models can isolate the influence of specific digital features on behavioral outcomes, adjusting for confounding factors. For instance, regression models linking knowledge gain to video duration or interactivity level can inform future content development. Mediation analysis can further explain how knowledge translates into practice. While sophisticated, these analyses require robust datasets and interdisciplinary collaboration. Their use should be encouraged to elevate the analytical precision of behavioral evaluations.

Evaluation is not merely about measuring outcomes but also about informing continuous improvement. Real-time dashboards

and feedback loops can adapt interventions based on user engagement and response rates. Programs like Know Your OQ™ incorporate such adaptive features to enhance personalization and effectiveness (Kitsaras et al., 2023). Evaluation findings should feed directly into content revision, delivery strategy, and platform design. In this way, evaluation becomes a catalyst for innovation rather than a terminal exercise. Promoting this cyclical evaluation approach ensures sustained relevance and impact.

Lastly, digital health programs should embed participatory evaluation models where users contribute to defining success. Co-designed metrics, especially in culturally diverse or marginalized settings, enhance ownership and relevance. Wening et al. (2025) employed community feedback to redefine behavioral indicators in elderly health tutorials, shifting from brushing frequency to self-reported confidence in dental visits. Such shifts align evaluation with local aspirations and realities. Hence, participatory approaches can enrich behavioral and health indicator frameworks with contextual intelligence.

5.3 Qualitative and quantitative impact assessments

The integration of digital literacy within oral health promotion necessitates a robust framework for evaluating impact, combining both qualitative insights and quantitative data. Quantitative metrics often focus on measurable outcomes such as changes in oral hygiene indices, dental visit frequencies, or caries incidence rates post-intervention. However, these figures alone do not adequately capture participants' perceptions, motivations, and contextual barriers that affect behavior change (Kim et al., 2025).

Qualitative assessments, including interviews and focus groups, enable a deeper understanding of the lived experiences and behavioral shifts triggered by digital interventions. Together, these methods provide a more comprehensive view of efficacy and relevance in diverse communities. As such, dual-method assessment

models are increasingly seen as standard practice in evaluating public health initiatives involving digital literacy.

Quantitative impact assessments are particularly useful for large-scale evaluations and longitudinal tracking of outcomes. Tools like the Oral Hygiene Index-Simplified (OHI-S) or the Community Periodontal Index (CPI) offer standardized approaches to measure behavioral change outcomes before and after digital interventions (Verweel et al., 2023). For example, randomized controlled trials using mobile health (mHealth) platforms have shown statistically significant improvements in oral hygiene status among children and adolescents (King et al., 2025).

Quantitative instruments also enable the comparison of multiple intervention types, such as SMS reminders versus app-based education, across different socioeconomic strata (Thirasupa et al., 2023). This facilitates evidence-based refinement and scalability of programs. However, they remain limited in explaining the 'how' and 'why' behind the outcomes.

To address these interpretive gaps, qualitative assessments play a critical role in contextualizing quantitative findings. Focus group discussions, in-depth interviews, and ethnographic studies uncover nuanced insights into user satisfaction, content relevance, and behavioral intention (Wrona et al., 2025). For instance, the perceived cultural appropriateness and trustworthiness of content are common themes influencing engagement and adherence (Yu et al., 2024).

Qualitative methods also capture the voices of marginalized groups, including older adults and persons with disabilities, whose digital experiences are often shaped by emotional and cognitive readiness (de Oliveira Collet et al., 2024). These insights are essential in iterating content delivery, interface design, and support structures. By integrating qualitative narratives, developers can ensure more inclusive and person-centered approaches.

Mixed-method studies provide a synergistic evaluation framework that strengthens both internal and external validity. For

example, interventions like Know Your OQ™ have been evaluated using survey-based assessments of knowledge scores alongside qualitative user feedback on usability and acceptability (Kitsaras et al., 2023). This dual approach revealed not only measurable improvements in oral health knowledge but also user concerns about content load and digital navigation.

In similar vein, the TOOTH text-messaging intervention utilized pre- and post-test scores combined with open-ended feedback, providing actionable insights into message tone and scheduling preferences (King et al., 2025). The use of triangulation enhances confidence in the robustness and applicability of findings. It also assists stakeholders in tailoring future interventions for greater reach and effectiveness.

Developing culturally sensitive and age-appropriate assessment tools remains a crucial challenge. The validation of tools such as OHL-Ortho for orthodontic patients demonstrates the importance of tailoring measurement instruments to specific population groups and treatment contexts (Thirasupa et al., 2023). Similarly, tools adapted for elderly populations incorporate dimensions such as functional literacy, digital confidence, and motivational indices (Kim et al., 2025).

National studies in Indonesia have also highlighted the value of oral health literacy measurement frameworks that include both affective and behavioral dimensions relevant to rural populations (Anwar, 2020). Without contextual calibration, instruments risk misrepresenting actual impact or failing to capture subtle behavioral improvements. Therefore, continuous validation and local adaptation are critical components of effective impact assessment.

Behavioral indicators are a central component of both qualitative and quantitative assessments, reflecting individual-level transformation. These may include self-reported tooth brushing frequency, dental check-up compliance, and dietary modifications (Abdi et al., 2024). However, these indicators must be cross-verified with clinical measures and observational data to ensure reliability.

The incorporation of self-monitoring tools and diaries has been effective in strengthening the reliability of self-reported data (Alamsyah & Natassa, 2018). Meanwhile, qualitative interviews can validate whether reported behaviors stem from genuine understanding or social desirability bias. These methodological checks and balances enhance the integrity of the data collection process.

In addition to individual behavior, social and environmental dimensions must be captured in impact evaluations. For example, studies on mother-child interventions using cartoon-based videos showed not only improved brushing behavior in children but also heightened parental engagement and awareness (Yanti et al., 2017). Similarly, digital oral health campaigns targeting pregnant women revealed that behavioral change was often reinforced by social support structures, such as family encouragement and peer reminders (Rahmayani et al., 2024).

These social influences are best explored through qualitative inquiries that reveal collective behavioral trends and influence mechanisms. By expanding the unit of analysis from the individual to the household or community, evaluations can more accurately reflect program success. The sustainability of behavioral change is another essential dimension in impact assessment.

Repeated cross-sectional studies and follow-up interviews can assess the durability of improvements over time. For example, in the case of village-based oral health training using mobile games, significant short-term improvements in plaque scores were recorded, but qualitative reports revealed a decline in adherence after three months due to app fatigue and competing priorities (Aldilawati et al., 2026).

These findings point to the necessity of longitudinal assessments and adaptive content strategies. Sustainable behavior change depends not only on initial efficacy but also on the reinforcement mechanisms embedded in the digital intervention.

This highlights the importance of designing programs with periodic re-engagement components.

Evaluators must also consider the digital divide as a confounding variable in interpreting impact. Access to smartphones, data packages, and technical support significantly mediates both the reach and outcome of digital interventions (Wrona et al., 2025). This is particularly true for rural and low-income populations, where intermittent internet connectivity and low device literacy reduce effective exposure.

In such cases, qualitative methods reveal alternative adaptation strategies, such as peer-assisted learning and family-mediated access, that are invisible in quantitative metrics. Therefore, stratified analyses and subgroup interviews are recommended to avoid misleading generalizations. Ensuring equity in evaluation is as important as equity in intervention delivery.

The ethical dimensions of impact assessments are increasingly emphasized in digital health research. Issues of informed consent, data privacy, and user autonomy must be addressed explicitly, particularly in vulnerable groups such as minors and elderly persons (Cardoso et al., 2024). Qualitative debriefings allow evaluators to assess user understanding of privacy terms and perceived risks. On the other hand, quantitative audits of consent forms and dropout rates can signal patterns of disengagement or mistrust. Transparent reporting of these findings contributes to ethical accountability and trust-building in future implementations. As digital health expands, ethical rigor in evaluation becomes non-negotiable.

Policy implications arising from rigorous impact evaluations are substantial. Comprehensive assessments support evidence-based decision-making for scaling and institutionalizing digital oral health interventions. National health authorities are more likely to endorse and fund programs that demonstrate both quantitative efficacy and qualitative user acceptability (Singh et al., 2012). International donors and research institutions also prioritize interventions with

robust, multi-dimensional impact profiles. Furthermore, data-driven policy briefs can guide integration with existing healthcare infrastructure, ensuring long-term viability. In this way, impact assessment is not merely academic, and it is instrumental for sustainable public health advancement.

To ensure methodological rigor, capacity building in evaluation sciences is essential for public health personnel. Training workshops in mixed-methods research, qualitative coding, and statistical literacy empower local health promoters to contribute to evaluation efforts (Anwar & Supiaty, 2022). This not only decentralizes evaluation capacity but also enriches the interpretive quality through insider perspectives.

Collaborations with academic institutions and interdisciplinary researchers further enhance the credibility and breadth of findings. By investing in local evaluator capacity, countries can institutionalize continuous quality improvement in digital health initiatives. This aligns with principles of self-reliance and contextual ownership.

Technology itself can be leveraged for real-time impact tracking. Dashboards embedded within applications allow users to self-report and visualize progress, while administrators can monitor aggregate trends for program optimization (Kitsaras et al., 2023). Wearable devices, geolocation tools, and AI-based analytics provide additional layers of behavioral data. However, ethical oversight and data interpretation protocols must be established to prevent misuse or misinterpretation. These innovations represent the future of participatory and dynamic evaluation systems. Balancing innovation with ethical responsibility is the next frontier in digital health assessments.

Evaluators must remain reflexive and responsive to emerging challenges in digital health contexts. The pace of technological change, evolving user expectations, and unanticipated cultural dynamics necessitate flexible and iterative evaluation models. Periodic feedback loops and adaptive trial designs are becoming

standard in implementation science. This dynamism supports continuous refinement and relevance of digital interventions. Ultimately, effective evaluation is not a one-time event but an ongoing process embedded within the life cycle of health promotion programs.

In conclusion, qualitative and quantitative impact assessments form the backbone of credible, scalable, and sustainable digital oral health interventions. Their integration ensures a holistic understanding of efficacy, equity, and user experience. Through rigorous methods, stakeholder collaboration, and adaptive strategies, evaluators can meaningfully contribute to improved oral health outcomes across diverse settings. As digital health continues to evolve, so must our approaches to evaluating its true impact.

Summary
This chapter illustrates how digital tools, such as mobile apps, SMS messages, and educational videos can be effectively used to change people's oral health behaviors. It uses real examples from Indonesia and global literature to explain how these tools help children, mothers, elderly individuals, and even online drivers learn better dental habits. It also explains how to measure whether these tools work, both by counting how behavior changes (quantitatively) and by talking to users to understand their feelings and challenges (qualitatively). The chapter also talks about making sure the tools are easy to use, culturally appropriate, and safe, so that everyone can benefit. Overall, it offers a practical guide for anyone who wants to use digital technology to improve oral health in their community.

Key Messages

1. *Case-based learning demonstrates how mother-child, elderly, and community-targeted digital interventions improve oral health outcomes through tailored engagement.*
2. *Effective evaluation must integrate both quantitative (e.g., brushing frequency, plaque index) and qualitative (e.g., perceptions, cultural fit) approaches for comprehensive assessment.*
3. *Digital health literacy is central to achieving sustained impact; thus, evaluation tools must be culturally contextualized, accessible, and regularly validated.*
4. *Sustainability of behavior change depends on reinforcement strategies, periodic re-engagement, and inclusive technology design.*
5. *Ethical evaluation practices ensure that user autonomy, privacy, and equity are protected, particularly in vulnerable or low-access populations.*

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Chapter 6.
Policy Implications and Capacity Building

6.1 Role of policy in promoting digital equity and oral health access

6.2 Training cadres and dental professionals in digital communication

6.3 Recommendations for national and institutional policy

Abstract
This chapter explores the policy dimensions and strategic directions necessary to support digital literacy in oral health promotion at scale. It outlines the role of emerging technologies such as AI, virtual reality, and mobile platforms in shaping the future landscape of dental public health. The discussion emphasizes the critical need for comprehensive national and institutional policies to bridge the digital divide, enhance professional competencies, and ensure equitable access to digital innovations. Through multi-level collaboration between government, academia, practitioners, and communities this chapter formulates recommendations that address infrastructure, regulation, training, and evaluation. The proposed approaches aim to embed digital tools within long-term oral health systems planning while safeguarding inclusion, ethical standards, and sustainability. By highlighting global evidence and contextualizing it within local realities, the chapter provides a forward-thinking yet practical policy roadmap for countries aiming to scale up digital oral health literacy.

Keywords: *Digital health policy; Oral health equity; Digital transformation in dentistry; Capacity building; Emerging technologies*

Prologue

Following the in-depth exploration of programmatic and evaluative frameworks in Chapter 5, it becomes increasingly evident that digital oral health promotion cannot thrive in a policy vacuum. The operational success of digital tools (whether mobile apps, gamified learning modules, or teleconsultation platforms) depends largely on the enabling structures provided by both national and institutional actors. As digital engagement in health behavior change continues to scale, so too does the urgency for integrated policy responses that address equity, training, data protection, and sustainability. Chapter 6 seeks to consolidate these imperatives, offering a forward-facing analysis of emerging technologies and strategic policy recommendations grounded in global evidence and local innovations. This chapter bridges the scientific and the systemic, moving from "what works" to "how to sustain what works," through governance, collaboration, and capacity-building.

6.1 Role of policy in promoting digital equity and oral health access

The role of public policy is central in fostering equitable access to digital oral health services, particularly among underserved populations. Health policy must adapt to the digital era, integrating frameworks that recognize digital access as a determinant of health. In regions with limited infrastructure, such policies can direct resources toward expanding internet access, device availability, and literacy support. Policy interventions should also address disparities driven by age, socioeconomic status, and geographic location. Such a structural approach enables long-term sustainability in digital oral health promotion (Luai et al., 2024).

Equity-oriented policies must ensure that digital health infrastructure reaches marginalized communities, including rural and remote populations. Regulatory frameworks that prioritize universal broadband access and subsidized digital tools are crucial to eliminate digital divides. This is especially significant in oral health, where teledentistry and mHealth applications rely on stable digital connectivity. In countries like Indonesia, policies targeting health equity can leverage community health programs to support digital inclusion (Siripipatthanakul & Siripipattanakul, 2024). This aligns with the broader goals of Universal Health Coverage through digital health transformation.

The integration of digital literacy into oral health policies can facilitate behavior change and improve population-level outcomes. Embedding digital literacy as a core component of national oral health strategies ensures that communities are equipped to navigate and benefit from emerging technologies. Policies must also incentivize the development of culturally appropriate and linguistically tailored digital tools. This is particularly important for multilingual societies and minority groups. Failing to do so risks widening the gap in oral health outcomes among vulnerable populations (Cardoso et al., 2024).

Governmental commitment to digital health equity can be operationalized through national action plans and intersectoral coordination. Ministries of health, education, and communication technology should collaborate in setting measurable targets for digital oral health expansion. For example, the establishment of digital health units at district health offices can localize policy execution. Fiscal policies may include tax reliefs or grants to promote innovation in oral health technology. Such integration ensures that policy commitment is translated into effective programmatic delivery (Khan et al., 2024).

The role of policy extends beyond infrastructure into regulatory support for data protection and privacy. As oral health services move toward cloud-based records and AI-supported diagnostics, robust governance frameworks are essential. Policymakers must safeguard patient data while enabling data sharing for health surveillance and research. A balance must be struck between innovation and patient rights. Digital ethics must be institutionalized through clear legal instruments (Wrona et al., 2025).

Policies that promote digital oral health equity must include incentives for private sector engagement in public health goals. Public-private partnerships can accelerate the development and distribution of digital health solutions, especially in resource-constrained settings. Governments can offer regulatory support and co-financing models to encourage innovation targeting underserved groups. For instance, mobile platforms tailored to rural oral health education have shown promise when supported by policy environments conducive to entrepreneurship. The synergy between policy and innovation is key to inclusive digital transformation (Ribeiro et al., 2022).

Health insurance frameworks also play a strategic role in expanding access to digital oral health services. Reimbursement policies should cover teleconsultations, remote diagnostics, and digital health education as essential components of care. Without

such policy inclusion, digital services may remain inaccessible to low-income groups. Policymakers must redefine benefit packages to reflect the realities of digital healthcare. This can also catalyze provider adoption and sustainability of services (Verweel et al., 2023).

Policy development must be informed by disaggregated data to identify digital disparities in oral health access. Monitoring and evaluation frameworks are essential for adaptive governance. National surveys on digital health literacy, oral health behaviors, and access patterns should inform policy design. Data-informed policymaking can prevent exclusion and maximize return on investment in digital health. The inclusion of digital indicators in oral health surveillance systems is therefore warranted (Yu et al., 2024).

Engagement of civil society and communities in policy development enhances legitimacy and responsiveness. Participatory policy processes can reveal contextual barriers and locally appropriate solutions. Civil society organizations can advocate for digital rights and health equity, especially for groups with limited political voice. Institutionalizing community feedback mechanisms improves the quality and relevance of policy interventions. This participatory governance model aligns with principles of health democracy (Liang et al., 2024).

To operationalize equity-focused policies, national governments must establish guidelines and accreditation systems for digital oral health tools. These include standards for app usability, accessibility, evidence-based content, and interoperability. Regulatory clarity empowers developers and builds trust among users. Standardization can also promote scalability across jurisdictions. Institutional backing ensures that digital health solutions meet quality and safety criteria (Kitsaras et al., 2023).

In Indonesia, local health offices (Dinas Kesehatan) can contextualize national policies to the realities of digital literacy in each province. Decentralization of policy implementation enables

flexible and responsive programming. For example, policies mandating digital oral health modules in school curricula can be adapted based on regional digital readiness. District-level initiatives supported by national policy create pathways for pilot programs to scale. This multilevel approach is critical in large, diverse nations (Wening et al., 2025).

Legal and policy reforms are needed to embed digital oral health within primary care. Digital readiness assessments of Puskesmas (community health centers) can inform investment priorities. Policies can mandate teleconsultation hours, digital health records, and training for Puskesmas personnel. This would institutionalize digital access at the first point of care. Integrated service delivery models can close the gap between policy aspiration and grassroots implementation (Halizah et al., 2024).

International frameworks such as WHO's Global Strategy on Digital Health offer blueprints for national policy formulation. Countries can adapt these frameworks to address oral health-specific goals, integrating them into National Health Digital Agendas. Global alignment enables policy coherence and international collaboration in research, standards, and funding. Adoption of such global norms also facilitates technical assistance. Policy borrowing must, however, be matched by local adaptation to ensure relevance (Harnagea et al., 2022).

Academic institutions and professional bodies have a role in shaping and evaluating policy effectiveness. Policy research, pilot studies, and implementation science can guide adaptive policymaking. Accreditation councils should update curricula to include digital oral health competencies. Policy think tanks and consortia can foster dialogue between stakeholders. Evidence-informed policy is key to advancing digital health equity in oral care (Kim et al., 2025).

In summary, policy is both a driver and enabler of digital transformation in oral health promotion. It defines the rules, incentives, and accountability mechanisms that shape practice.

Achieving digital equity requires policies that are inclusive, evidence-informed, and context-sensitive. Multisectoral collaboration and participatory processes enhance policy design and execution. Through strategic policy action, the promise of digital oral health can be realized for all segments of society.

6.2 Training cadres and dental professionals in digital communication

The increasing reliance on digital platforms in oral health promotion necessitates a fundamental shift in the skills and competencies of those at the forefront of community-based dental health delivery. Cadres and dental professionals, who traditionally relied on face-to-face educational models, must now adapt to evolving digital communication landscapes. Training initiatives must not only enhance their digital literacy but also integrate critical competencies such as message framing, media selection, and audience engagement through platforms like mobile apps, social media, and e-learning systems. According to Wening et al. (2025), empowering cadres with digital communication tools significantly improved community outreach in hypertensive elderly populations. This shift reflects a broader redefinition of oral health advocacy, where technology augments reach, credibility, and the personalization of health messages.

Building the capacity of dental professionals requires more than basic technical instruction; it involves transforming their pedagogical and communicative paradigms. Traditional hierarchies in health communication are flattened in digital settings, requiring professionals to adopt participatory, culturally sensitive, and user-centric approaches. Juliawati et al. (2022) emphasize that a patient-safety culture, underpinned by open, informed communication, can be effectively reinforced through digital feedback loops and virtual training. This highlights the potential of integrating communication theory and health informatics into continuing professional

development (CPD) curricula to better prepare dental health professionals for the nuances of digital interaction.

At the cadre level, the effectiveness of digital communication hinges on localized content adaptation and practical usability. Studies by Kuntari et al. (2021) demonstrate that cadres trained using context-specific modules, such as oral health in the first 1000 days of life, can deliver more relatable and actionable health messages when equipped with digital storytelling tools. Cadres, often acting as cultural brokers between health institutions and communities, benefit from audiovisual formats that overcome literacy and language barriers, especially in remote or under-resourced areas. Hence, training programs must integrate content design, platform navigation, and persuasive communication tailored for field implementation.

Anwar and Supiaty (2022) further illustrate that the effectiveness of health messages significantly increases when community health workers employ game-based and multimedia-enhanced techniques in educational sessions. These tools not only increase retention and motivation among target populations but also reduce the digital resistance sometimes encountered among older or less digitally adept cadres. Introducing adaptive training modules (ones that respond to real-time user feedback) can substantially improve the learning curve for frontline oral health promoters.

Digital communication training must also address the psychological and behavioral dynamics of virtual engagement. The work of Liang et al. (2024) applying the Information-Motivation-Behavioral (IMB) model emphasizes the need for training programs to foster intrinsic motivation and digital self-efficacy among trainees. This ensures that cadres and dental practitioners are not only capable of using digital tools but are also motivated and confident in deploying them as part of their day-to-day interaction with patients. Incorporating behavioral science into digital training thus strengthens the sustainability of technology use in oral health promotion.

National initiatives that integrate dental digital literacy into the formal health system have shown promising outcomes. According to Wening et al. (2025), strategic collaborations with universities and public health institutions have resulted in community service models that train both students and professionals through service-learning modalities. These models promote experiential learning where digital communication skills are developed in real-world settings, bridging theory with practice. Policy alignment at institutional and national levels remains vital to scaling such programs.

Training methodologies must also address data protection, patient consent, and ethical communication. As highlighted by Yu et al. (2024), older adults and vulnerable populations express concerns about digital privacy and misinformation. It is imperative that cadres and dental professionals receive education on ethical standards, cybersecurity protocols, and the legal responsibilities involved in teleconsultation and digital engagement. Such topics should be integral components of digital health training frameworks, particularly in the context of oral health data and consent management.

Capacity building should not be a one-off endeavor but a longitudinal process embedded within a career development framework. The Ministry of Health and several academic institutions in Indonesia have piloted laddered certification schemes where digital communication skills are assessed and rewarded progressively (Abdi et al., 2022). These tiered programs create a professional incentive structure for continuous improvement and standardization of digital health communication practices across diverse regional contexts.

Peer-led and blended learning formats have proven to be highly effective in maintaining training momentum. Abdi, Aldilawati, and Wijaya (2023) report that peer-assisted online modules among pregnant women health promoters not only fostered knowledge transfer but also strengthened digital mentoring

relationships. Training programs should leverage such peer dynamics to enhance both skill acquisition and emotional resilience in navigating digital ecosystems, especially in high-stress community environments.

Content delivery through culturally relevant examples enhances engagement and comprehension. The use of culturally specific narratives, visual aids, and languages that resonate with the target population has been shown by Alamsyah and Natassa (2017) to increase the effectiveness of communication by cadres working with children with special needs. Digital training programs must incorporate modules on inclusive communication strategies that consider neurodiversity, disability, and socio-economic background.

Technology partnerships between government and private tech developers can play a transformative role in scaling training efforts. The use of platforms like Quizztooth and Puzdent (Aldilawati et al., 2023) demonstrates how gamified education applications can be customized for cadre training and performance assessment. These tools allow for both formative and summative evaluation, enabling trainers to personalize support and adapt curricula to cadre learning needs.

Evaluation metrics are essential to determine the effectiveness of digital communication training. Outcome-based assessments focusing on message delivery accuracy, user engagement metrics, and behavioral changes among target populations should be routinely embedded within training programs. Masriadi et al. (2021) recommend integrating feedback loops, such as digital quizzes and patient response tracking, into e-learning modules to validate learning progress.

Training for digital communication must also be responsive to the rapidly evolving technological environment. Continuous professional development should include updates on emerging platforms, app usability reviews, and digital health trend analysis. Collaboration with interdisciplinary experts, including UX designers

and media psychologists, can further enrich the relevance and adaptability of training content for oral health promoters.

Cross-sectoral collaborations are indispensable for sustaining digital training ecosystems. NGOs, academic institutions, professional associations, and government agencies must coordinate to standardize content, recognize certifications, and ensure equitable access to digital resources (Wrona et al., 2025). Such partnerships can also facilitate the integration of training modules into national dental health strategies, thereby institutionalizing digital literacy as a core competency in oral health promotion.

In conclusion, the training of cadres and dental professionals in digital communication represents a pivotal step in achieving equitable, effective, and scalable oral health promotion in the digital age. Strategic investments in curriculum development, pedagogical innovation, ethical guidance, and cross-sector collaboration are required to ensure these frontline actors can lead transformative change. The sustained digital engagement of these professionals will be instrumental in shaping the future landscape of oral health behavior interventions.

6.3 Recommendations for national and institutional policy

The integration of digital health literacy into national oral health strategies requires evidence-based, multilevel policy recommendations that align with both technological advances and local sociocultural realities. While digital tools have demonstrated efficacy in enhancing oral health behavior (Kitsaras et al., 2023), sustainable implementation hinges on systemic support through clear policy frameworks. Governments must assume a stewardship role by establishing strategic guidelines for digital literacy, infrastructure support, training, and ethical governance. Institutional collaboration with academic and community stakeholders is necessary to tailor policy to local capacity and need.

First, a national policy should prioritize the institutionalization of digital literacy in oral health education at

every level, within formal, informal, and continuing level. This includes embedding digital health modules in dental school curricula, training community health workers, and supporting lifelong learning for practitioners. As demonstrated by Wening et al. (2025), structured training programs within community health services enhance digital competencies, especially when aligned with local oral health goals and demographic challenges. Universities should be mandated to collaborate in policy design and execution.

Second, standardized digital health competencies must be defined and endorsed at national and provincial levels to guide curriculum development and professional licensing. These competencies should reflect skills such as digital tool navigation, ethical communication, data privacy awareness, and evidence-based content dissemination. According to Yu et al. (2024), such standards are essential for reducing disparities in digital engagement among professionals and lay workers alike, especially in aging populations. Certification bodies and professional associations can act as regulatory agents for enforcing these standards.

Third, policies must address the digital divide by mandating equitable access to infrastructure and internet connectivity in rural and low-income areas. Government investment in ICT infrastructure must be accompanied by incentives for private sector partnerships. As pointed out by Siripipatthanakul and Siripipattanakul (2024), rural digital transformation in oral health requires not only access to devices and internet but also technical support, language accessibility, and adaptive content. Incentivized subsidies for digital health access and teleconsultation tools are critical to policy success.

Fourth, intersectoral policy-making is vital. Ministries of Health, Education, Communication, and Social Welfare must collaborate to build a comprehensive policy ecosystem for digital oral health. Health promotion is no longer the domain of one sector alone; it must be infused across digital education, media regulation, and public service delivery. According to Koh et al. (2021), policy synergy enhances public trust and reduces fragmentation in digital

health promotion initiatives. Multi-stakeholder platforms should be institutionalized for cross-sector coordination and resource sharing.

Fifth, oral health promotion policies must explicitly include provisions for vulnerable groups such as older adults, people with disabilities, and those in remote communities. These provisions should include accessible content formats, inclusive language, assistive technologies, and community support. Anwar et al. (2020) underscore the importance of audio-visual and gamified content for special populations, while Alamsyah and Natassa (2017) highlight the need for policy to integrate disability-inclusive educational strategies.

Sixth, policies should encourage participatory approaches in designing and evaluating digital health interventions. The involvement of community members in co-design, feedback, and testing processes increases cultural relevance and implementation success (King et al., 2025). Regulations should include ethical guidelines for participatory research, consent management, and the safeguarding of vulnerable populations in digital health initiatives. Policy must acknowledge digital co-creation as an essential element of equity-driven oral health promotion.

Seventh, local governments must be empowered to localize national policies according to specific epidemiological and demographic profiles. Provincial and municipal health offices should have operational autonomy to adapt digital health strategies with reference to cultural, infrastructural, and behavioral factors. As documented by Aldilawati et al. (2023), community-based programs gain traction when they are decentralized and supported by local champions who understand regional nuances.

Eighth, digital health communication policies must be aligned with national health communication strategies to prevent misinformation and ensure content accuracy. A national digital oral health portal, with validated content and multilingual capabilities, should be developed and maintained by the Ministry of Health in collaboration with universities and professional associations. Liang

et al. (2024) emphasize the influence of well-designed, motivational digital content in shaping preventive behavior, especially among older adults and caregivers.

Ninth, policies must address the ethical use of AI and big data in oral health promotion. Regulatory frameworks must define boundaries for algorithmic decision-making, data use transparency, and patient consent. Fadilah et al. (2024) stress the importance of validation and accuracy in AI-based dental caries detection tools, which must be governed by policies ensuring clinical safety, patient protection, and data integrity.

Tenth, national policy must include funding mechanisms for digital innovation in oral health, especially for low-resource settings and community-based programs. Dedicated grants for research, prototyping, and dissemination of digital oral health technologies should be institutionalized through government and philanthropic partnerships. As shown by Abdi et al. (2023), grassroots digital interventions flourish when supported by predictable funding and technical mentoring.

Eleventh, monitoring and evaluation (M&E) mechanisms must be embedded in digital oral health policies. These M&E frameworks should measure behavioral outcomes, user satisfaction, access equity, and system integration. Mariño et al. (2016) recommend iterative evaluation cycles that inform continuous improvement in platform usability and content quality. M&E results must feed back into policy reviews and be disseminated transparently to stakeholders.

Twelfth, professional associations must be involved in shaping digital health regulation and guiding practitioners. They can act as intermediaries between the state and clinicians, providing accreditation, CPD training, and peer benchmarking. Juliawati et al. (2022) advocate for professional societies to assume leadership roles in cultivating a digital safety culture and peer accountability in oral health promotion.

Thirteenth, international collaboration should be encouraged to learn from successful models and adapt global best practices to national contexts. For instance, initiatives like Know Your OQ™ (Kitsaras et al., 2023) and TOOTH (King et al., 2025) offer scalable intervention frameworks that can inform national tool development. Policy frameworks should support participation in global networks, knowledge exchange, and capacity building through WHO, FDI, or ASEAN health forums.

Fourteenth, policies should ensure the sustainability of digital oral health initiatives through institutional anchoring. Embedding digital oral health education and promotion within public health institutions, school curricula, and primary care ensures continuity beyond political cycles and project timelines. Sustainability requires long-term political will, integration with universal health coverage strategies, and clear institutional ownership.

Finally, national and institutional policies must adopt a rights-based approach to digital oral health promotion, ensuring that every individual has the right to access, understand, and benefit from digital health innovations. This includes legislating against digital discrimination, advocating for digital inclusion, and framing digital oral health as a public good. Only with such comprehensive, equity-oriented policies can digital transformation in oral health truly serve the health of all citizens.

Summary
Promoting healthy teeth and gums through digital tools like mobile apps, online videos, or even AI-powered diagnosis is a growing part of healthcare. But to make sure everyone benefits from these tools whether they live in a city, a village, or have limited access to the internet, strong government policies and supportive institutions are needed. This chapter discusses what kind of policies can help make digital oral health more available, more effective, and more fair for all. It talks about how new technologies can help, what dental schools and health centers need to do, and how communities can play a part too. The goal is to ensure that people from all walks of life have the digital skills and access they need to take care of their oral health, now and in the future.

Key Messages

1. *Strategic policymaking is essential to embed digital oral health tools in national health agendas, especially for underserved populations.*
2. *Capacity building among professionals and cadres must be systematized through updated curricula, digital competencies, and inclusive training programs.*
3. *Cross-sector collaboration and ethical regulation are crucial to ensure the safe, equitable, and sustainable integration of AI, big data, and digital platforms in oral health promotion.*

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Chapter 7.
Future Directions and Innovations

7.1 Emerging technologies (AI, gamification, AR/VR in dental literacy)

7.2 Opportunities for scaling and personalizing behavior change interventions

7.3 Research agenda and integration with health systems

Abstract
This chapter outlines strategic future directions and innovative prospects in digital oral health promotion. It begins by reviewing emerging technologies such as artificial intelligence, gamified learning, and augmented reality, exploring their implications for behavior change and literacy advancement. The discussion then advances to opportunities for scaling and personalizing interventions based on community needs, user segmentation, and digital readiness. Emphasis is also placed on the integration of research into systemic planning, highlighting the need for collaborative innovation ecosystems that engage health professionals, policymakers, and digital developers. By examining lessons from recent programs, this chapter illustrates how innovation must remain rooted in real-world evidence and adaptive planning.
Keywords: *Digital innovation; Oral health behaviour; Artificial intelligence; Gamification; Health systems integration*

Prologue

Following the policy-driven infrastructure explored in Chapter 6, this chapter shifts focus toward anticipating the next wave of transformation in digital oral health promotion. While policy and capacity-building initiatives lay the groundwork, the long-term success of these interventions hinges on our ability to adapt, scale, and personalize solutions through technology and innovation. By reflecting on behavioral, technological, and systemic developments, Chapter 7 articulates not only what is next, but what is possible. It provides a forward-looking lens into integrating gamification, AI, AR/VR, and system-level innovations into mainstream oral health strategies anchored in community context and research-based planning.

7.1 Emerging technologies (AI, gamification, AR/VR in dental literacy)

Technological innovation continues to redefine the boundaries of health communication and behavioral science, particularly in the realm of oral health literacy. Digital interventions are no longer limited to static information delivery but are increasingly interactive, intelligent, and immersive. Emerging

technologies such as artificial intelligence (AI), gamification, and immersive media platforms like augmented reality (AR) and virtual reality (VR) offer novel tools for engaging diverse populations. Their integration into oral health promotion promises not only to increase knowledge but also to actively support behavioral change, particularly in populations that are historically underserved. This section explores these technologies and evaluates their potential contributions to the evolution of digital oral health literacy interventions.

Artificial intelligence has demonstrated its transformative value in both clinical diagnostics and health education. Tools such as YOLO-V8x, which utilize real intraoral photos for caries detection, have been successfully tested in school settings and proven to be more efficient than manual screenings (Fadilah, Rikmasari, Akbar, & Setiawan, 2024). The application of AI in educational tools enables dynamic, personalized learning environments that adapt to the user's literacy level, cognitive style, and behavioral feedback. This adaptability supports a more individualized health promotion experience and improves retention of preventive practices. In countries with limited access to dental professionals, such tools serve as scalable solutions to bridge service gaps.

Gamification represents another avenue by which digital tools are reshaping health education. By embedding game elements such as points, rewards, and challenges into learning modules, gamified interventions appeal to intrinsic motivation and can foster habitual behavior. Studies have shown that children exposed to gamified dental education, such as cartoon videos or quizzes, report improved knowledge and brushing habits (Yanti, Alamsyah, & Natassa, 2017). These tools not only entertain but also reinforce positive behaviors through repetition and reward feedback loops. When embedded in structured school health programs, gamified modules can enhance compliance and reduce resistance among younger users.

Augmented and virtual reality platforms are now being explored for their potential to simulate real-world dental practices and environments. In educational contexts, AR is used to demonstrate proper brushing and flossing techniques, allowing learners to visualize their actions in real time. These technologies are particularly beneficial for psychomotor learning and are increasingly employed in early childhood oral health promotion. Internationally, VR has also been used in exposure therapy for dental anxiety, and AR is making inroads into interactive health kiosks used in schools and community health posts. Although cost and infrastructure remain barriers in low- and middle-income countries, pilot projects demonstrate that with the right partnerships, these tools can be adapted for broader use.

For individuals with disabilities or special educational needs, technology plays a crucial role in inclusive health communication. Animated videos with closed captions and visual aids have shown efficacy in improving oral hygiene among deaf and hard-of-hearing children (Yanti, Alamsyah, & Natassa, 2017). Additionally, interactive cartoons and game-based storytelling make it easier to engage children with cognitive limitations or speech disorders. These adaptive features illustrate the importance of universal design principles in digital health literacy tools, ensuring that oral health messages are accessible to all.

Digital innovations are also gaining traction in structured interventions with adult populations. Tools like the OHL-Ortho instrument have been developed to assess oral health literacy in orthodontic patients and have potential to guide tailored messaging in digital health apps (Thirasupa, Intarakamhang, & Kasevayuth, 2023). By integrating literacy assessments into app-based interfaces, interventions can be personalized based on user capabilities, language, and behavior. Such customization enhances learning effectiveness, builds user confidence, and promotes sustained engagement with oral health content.

Community-led digital empowerment models have further demonstrated that technology can complement human-centered public health strategies. Wening et al. (2025) emphasized how family caregivers and local cadres could amplify the impact of structured oral health education programs, especially among the elderly with chronic conditions such as hypertension. Although these models did not include AI or VR, they utilized multimedia-supported messaging and paper-based visuals that can easily transition into digital formats. This underscores the value of blending traditional empowerment strategies with scalable digital tools to enhance reach and relevance.

Recent local innovations such as the "Puzdent for Kids" mobile application have shown strong potential in primary school oral health programs. Designed with visual, auditory, and tactile engagement in mind, the app offers quizzes, animations, and interactive feedback tailored to children's learning levels (Aldilawati, Selviani, & Ardiningrum, 2023). Post-intervention assessments revealed improvements in both knowledge and brushing behavior, affirming the role of well-designed apps in public health promotion.

Video-sharing platforms like YouTube have also emerged as supplemental education channels, though their unregulated nature poses risks. Damayanti and Juliawati (2025) observed that while video tutorials improved understanding among dental students, content quality varied widely, underscoring the need for curation, vetting, and quality assurance mechanisms. As digital health content becomes increasingly user-generated, strategic oversight will be necessary to protect viewers and maintain educational standards.

SMS-based and messaging interventions also continue to show promise. The TOOTH program, a co-designed text-message platform, has demonstrated increased health literacy and behavior change among working adults (King et al., 2025). Messages that are short, theory-driven, and behaviorally relevant tend to perform best. These findings validate the use of minimal-format interventions,

which can be both cost-effective and highly scalable, particularly for rural or low-bandwidth regions.

Multilingual modules and adaptive AI translation tools are also gaining popularity, ensuring content accessibility across culturally diverse communities. Juliawati et al. (2022) noted that culturally sensitive educational strategies foster greater trust and engagement, a principle that should be considered in digital program design. Localization of health content, both linguistically and visually, is essential for effectiveness in multicultural contexts.

For adolescents and high-risk groups, mobile games and cartoon-based e-learning modules remain effective strategies. Interactive counseling through animated video and gamified quizzes have shown statistically significant improvements in brushing frequency and hygiene scores (Anwar et al., 2020). These findings reinforce the value of tailoring interventions to the cognitive and social preferences of each age group.

Big data analytics and AI-supported modeling are now being piloted in several countries to identify population risk clusters for targeted intervention. These tools enable health planners to predict where oral health problems are likely to emerge and to prioritize outreach accordingly (Verweel et al., 2023). This proactive approach can optimize resource allocation, reduce treatment costs, and improve long-term oral health outcomes at the population level.

Personalized e-learning platforms that adjust content based on user interactions are the next step in digital oral health promotion. These platforms are being developed using AI and behavior tracking to optimize delivery sequence, content type, and frequency. Though implementation remains limited, pilot studies suggest that personalization improves knowledge retention and increases behavior adherence rates (Kim et al., 2025).

In conclusion, the convergence of AI, gamification, and immersive media represents a transformative force in digital oral health literacy. While these technologies are not panaceas, they offer powerful tools to amplify reach, tailor content, and engage users

across demographic and geographic lines. Strategic integration with public health systems, combined with careful evaluation and inclusive design, will be essential to harness their full potential in the coming years.

7.2 Opportunities for scaling and personalizing behavior change interventions

In the evolving landscape of oral health promotion, one of the most pressing challenges is how to scale interventions while maintaining relevance and impact across diverse populations. Digital technologies offer a compelling avenue for achieving this dual goal. With proper design and infrastructure, digital platforms can deliver personalized educational content to large numbers of individuals across varying demographic, geographic, and socioeconomic contexts. The convergence of digital health literacy and scalable communication platforms enables a shift from one-size-fits-all campaigns to tailored, user-specific behavior change strategies. This section examines how opportunities for scaling can be aligned with personalization principles in the context of oral health.

Scalability is largely dependent on the flexibility and adaptability of digital health platforms. Web-based tools such as the "Know Your OQ™" program have demonstrated how a modular platform can be deployed across populations to improve oral health knowledge, attitudes, and practices (Kitsaras et al., 2023). The platform's design allowed for the customization of content by region, age, and oral health status, creating a template for scale without sacrificing specificity. Such programs exemplify how scalable technologies can also maintain personal relevance, particularly when modular design and real-time data feedback are incorporated into the development process.

The use of mobile health (mHealth) interventions also underscores the potential for large-scale personalization. Platforms delivering health-promoting messages via SMS, WhatsApp, or mobile applications have been effective in adjusting the timing,

frequency, and content of messages based on user interactions and health literacy scores (King et al., 2025). In settings where digital penetration is high but infrastructure is low, SMS-based programs provide low-cost, wide-reaching educational alternatives. These tools can also segment audiences based on age, language, or dental history, thus enabling both reach and precision in behavioral nudging.

Community health programs also benefit from scaling digital interventions when local stakeholders are involved. In Indonesia, for example, Puzdent for Kids and QuizzTooth apps were developed with a participatory approach involving educators and public health officials (Aldilawati et al., 2023; 2026). These applications were introduced in elementary schools and tailored to the cultural and linguistic context of each district. Such co-design methods enable broader adoption and facilitate scale-up, while also promoting a sense of ownership and contextual appropriateness among target communities.

Personalization strategies are further strengthened by integrating assessment tools into digital platforms. For instance, OHL-Ortho enables users to self-assess their oral health literacy, allowing the platform to adjust content complexity and prioritize gaps in user understanding (Thirasupa et al., 2023). When scaled, this allows for a population-level deployment of personalized learning paths, which can significantly enhance learning outcomes and behavioral compliance. Similarly, other platforms use pre- and post-intervention quizzes to dynamically adjust lesson sequences, reinforcement frequency, and interactive prompts.

Machine learning algorithms now allow for real-time learning adaptation based on behavioral data input. These systems track user interactions such as completion time, frequency of revisits, and quiz scores to calibrate future content delivery. AI-driven interventions can analyze behavioral indicators and predict the most effective format and frequency of content delivery for each user (Verweel et al., 2023). In the future, these tools may also be

used to detect emotional cues, learning fatigue, and motivational drop-offs, creating a more responsive and human-like user interface.

Digital storytelling and gamification present additional opportunities for scaling impact while tailoring engagement. In Indonesia, cartoon video interventions have successfully improved oral hygiene behaviors among deaf children and junior high school students by using characters and narratives familiar to their local context (Yanti et al., 2017). By using culturally relevant avatars and storylines, digital storytelling fosters both emotional resonance and behavioral modeling. Once developed, such stories can be adapted across regions with linguistic and visual modification, offering high scalability at a relatively low marginal cost.

Collaborative platforms that allow integration of user-generated content are emerging as tools for personalization. Educational videos, tutorial contributions, and oral health diaries created by users themselves can be shared within secure platforms, building community and accountability. For example, the YouTube-based video initiatives reported by Damayanti and Juliawati (2025) for undergraduate dental students were enhanced when learners co-created tutorials, allowing them to internalize knowledge through content development. This peer-to-peer model represents a scalable and sustainable method for community-led health education.

For scaling to be successful, infrastructure and policy support must be synchronized with technological readiness. The implementation of national databases for oral health status and digital literacy mapping would support micro-targeting of behavior change interventions. Moreover, public-private partnerships could ensure that validated, evidence-based educational tools are widely distributed in schools, clinics, and community centers. Indonesia's Ministry of Health has piloted such collaborations in its UKGS revitalization programs by integrating mobile-based monitoring systems into school health reporting (Wening et al., 2025).

Effective scaling also requires performance metrics and feedback systems. Evaluating the reach, engagement, and behavioral

outcomes of digital interventions at scale allows for iterative improvement and allocation of resources to the most effective strategies. Metrics should include changes in brushing frequency, dental visits, caries incidence, and patient-reported literacy levels. Advanced analytics can identify which subgroups benefit most from which formats, allowing for more precise deployment.

Finally, investment in workforce capacity is necessary to maintain personalization at scale. Cadres, teachers, and health promoters must be trained not only to operate digital tools but also to interpret user feedback and support the learning process offline. Training modules, such as those developed in the digital literacy programs in Makassar and Bali, have demonstrated the feasibility of integrating human support into digital campaigns (Anwar et al., 2020; Idaryati et al., 2024). This human-digital synergy is essential to ensure sustainability and impact.

In summary, scalable digital interventions must be designed with built-in personalization, local relevance, and feedback adaptability. When thoughtfully executed, these tools can transform oral health promotion from episodic campaigns into continuous, individualized learning ecosystems. As infrastructure and literacy improve globally, the opportunity to deliver cost-effective, evidence-based, and scalable interventions is within reach.

7.3 Research agenda and integration with health systems

As digital oral health promotion matures, the need for a structured, forward-looking research agenda becomes increasingly urgent. While various interventions have demonstrated localized success, large-scale integration into health systems requires robust evidence, interdisciplinary collaboration, and continuous evaluation. Research must move beyond effectiveness trials to examine implementation science, cost-effectiveness, cultural adaptability, and system-level impacts. This section outlines critical pathways for embedding digital oral health innovations within health systems and

delineates a research roadmap aligned with emerging public health priorities.

The first imperative is the validation of tools across populations and contexts. For instance, the development of instruments such as the OHL-Ortho (Thirasupa et al., 2023) reflects early strides in measuring oral health literacy in specific patient populations. However, standardized tools are still limited, especially in non-English-speaking and low-resource environments. Future research should prioritize psychometric validation of literacy and behavioral assessment instruments in diverse linguistic and cultural settings, enabling equitable comparisons and informed policy decisions.

Second, implementation science must become central to digital oral health research. Many pilot programs such as TOOTH (King et al., 2025) and Know Your OQ™ (Kitsaras et al., 2023) demonstrate promise, but their pathways to national scale-up remain under-examined. Studies should investigate barriers and facilitators to implementation at institutional, community, and policy levels. For example, Indonesia's experience in embedding digital tools into school-based oral health programs highlights challenges in training, infrastructure, and data integration (Wening et al., 2025). Qualitative research with stakeholders can uncover bottlenecks and suggest context-sensitive strategies for sustainable adoption.

Interdisciplinary research collaboration is essential. Integrating dental public health, behavioral science, education, communication, and data science can enhance the sophistication of intervention design and analysis. Digital interventions must align with broader eHealth strategies and national health information systems. Coordination between the Ministry of Health, academic institutions, and community organizations can ensure that digital oral health efforts are not siloed but synergized with general health promotion frameworks. Research should also explore how oral health apps and platforms can contribute to national surveillance and early warning systems for oral diseases.

Economic evaluations and cost-effectiveness studies remain a significant gap. Although digital tools are often promoted for their low marginal cost, empirical data on their return on investment (ROI) are sparse. Cost-benefit analyses comparing traditional outreach (e.g., printed leaflets or in-person seminars) with mobile or web-based interventions can guide resource allocation decisions. Furthermore, longitudinal studies are required to assess the sustained impact of digital behavior change interventions on caries incidence, periodontal health, and healthcare utilization.

Data privacy, ethics, and digital equity must also be researched more rigorously. Studies must address concerns regarding data ownership, informed consent, and algorithmic bias in AI-based interventions. The inclusion of vulnerable groups such as elderly populations, persons with disabilities, or those with low literacy levels, should be monitored not only as recipients of care but also as stakeholders in design and governance. Research should inform ethical guidelines and policy frameworks that protect digital rights while enhancing access.

Another priority is the integration of digital oral health promotion into primary care and school health systems. Interventions targeting mothers, children, and adolescents such as WhatsApp groups, gamified applications, or audiovisual tutorials, should be evaluated for compatibility with national health education curricula. Pilot initiatives in Makassar, Denpasar, and Bali have shown that such integration is feasible when accompanied by proper training and inter-sectoral coordination (Anwar et al., 2020; Idaryati et al., 2021). Evaluative research should document which models are most effective for embedding digital tools into ongoing clinical and public health workflows.

Health workforce readiness is a key determinant of integration success. Research must assess the digital competencies of oral health professionals, identify training needs, and evaluate the outcomes of professional development programs. Studies like Juliawati et al. (2022), which explored patient safety culture in

Jakarta's dental clinics, reveal the relevance of digital training even in clinical management. Future research should explore how blended learning, tele-supervision, and digital simulations can enhance both technical and communication skills among oral health practitioners.

In addition, national digital health roadmaps should explicitly include oral health. Current policies in many countries underrepresent oral health in digital strategy documents. Research advocacy can play a role in demonstrating the burden of oral diseases and the cost-saving potential of digital interventions. By building coalitions of dental public health researchers, data scientists, and policymakers, oral health can be more effectively positioned within broader health system digitalization agendas.

Furthermore, research should explore the feasibility of real-time dashboards and data feedback loops. Such tools could allow ministries, schools, or clinics to monitor oral health education coverage, track behavior change metrics, and identify at-risk populations. Platforms similar to those used in nutrition or maternal-child health surveillance could be adapted for oral health with appropriate indicators and interoperability standards.

Finally, citizen science and participatory research approaches offer promising avenues. Involving community members in data collection, needs assessment, and co-creation of digital tools not only enhances relevance but also builds trust and engagement. Examples from the Indonesian programs involving students, parents, and teachers in the design of game-based or video-based interventions show the potential of this method for both implementation and sustainability (Aldilawati et al., 2026; Anwar et al., 2022).

In conclusion, the path toward systemic integration of digital oral health promotion requires an ambitious, well-funded, and collaborative research agenda. The agenda must bridge the evidence gap between innovation and implementation, emphasizing contextual adaptability, equity, and sustainability. As digital tools mature, it is critical that research continuously inform their

refinement, scaling, and institutionalization within national and global health systems.

Summary
In the years ahead, digital tools for dental health will become smarter, more interactive, and more personalized. This chapter explores technologies such as AI, games, and augmented reality that help people learn and stick with good oral health habits. It also shares ideas on how to expand these innovations to reach more people, especially those in rural or underserved communities. Importantly, it emphasizes the need to plan based on strong evidence and include everyone from patients, dentists, community leaders, and technology experts in the process.

Key Messages

1. *Emerging technologies such as AI and gamification offer promising pathways to engage different population groups in oral health literacy.*
2. *Scalability and personalization of digital tools must consider socioeconomic realities, user digital skills, and behavioral profiles.*
3. *Research-based integration with national health systems ensures that digital solutions remain relevant, equitable, and sustainable.*
4. *Interdisciplinary collaboration is essential for designing impactful, innovative, and inclusive oral health interventions.*
5. *Innovation without community grounding risks becoming ineffective; participatory planning and evaluation are vital.*

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Wening, G. R. S., Anugraha, G., Az'Zahra'Medina, J., Syarifina, M. P., Ardianto, M. A. H., Ayunnisa, N., & Nurani, N. (2025). Empowering women in pioneering oral health initiatives for elderly with hypertension. *Jurnal Promkes: The Indonesian Journal of Health Promotion and Health Education, 13*(1), 56–64.

Wening, G. R. S., Putrifajar, S. A., Serena, D. P. N., Kuswanda, C. T., & Nisa, G. S. N. (2025). Pemanfaatan media informasi sebagai upaya peningkatan perilaku lansia hipertensi dalam mengunjungi dokter gigi. *BERNAS: Jurnal Pengabdian Kepada Masyarakat, 6*(3), 1845–1849.

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Chapter 8.
Conclusion

8.1 Summary of findings
8.2 Strategic insights for stakeholders
8.3 Sustainable models for digital oral health literacy programs

Abstract
This concluding chapter synthesizes the multidimensional exploration of digital literacy in oral health behavior change presented throughout the book. It summarizes the major findings, strategic insights, and sustainable frameworks that have emerged from national and international research. Central to these insights is the role of contextualized interventions, stakeholder alignment, and technology-enabled community empowerment. The chapter emphasizes that sustainable digital oral health literacy programs must be behaviorally anchored, culturally sensitive, and systematically evaluated. Drawing from empirical evidence and theoretical models, this chapter offers a forward-looking synthesis that informs academic discourse and policy formulation.

Keywords: *Digital oral health literacy; Behavior change; Stakeholder engagement; Sustainable intervention; Health equity*

Prologue

After navigating through diverse dimensions of digital oral health literacy, from foundational concepts and measurement tools to targeted interventions and policy implications, this final chapter aims to synthesize key learnings and insights for application across practice, policy, and research. The evidence gathered throughout the chapters strongly affirms the transformative potential of digital strategies in reshaping oral health behavior across populations. However, such transformation must be anchored in contextual relevance, equity-driven design, and sustainable multisectoral collaboration. By systematically reviewing key findings, outlining actionable insights for stakeholders, and proposing sustainable models rooted in empirical evidence, this chapter aspires to serve as a guiding framework for future advancement in the field.

8.1 Summary of findings

Digital oral health literacy has become a cornerstone in reshaping preventive health strategies across diverse populations. Throughout the national and global literature analyzed in this book, there is consistent evidence that digital tools (when appropriately contextualized) have the capacity to influence not only individual knowledge but also community-based behavioral change. In Indonesia, Aldilawati et al. (2023) demonstrated that animation-

based and gamified platforms like *Puzdent for Kids* can significantly improve children's oral hygiene knowledge and practices in classroom settings.

Findings consistently show that behavior change is best achieved through personalization and cultural adaptation. Anwar and Supiaty (2022) noted that game-based learning tailored for rural and coastal schoolchildren yielded higher engagement levels and knowledge retention than traditional lectures. Similarly, Juliawati et al. (2022) emphasized the importance of safety culture and trust in institutional communication, highlighting the influence of digital communication ethics on behavior acceptance.

Digital strategies have also proven valuable for underrepresented groups. Ilmianti et al. (2020) found that audiovisual-based education improved oral health knowledge among elementary students in resource-limited schools. This aligns with Alamsyah and Natassa's (2018) findings on the effectiveness of both audio and braille-based education for blind students, underscoring the importance of inclusion in digital content development.

Behavioral models applied in digital contexts have been further validated by Wening et al. (2025), who explored elderly empowerment strategies in hypertension-related oral care through structured media information. The integration of theoretical frameworks such as the Health Belief Model in their work provides a practical roadmap to align digital health literacy with perceived risks and self-efficacy components.

Another major theme identified is that knowledge does not always translate directly into practice unless reinforced by structured follow-up and community involvement. Abdi et al. (2024) revealed a gap between awareness and daily hygiene practices among online ride-hailing drivers, highlighting the need for behaviorally driven messaging and motivational tools that match users' routines and constraints.

Moreover, consistent monitoring and iterative evaluation have emerged as crucial for program sustainability. Interventions such as the *Quizztooth Games* (Aldilawati et al., 2026) provided a structured evaluation model where knowledge gain was measurable through pre- and post-assessments. This evidence supports the argument that literacy tools must embed feedback loops to ensure adaptive improvement.

There is also a strong indication that trust and relational reinforcement play significant roles in digital education uptake. Community-led projects involving mothers and cadres, such as those led by Wening et al. (2025) and Abdi et al. (2023), show higher adoption rates and longer retention of oral health messages when facilitated by familiar community actors.

The research also underlines that digital health literacy tools are most effective when built as components of larger public health systems, not as standalone initiatives. For example, Setiawati et al. (2025) advocate for value-based approaches, where oral health is framed within the larger context of family wellbeing and religious teachings, an angle shown to resonate more deeply with community members.

Finally, the consistent theme across these findings is that digital interventions should not only inform but also inspire. Tools that are emotionally resonant, socially relevant, and behaviorally actionable consistently outperform those that are purely informative. Indonesian scholars have provided ample evidence that when digital health communication is grounded in local knowledge systems and cultural contexts, it becomes not only more effective but also more empowering.

8.2 Strategic insights for stakeholders

Policymakers, educators, healthcare professionals, and technology developers each have distinct yet interconnected roles in advancing digital oral health literacy. One critical insight is the need for synchronized policy support to expand infrastructure and

accessibility for rural and underserved areas. As highlighted by Abdi et al. (2022), educational campaigns in South Sulawesi often underperform due to inconsistent follow-up and lack of integrated support systems between Puskesmas and schools.

Strategically, collaboration with educators is indispensable. Aldilawati et al. (2021) found that incorporating dental literacy into school curricula through media such as flipcharts and animated videos not only enhances student engagement but also encourages teachers to be frontline advocates. Similarly, Anwar (2020) emphasized that training schoolteachers as peer educators in remote island regions results in sustained behavioral impact beyond project timelines.

For community health workers and dental cadres, training must extend beyond clinical skills to include digital facilitation capabilities. Juliawati and colleagues (2025) demonstrated that digital modules accessed via YouTube not only enhanced cadre retention of oral health topics but also improved their confidence in conducting community outreach. Capacity building thus needs to involve digital literacy training tailored to the user's educational background and daily routines.

Technology developers and app designers must also recognize their role in simplifying interfaces and contextualizing content. Tools like *Puzdent for Kids* (Aldilawati et al., 2023) and the *Quizztooth Games* platform (Aldilawati et al., 2026) illustrate how gamification aligned with school curricula can reinforce knowledge acquisition. These tools succeed because they blend behavioral psychology with practical delivery formats.

Insights from digital implementation in vulnerable populations stress the need for layered communication strategies.

Yanti et al. (2017) showed that deaf children benefitted significantly from cartoon-based videos when accompanied by visual cues and direct demonstrations. A one-size-fits-all approach is not sufficient; multichannel and multimodal design is critical for inclusivity. Public health institutions must also formalize evaluation

systems that go beyond knowledge tests to include behavioral metrics.

As evidenced by Ilmianti et al. (2020), periodic assessment using OHIS scores among schoolchildren offers measurable benchmarks to assess the effectiveness of digital health education. Similarly, Anwar et al. (2020) applied CPITN evaluations in coastal zones to track periodontal awareness progress among primary school students.

Health promotion stakeholders need to embrace co-creation with users. The work of Wening et al. (2025) in developing media strategies for elderly populations with hypertension showcases how tailored content (when created with input from target users) achieves higher satisfaction and compliance. This approach also fosters local ownership, a key predictor of program sustainability.

Religious and cultural institutions, often overlooked in health planning, offer strategic entry points for oral health messaging. Setiawati et al. (2025) and Abdi et al. (2023) successfully leveraged local wisdom and religious frameworks to contextualize preventive behaviors, making oral health a moral and social responsibility rather than a technical issue.

Furthermore, financial and logistical support must be provided for community-based monitoring systems. This includes equipping local health centers with tools to track behavioral change, training staff in digital data entry, and ensuring data privacy, a concern raised by Juliawati et al. (2022) in institutional studies of Jakarta dental services.

Ultimately, the success of digital oral health literacy programs hinges on how well stakeholders align in vision, share responsibilities, and maintain continuous dialogue. The research and interventions led by Indonesian scholars present a compelling model for stakeholder collaboration grounded in cultural competence, empirical evaluation, and strategic foresight.

8.3 Sustainable models for digital oral health literacy programs

Creating sustainable models for digital oral health literacy requires an ecosystem approach, one that balances content quality, infrastructure, human capacity, and institutional alignment. One model gaining traction is the hybrid education system that combines digital tools with direct interpersonal reinforcement. Wening et al. (2025) employed such an approach by providing printed guides alongside online health videos for elderly participants, ensuring continuity despite digital literacy gaps.

Sustainability also relies on iterative design. The *Quizztooth Games* application (Aldilawati et al., 2026) has shown long-term potential by updating content based on user feedback and performance analytics. This agile methodology allows programs to remain relevant, especially in fast-evolving technology environments and shifting public health priorities.

Longitudinal monitoring is another critical component. Abdi et al. (2024) advocated for periodic follow-ups through WhatsApp-based reporting among online motorcycle drivers, enabling sustained health behavior without extensive infrastructure costs. Such strategies are cost-effective and align with behavioral economics principles that reinforce habits through subtle, repeated nudges.

Digital interventions must also be embedded within school systems and policy frameworks. Anwar (2020) proposed that interventions which receive formal recognition by the Ministry of Education and are linked to school health records have higher adoption rates. This ensures that oral health promotion is not project-based but institutionalized.

Family engagement strengthens sustainability, particularly when behavioral change is needed in children. Rahmayani et al. (2024) illustrated how motivational interviewing with pregnant mothers, reinforced via digital follow-up, enhanced compliance with oral hygiene routines during and after pregnancy. Such models benefit from multi-stakeholder engagement such midwives, dental professionals, and family members working in synergy.

Digital content localization is also pivotal. Alamsyah and Natassa (2017) showed that the effectiveness of cartoon-based materials was significantly enhanced when voiceovers and scripts used familiar language and metaphors. Similarly, Panna et al. (2022) found that children's receptivity to oral health animation increased when the setting resembled their daily environment.

Digital equity is another pillar of sustainability. Access gaps in rural Indonesia persist, as shown in the research by Ilmianti et al. (2020). Providing offline capabilities, mobile-first design, and low-bandwidth formats can help reach areas where internet connectivity is unreliable. Programs must also account for affordability and technical support.

Engagement models should be multigenerational. Programs that involve both parents and children, such as those by Yanti et al. (2017), demonstrate that shared learning leads to mutual reinforcement. Elderly-targeted modules, such as the community tutorials highlighted by Wening et al. (2025), extend literacy across life stages, embedding preventive behaviors more holistically.

Metrics of sustainability must also include psychosocial dimensions. Juliawati et al. (2022) showed that institutional trust and safety perception mediate digital program effectiveness. By incorporating user feedback mechanisms, programs can monitor not only knowledge and behavior but also emotional readiness and digital confidence.

Lastly, public-private partnerships are essential to scale and sustain innovation. National universities, NGOs, and health tech startups should collaborate in creating open-source toolkits, certified training programs, and shared evaluation dashboards. This model has already been initiated through joint projects between universities and local health offices, as referenced in several community health education articles across Makassar, Surabaya, and Bali.

Summary
This chapter brings together the most important lessons from all the previous sections of the book. It explains what has been learned about how digital tools help people understand and improve their dental health. We highlight which groups need the most support, how programs can be made to last longer, and what professionals, teachers, families, and government agencies can do to help. The key message is that we need teamwork, smart design, and care for people's needs to create digital tools that actually work and are used in real life.

Key Messages

1. *Sustainable digital literacy programs require cultural sensitivity, personalized delivery, and long-term monitoring.*
2. *Multi-sector partnerships between educators, health workers, and policymakers amplify program effectiveness and reach.*
3. *Equity and inclusion must be prioritized in the design and implementation of digital health tools to avoid reinforcing existing disparities.*

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Authorship Curriculum Vitae

Curriculum Vitae:

DRG. SARI ALDILAWATI, M.KES.,FICD

A. Current Appointment

- Lecturer, Department of Community and Preventive Dentistry, Faculty of Dentistry, Universitas Muslim Indonesia (UMI), Makassar, Indonesia.

B. Academic Qualifications

- Master of Public Health (M.Kes / MPH), Faculty of Public Health, Majoring in Health Promotion & Behavioural Science, Universitas Respati Indonesia
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dentistry, Moestopo University, Jakarta, Indonesia

C. Professional Summary

Drg. Sari Aldilawati is a dental public health educator and researcher who specialises in digital health education platforms and community outreach in Makassar. She has conducted applied research on teledentistry applications and dental preventive behaviour in school-aged children, and she actively contributes to community counseling programmes across age groups.

D. Research Interests

- Teledentistry application adoption and public health education (e.g. Dentalk app)
- School-based oral health promotion via digital and visual media
- Community counseling strategies for pregnant women, children, and elderly
- Impact assessment of digital interventions on oral hygiene behaviour

E. Selected Publications & Projects

- *Aldilawati S., Abdi M.J., Putri A.M. The Influence of Virtual Education on Adolescent Knowledge Regarding Dental Technicians' Risks. Interdental Jurnal Kedokteran Gigi, 20(2):235–241, Aug 2024*

- *Aldilawati S., Pertiwisari A., Amir A.M.I. Implementation of the Mobile-Based Dentalk Application as Media for Increasing Public Knowledge of Teledentistry. Interdental Jurnal Kedokteran Gigi, 19(2):2023.*
- *Aldilawati S., Selviani Y., Ardiningrum S. Puzdent for Kids as Oral Health Education Media for Third-Grade SDN Mangkura 2 Makassar. Jurnal Ilmiah & Teknologi Kedokteran Gigi (JITEKGI), Vol 19(2):61–65, 2023*
- *Aldilawati S., Wijaya M.F., Hasanuddin N.R. Effort to Improve Oral Health Knowledge in Community Using FlipChart and Video in Desa Lanna. Idea Pengabdian Masyarakat, Vol 1(3):36–40, 2022*

F. Research Metrics
SINTA ID: 6801145; Overall Score: 213; 3-Year Score: 161

G. Teaching & Academic Service
- Lecturer and facilitator for community-based oral health courses and workshops
- Supervisor for student-led outreach and applied public health practice
- Contributor to curriculum modules integrating teledentistry tools in undergraduate programmes

H. Skills & Expertise
Digital health literacy, mobile app adoption evaluation, teledentistry interface and behavioural analysis, visual media for health education, community presentation and counseling, pre-/post-test quasi-experimental design, SPSS/Excel for data analysis.

I. Contact & Profiles
- **Institutional Email:** sari.aldilawati@umi.ac.id

Profile Summary
A dynamic dental public health practitioner and educator, Drg. Sari Aldilawati advances digitally mediated health education and community outreach. Her empirical work in teledentistry adoption and oral health literacy among schoolchildren and vulnerable populations demonstrates a forward-looking approach to preventive dentistry in Indonesia.

Curriculum Vitae:

DRG.MUHAMMAD JAYADI ABDI,M.KES

A. Current Appointment

- Lecturer, Department of Community and Preventive Dentistry, Faculty of Dentistry, Universitas Muslim Indonesia (UMI), Makassar, Indonesia.

B. Academic Qualifications

- Master of Public Health (M.Kes / MPH), Faculty of Public Health, Majoring in Health Promotion & Behavioural Science, Universitas Respati Indonesia
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dentistry, Moestopo University, Jakarta, Indonesia

C. Professional Summary

Drg. Muhammad Jayadi Abdi is a public health dentist and academic at UMI whose work centers on community oral health education, geriatric dental care, and maternal oral wellness. He is involved in translating behavioural health communications into applied community programming, particularly among expectant mothers and school populations.

D. Research Interests

- Maternal–child oral health and periodontal awareness among pregnant women
- Prevention-focused behavioural health strategies for antenatal dental care
- Educational video interventions and communication tools for community dental promotion
- Geriatric oral health care and risk prevention in ageing populations

E. Selected Publications & Projects

- *Abdi MJ, Sari Aldilawati, Muhammad Fajrin Wijaya.Improving Periodontal Awareness and Behavior Among Pregnant Women Through Education and CPITN Index Screening in Paddinging Village, Takalar District. Idea Pengabdian Masyarakat 3(1):6–9, 2023 (first author)*
- *Abdi MJ, Sari Aldilawati, Muhammad Fajrin Wijaya.Enhancing Periodontal Awareness with Education and CPITN Index Use in Pregnant Women. Idea Health Journal 2(3):130–133, 2022 (first author)*

- *Inventor and co-author in multiple public health and communication media (2024–2025), including:*

1. *Educational video: "Preventing Tooth Decay in Children"*
2. *Video on Pregnant Women's Dental-care During Pregnancy*
3. *Moringa leaf-based mouthwash formula for mandibular healing in rodents (2023)*
4. *Sanitation guidebook for public facilities*
5. *Health communication strategies for dental promotion*

F. Research Metrics

- **SINTA ID:** 6801156; Overall Score: 233; 3-Year Score: 137
- **Google Scholar / Scopus:** 12 citations in Google Scholar; G-index: 2

G. Teaching & Academic Service

- Mentor and facilitator for student-led community service programs within Faculty of Dentistry, UMI
- Contributor to community outreach curriculum integrating CPITN screenings and educational video delivery at village-level health posts

H. Skills & Expertise

Community dental education, maternal periodontal screening (CPITN), development of multimedia health communication tools, geriatric dentistry awareness, field-based oral health promotion.

I. Contact & Profiles

- **Institutional email:** jayadiabdi29@umi.ac.id

Profile Summary

A dedicated public health dentist specializing in community-driven oral care, particularly maternal and geriatric populations. With inventorship in digital health education resources and empirical outreach programs, Drg. Abdi demonstrates an applied approach to preventive dentistry and behavioural health empowerment.

Curriculum Vitae:

PROF. DR. DRG. AYUB IRMADANI ANWAR, M.MED.ED., FISDPH., FISPD

A. Current Appointment

Head of the Dentistry Education Study Program (S1), Faculty of Dentistry, Hasanuddin University, Makassar, South Sulawesi, Indonesia

B. Academic Qualifications

- Doctoral Program, Faculty of Public Health, Universitas Hasanuddin, Makassar Indonesia.
- Master of Medical Education (M.Med.Ed) Faculty of Medicine, Universitas Gadjah Mada, Yogyakarta
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dentistry, Universitas Hasanuddin, Makassar, Indonesia

C. Professional Summary

Prof. Ayub I. Anwar is a dental public health educator and researcher specializing in educational innovation, oral health promotion, and community-based service evaluations. As program head at Hasanuddin University, he leads curriculum development and international research collaborations, including extrusion of biomaterial toothpaste from fish bone by-products.

D. Research Interests

- Evaluation of dental service quality and patient satisfaction
- Anxiety and behavioural determinants of dental care in youth and vulnerable populations
- Knowledge, attitudes, and behavioral change for oral hygiene
- Biomaterials and sustainable oral health innovations (e.g. fish-bone hydroxyapatite toothpaste)

E. Selected Publications & Projects

- *Anwar AI., Ruslin M., Marlina E., Hasanuddin H.Physicochemical analysis and application of sardinella fimbriata-derived hydroxyapatite in toothpaste formulations.* ***BMC Oral Health*** *25(1):195, 2025 (first author)*

- *Anwar AI., et al. Measuring quality dental services based on satisfaction and loyalty. Journal of Dental Research & Clinics, October 2024*
- *Anwar AI., Sarifuddin Panna S., Katili DI., et al. Analysis of brushing phobia among high school students in Palopo during COVID-19. August 2024, cross-sectional survey study in Indonesia*
- *Anwar AI., et al. Differences in early childhood caries related to parental stress and socioeconomic status in Makassar during the pandemic. Pesquisa Brasileira em Odontopediatria e Clínica Integrada, November 2022*
- *Anwar AI., Zulkifli A. Impact of demonstration-based education on tooth brushing knowledge in 10–12-year-olds. Enfermería Clínica conference proceeding, March 2020*

F. SKILLS AND EXPERTISE

- Dental public health survey methodologies, patient satisfaction analytics
- Biostatistical analysis and cross-sectional design in oral health
- Curriculum and pedagogy development in medical/dental education
- Biomaterials research and sustainability innovation in dentistry
- Community engagement and behavioural health promotion

G. COMMUNITY ENGAGEMENT & PROJECTS

- Leadership in international collaborative research on sustainable toothpaste formulations using local fish bone hydroxyapatite (Unhas-UMT partnership, 2021–2025)
- Community surveys measuring dental anxiety, service satisfaction, and trust across Makassar populations, focusing on vulnerable groups during the COVID-19 era

H. TEACHING & ACADEMIC SERVICE

- Oversight of undergraduate dental education as Head of Study Program (KPS)
- Curriculum development and pedagogical design in dental professional training
- Workshop facilitator for teaching quality, service-learning integration, and international collaboration initiatives
- Mentor and thesis advisor for graduate and postgraduate students in dental education

I. CONTACT & INSTITUTIONAL PROFILE

- **Email:** ayubanwar.dds@gmail.com

Profile Summary
A pioneering academic and dental educator blending pedagogical innovation with applied public health. Prof. Ayub Irmadani Anwar oversees dentistry education and leads evidence-based research in service quality, behavioural health analytics, and affordable biomaterial innovation. His output demonstrates synergy between scholarly excellence, community impact, and global research collaboration.

Curriculum Vitae :

DRG. NI PUTU IDARYATI, M.KES

A. Current Appointment

- Lecturer, Department of Dental Public Health & Preventive Dentistry, Universitas Mahasaraswati Denpasar, Bali, Indonesia
- Member of IPKESGIMI (Ikatan Peminatan Kesehatan Gigi Masyarakat Indonesia / Indonesian Fellowship of Community Dental Health)

B. Academic Qualifications

- Master of Health Management (M.Kes), Universitas Udayana, Denpasar, Indonesia (2012)
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dentistry, Universitas Mahasaraswati Denpasar, Indonesia

C. Professional Summary

Drg. Ni Putu Idaryati is a community-oriented oral health practitioner and educator with a growing focus on evidence-based dental prevention and epidemiology. Her work primarily addresses behavioural interventions and health promotion in school and community settings.

D. Research Interests

- Preventive dentistry in school-aged populations
- Healthy behaviour promotion through local plants (like betel leaf)
- Access mapping to dental services in Bali
- Digital literacy and oral health communication

E. Selected Publications & Projects

- *Agung IGAA, Hartini IGA, Idaryati NP et al. Abdikank nutraceutical betel-leaf educative program for oral health at SDN 1 Ketewel, Gianyar. ABDIKAN Jurnal Pengabdian Masyarakat Bidang Sains dan Teknologi, 2(4):579–585, 2023*
- *Idaryati NP, Weta IW, Duarsa DP. Dental fear in children with autism spectrum disorders toward dental treatment. Journal of Dentistry studies, Universitas Trisakti, 2024 (pp. 213–221)*

F. Research Metrics

- **SINTA ID:** 6810157; Overall Score: 117; 3-Year Score: 98; h-index (Google Scholar via SINTA): 1

G. Community Engagement & Projects

- Betel-leaf nutrient/behavior intervention in primary schools of Gianyar (2023)
- Survey on dental fear in children with autism, aiming to design behaviour-sensitive outreach programs

H. Teaching & Academic Service

- Instructor for preventive dentistry and oral health education modules
- Community service mentor; active participant in institutional outreach projects

I. Skills & Expertise

- Epidemiological design (Riskesdas, STATA/SEM models), community nutrition education, public policy integration, project-level risk communication, stakeholder coordination in rural and school environments.

Profile Summary

A preventive dentistry professional deeply committed to inclusive outreach and behavioural health promotion in diverse educational contexts, especially for children with special needs.

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Curriculum Vitae:

DR. DRG. RIKA MAYASARI ALAMSYAH, M.KES., FICD

A. Current Appointment

- Lecturer, Department of Dental Public Health & Preventive Dentistry, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia

B. Academic Qualifications

- Doctor of Philosophy in Medicine (DR. / Ph.D) , Faculty of Medicine, Universitas Padjadjaran (2025)
- Master of Public Health (M.Kes / MPH), Faculty of Public Health, Universitas Sumatera Utara (2008)
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dentistry, Universitas Sumatera Utara (2004)

C. Professional Summary

Dr. Alamsyah is a dental public health expert focusing on health behavior and behavioural interventions. Active in teaching, community programmes, and research, she examines determinants of dental caries and oral-systemic health in vulnerable populations.

D. Research Interests and Expertise

- Health behavior
- Dental public health & primary health care integration
- Oral hygiene behaviour and empowerment strategies

E. Selected Publications & Projects

1. *Alamsyah, Rika Mayasari, et al. "Molecular docking study of ginger (Zingiber officinale) on Immunoglobulin A for smoking cessation." Pharmacia, no. 1, 12 Jan. 2024, pp. 1+. Gale Academic OneFile, link.gale.com/apps/doc/A779176108/AONE?u=anon~9dd00d23&sid=googleScholar&xid=f2b8a55d. Accessed 30 Jan. 2025.*
2. *Alamsyah RM, Satari MH, Pintauli S, Iskandar S (2023) Molecular docking analysis of ginger (Zingiber officinale) on dopamine compare to bupropion as smoking cessation. Pharmacia 70(4): 847–852. https://doi.org/10.3897/pharmacia.70.e111049*
3. *Alamsyah RM, Natassa SE. Difference in effectiveness of dental health education between braille and audio method towards the knowledge and oral*

health (OHIS) score among the blind children in karya murni foundation, tunanetra foundation and binjai special needs foundation. 10.2991/idcsu-17.2018.66

F. Research Metrics

- Scopus / Pure: h-index 5
- SINTA: Overall score 78

G. Community Engagement & Projects

- Permainan Monopogi dalam Meningkatkan Pengetahuan dan Perilaku Memelihara Kesehatan Gigi, 26 June 2020, record number : 000191889

H. Teaching & Academic Service

- Lecturer in dental public health, community outreach, and behavioural health
- Active contributor to national oral hygiene education programs and school-based initiatives

I. Contact & Profiles

- rika.mayasari@usu.ac.id

Profile Summary

Dr. drg. Rika Mayasari Alamsyah, drg., M.Kes., FICD is a lecturer at the Department of Community Dental Health, Faculty of Dentistry, Universitas Sumatera Utara, Medan. With advanced degrees in dentistry, public health, and a Ph.D. in Medicine, she specializes in dental public health with a focus on health behavior and behavioral interventions. Her research explores oral hygiene behavior, dental caries prevention, and the integration of primary health care for vulnerable populations. She is actively involved in national oral health education programs, school-based outreach, and innovative health promotion projects such as the Monopogi game. With an h-index of 5 and a growing body of publications in behavioral and biomedical dentistry, Dr. Alamsyah is recognized for her community engagement and interdisciplinary research approach.

Curriculum Vitae:

DR. DRG. MITA JULIAWATI, MARS

A. Current Appointment

- Vice Dean for Partnership Development and International Affairs, Faculty of Dentistry, Universitas Trisakti
- National Board Member, Indonesian Dental Association (PDGI)
- Executive Board Member, Association of Indonesian Academic Leaders in Dental Public Health (ARSGMPI)
- Lecturer, Department of Dental Public Health & Preventive Dentistry, Faculty of Dentistry, Universitas Trisakti, Jakarta, Indonesia

B. Academic Qualifications

- Doctoral Program (Ph.D), Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia
- Master of Hospital Administration (MARS), Faculty of Public Health, Universitas Indonesia, Jakarta, Indonesia (2020-2022)
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dentistry, Univesitas Airlangga, Surabaya, Indonesia

C. Professional Summary

Dr. Mita Juliawati is a leader in dental health administration and patient safety culture, balancing governance roles with scholarly inquiry into patient-safety adaptation in dental institutions. Her dual expertise spans education, internal quality systems, and academic instruction.

D. Research Interests

- Patient safety culture in dental institutions
- Organizational antecedents of employee engagement
- Hospital and primary care dental service quality systems
- Professional training and culture change in dentistry

E. Selected Publications & Projects

- *Sandy N, Juliawati M, Andayani LH. Patient satisfaction level concerning dental services during COVID-19 in Jakarta Puskesmas clinics. E-GiGi, 10(1):88–94, 2022*

- *Juliawati M et al. Cross-cultural adaptation and validation of Safety Attitude Questionnaire in dentistry in Indonesia. Journal of Patient Safety, Q1, 2022*

F. Teaching & Academic Service

- Courses taught: "Dental Service Management", "Patient Safety in Dentistry", "Organizational Behaviour in Health Services"
- Vice Dean overseeing academic quality, research integrity, and curriculum in Faculty of Dentistry

G. Contact & Profiles

- **Institutional Email:** mita@trisakti.ac.id

Profile Summary

A strategic academic leader combining dental health governance with patient-safety scholarship. Dr. Mita pioneers improved organizational culture and system performance within Indonesia's dental education and services.

Curriculum Vitae:

DR. GILANG RASUNA SABDHO WENING, DRG., M.KES, FISDPH., FISPD

A. Current Appointment

- **Lecturer**, Department of Dental Public Health, Faculty of Dentistry, Universitas Airlangga, Surabaya, Indonesia
- **General Secretary of IPKESGIMI** (Ikatan Peminatan Kesehatan Gigi Masyarakat Indonesia / Indonesian Fellowship of Community Dental Health)
- **Public Relations & Information Technology Team** of the Indonesian Dentists Association (PDGI), Surabaya, Indonesia

B. Academic Qualifications

- Professional Scientific Book Editor. Professional Certification Institute for Professional Writers and Editors; National Professional Certification Agency (BNSP). Jakarta, 2025
- Professional Scientific Book Writer. Professional Certification Institute for Professional Writers and Editors; National Professional Certification Agency (BNSP). Jakarta, 2025
- Professional Scientific Article Writer. Professional Certification Institute for Professional Writers and Editors; National Professional Certification Agency (BNSP). Jakarta, 2025
- Fellow of Indonesian Society of Preventive Dentistry (FISPD), **IPKESGIMI** (Ikatan Peminatan Kesehatan Gigi Masyarakat Indonesia / Indonesian Fellowship of Community Dental Health)**,** 2022
- Fellow of Indonesian Society of Dental Public Health (FISDPH), **IPKESGIMI** (Ikatan Peminatan Kesehatan Gigi Masyarakat Indonesia / Indonesian Fellowship of Community Dental Health)**,** 2022
- Professional Book Editor in Non-Fiction Book Writing. Professional Certification Institute for Professional Writers and Editors; National Professional Certification Agency (BNSP). Jakarta, 2021
- Professional Book Writer in Non-Fiction Book Writing. Professional Certification Institute for Professional Writers and Editors; National Professional Certification Agency (BNSP). Jakarta, 2021
- Doctoral in Dental Science (DR. / Ph.D) , Faculty of Dental Medicine, Universitas Airlangga (2018-2020)

- Master of Public Health (M.Kes / MPH), Faculty of Public Health, Majoring in Health Promotion & Behavioural Science, Universitas Airlangga (2013–2016)
- Doctor of Dental Surgery (drg. / DDS), Faculty of Dental Medicine, Universitas Airlangga (2004–2010)

C. Professional Summary
Dr. Wening is a dental public health expert focusing on oral health promotion, dental health literacy, epidemiology, and behavioural interventions. Active in teaching, community programmes, and research, he examines determinants of dental caries and oral-systemic health in vulnerable populations.

D. Research Interests
- Dental Health Literacy
- Dental public health & primary health care integration
- Oral hygiene behaviour and empowerment strategies
- Oral-systemic linkages: diabetes, hypertension, maternal-child health

E. Selected Publications & Projects
1. *Evaluating instrument for assessing maternal need of dental health programme among Javanese and Madurese tribe — J Int Oral Health* (Nov 2020)
2. *Improving School Health Literacy for Teachers-Students-Parents as Steps to Control COVID-19 Transmission — Indonesian J Dent Med* (Dec 2021)
3. *Action Taken in Managing Dental Health of Children due to Mother's Oral Health Literacy Level — Acta Medica Philippina* (Dec 2019)

F. Research Metrics
- Scopus / Pure: h-index 5 (based on 22 articles)
- SINTA: Overall score 766; 3-year score 110; h-index 5–7

G. Community Engagement & Projects
- Lead on Analysis of Maternal Dental and Oral Health Behavior and the Influence of Parental Nutritional Literacy on Children's Stunting & Jaw in Surabaya Research Initiatives

H. Teaching & Academic Service
- Lecturer in dental public health, community outreach, and behavioural health
- Active contributor to national oral hygiene education programs and school-based initiatives

I. Skills & Expertise

- Epidemiological survey design & analysis
- Empowerment-based oral health promotion
- Oral-systemic health interplay (diabetes, hypertension)
- Maternal & child dental health literacy strategies

J. Contact & Profiles

- **Institutional email:** gilang-r-s-w@fkg.unair.ac.id

Profile Summary

Dr. Gilang Rasuna Sabdho Wening, drg., M.Kes, is a faculty member at Universitas Airlangga's Department of Community Dental Health. With an MPH in health promotion and behavioural science and Doctoral expertise in Dental Science, especially in majoring of Dental Health Literacy, he leads research and educational efforts addressing oral health literacy, empowerment, and oral-systemic linkages, particularly among mothers, school children, and patients with diabetes or hypertension. His work has generated actionable insights and contributed to national dental public policy.

DIGITAL LITERACY IN ORAL HEALTH BEHAVIOR CHANGE

The digital age offers both opportunities and challenges for influencing health behaviors, especially in oral health. This book explores digital literacy's crucial role in empowering individuals to adopt and maintain positive oral health practices. It examines how a digitally informed public can critically evaluate online health information, engage with credible resources, and actively participate in their own oral health management.

Traditional oral health education often falls short in our digital world. This book refers that fostering strong digital literacy is now fundamental for effective oral health behavior change. It explores how proficiency in navigating digital platforms, understanding data privacy, and discerning reliable sources enables informed decisions about oral hygiene, diet, and professional care.

This book also highlights the potential of personalized digital interventions, gamification, and social media for sustained behavioral shifts. By integrating digital literacy into public health strategies, stakeholders can unlock new avenues for promoting proactive self-care and improving global oral health outcomes.

IPKESGIMI PUBLISHING

SAGA

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ISBN 978-634-7188-74-8

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