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How to integrate and leverage digital health modalities for health promotion in early childhood education: Opportunities to improve intervention access and engagement

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Author Contributions

C.L.K. was a part of conceptualization, wrote the initial first draft, revised the draft, and reviewed the final document; L.F. was a part of conceptualization, revised the draft, and reviewed the final document; K.G. was a part of conceptualization, revised the draft, and reviewed the final document; R.E.L. was a part of conceptualization, revised the draft, and reviewed the final document; P.T. was a part of conceptualization, revised the draft, and reviewed the final document; T.v.A. was a part of conceptualization, revised the draft, created the figure, and reviewed the final document; and A.T. was a part of conceptualization, revised the draft, and reviewed the final document.

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Human Rights

This article does not contain any studies with human participants performed by any of the authors.

Informed Consent

This study does not involve human participants and informed consent was therefore not required.

Welfare of Animals

This article does not contain any studies with animals performed by any of the authors.

Abstract

Early childhood education (ECE) settings are important for the development of children's healthy eating and physical activity behaviors. Efforts to disseminate and implement health behavior promotion strategies in ECE settings have seldom optimized digital health, a missed opportunity highlighted by the COVID-19 pandemic. In this commentary, we discuss previous efforts to shift ECE-based health behavior programs to digital health modalities, notable opportunities for digital health in these settings, and a multilevel perspective to support future efforts. We propose future directions in digital health literacy, reaching various ECE settings, implementation science, and community partnerships to expand the use of digital interventions.

Lay Summary

The childcare industry was not able to adopt digital technologies as rapidly as schools and other settings during the pandemic, which widened an existing digital gap in this setting. The time is now to learn from effective school-based electronically delivered interventions and new advances (i.e. mobile health) to prepare childcare settings for a digital future and support their efforts to help children grow up healthy.

Keywords

eHealth; mHealth; young children

Introduction

Young children (0–5 years of age) spend most of their day in early childhood education (ECE) settings, making these environments key for promoting healthy eating, physical activity (PA), and family engagement [1, 2]. Over the past decade there has been an increase in interventions to promote healthy behaviors in this setting [3]. In parallel, there has been an increase in the use of digital health modalities across various settings to promote healthy behaviors and prevent chronic diseases [4]. Digital health modalities include eHealth, an overarching term for information and communication technology, such as the internet [5], to improve health and care, and mobile health (mHealth), which focuses on health practices supported by mobile applications and other wireless devices [6]. Although there has been an increase in digital health modalities, it is unclear how they are being applied within the ECE setting and what research and education/training opportunities are available.

Over the past two decades, health behavior research has increased use of digital health modalities to reach and engage participants, particularly within intervention research. For example, the number of articles reporting use of digital health modalities for addressing PA, sedentary behavior, and diet increased from 9 articles in 2000 to 363 articles in 2016 [4]. However, among 11 712 articles, only half focused on children and adolescents (47%, ages 5–18 years) [4]. Furthermore, despite the increase in studies using digital health modalities, a recent scoping review in children found that many of these digital interventions did not extend to the ECE setting and instead focused primarily on school-based interventions [7]. It is possible that the digital health modalities being used within the school setting

(e.g. interactive online lessons with individualized feedback, connection with health coach, and online forums [8], and implemented during class time [9]) to improve child fruit and vegetable intake [10], and PA, could translate to the ECE setting [11]. Similarly, the interventions that focus on the child directly or on teachers in order to indirectly impact child behaviors through changes to teachers knowledge and beliefs related to nutrition could also be applied to the ECE setting [12]. While it is important to apply the lessons learned from the school to ECE, ECE settings have a different structure than schools, and young children (e.g. ages 2–4 years) are at different developmental stages and have lower screen time recommendations (≤ 1 h/day of high-quality screen time) compared to older children (ages 5–18 years, ≤ 2 h/day) [13, 14]. Although effective evidence-based curricula for healthy eating and PA are available for ECE settings [15–20], these efforts have just recently begun to translate their content to digital health modalities for delivery [16, 18]. Therefore, understanding how digital health modalities can be used in ECE settings to improve child health behavior is important.

With the onset of the COVID-19 pandemic, digital health modalities became a critical vehicle to communicate, interact, and deliver interventions. The ECE setting, like many others, was impacted by travel restrictions, social distancing, and other infectious disease control measures, which in turn modified procedures and settings to deliver and ensure healthy meals and PA [21]. Unlike school-age children who used digital health modalities to deliver educational content, many ECE settings needed to operate in-person putting both providers and families at risk for infection. Accordingly, many ECE providers, as essential workers, reported moderate-to-high stress during the COVID-19 pandemic [22].

There were different adaptations to daily operations involving digital health modalities in the ECE setting. For example, the federal systems available to provide healthy food to ECE settings, such as the Child and Adult Food Program (CACFP), adapted by expanding food waivers during the pandemic [23]. One major barrier to implementation was switching the paperwork to a virtual system and translating in-person training to virtual format [24, 25]. However, another federal program, the Supplemental Nutrition Program for Women, Infant, and Children (WIC), switched similar components to a virtual format and reported high user satisfaction [26, 27]. Taken together, the COVID-19 pandemic demonstrated that the ECE setting is a distinct community that may benefit from bolstering its digital health integration.

With the end of the COVID-19 pandemic and the quickly changing digital landscape, we are at a unique point in time to learn from effective school-based eHealth interventions and new advances (i.e. mHealth) to prepare ECE settings for a digital future. Therefore, the goal of this commentary is to (i) highlight past efforts to move ECE health promotion curricula and strategies to digital health modalities, (ii) discuss special considerations of integrating digital health components into ECE settings, and (iii) describe implications for practice and future research. With this information, we hope that ECE researchers, practitioners, and staff will consider ways to integrate effective practices from school and ECE-based eHealth interventions and apply innovative multilevel approaches to use digital technology to support ECE teacher and child health.

Past: Efforts to adapt ECE-focused healthy eating and PA promotion strategies to digital health modalities

In its simplest form, digital health can be used to deliver otherwise in-person or print-based materials/resources (e.g. via website) to ECE providers, but it can also involve more sophisticated technologies such as mHealth, wearable technology, tailored interventions, chatbot support for websites, or video conferencing for technical assistance. A few evidence-based curricula for ECE providers related to diet and PA promotion have been adapted to the digital health format. For example, the Go Nutrition and PA Self-Assessment in Child Care (GoNAPSACC) program [15, 16], the Study of Health and Activity in Preschool Environments (SHAPES) [17, 18], and the Sustainability via Active Garden Education (SAGE) program [19, 20], are all either in process or already translated to web-based platforms. The GoNAPSACC program includes self-assessments, action plans, and resources for ECE teachers related to diet and nutrition, PA, and outdoor play. Although the program is effective at improving nutrition and PA environments [15], it is unclear if the translation to a webbased platform will have the same effect. A type-3 hybrid effectiveness-implementation trial is currently underway [16]. The SHAPES program, is an adaptive intervention to facilitate child PA through promoting changes in ECE facility PA policies, teacher education, and upgrading environments [17]. Recently, this curriculum was successfully translated into an online professional development program, including online modules, resources, and interactive web-based community forum [18], and the authors await their state-wide results. Finally, SAGE was developed using a community-engaged process over the course of a decade to link national health promotion and ECE guidelines to evidence-based practice using a garden-based curriculum [19, 20]. SAGE has well-developed online materials to support a customizable 12-unit curriculum with active games, songs, and science experiments in English and Spanish. The results of translating this program to a web-based platform are forthcoming. All three curriculums were originally examined in primarily (>50%) individuals of racial and ethnic minority background [15, 17, 20]. Moreover, SAGE utilized a community advisory board of individuals with diverse background to further create such curriculums [19]. It is unclear if the digital iterations of GoNAPSACC [16] and SHAPES [18] will continue to reach serve diverse individuals as they are currently underway.

Despite the development and dissemination of these innovative, evidence-based programs, this research has only scratched the surface of possibility in the digital domain [28–30]. The relatively modest translation of interventions to digital health modalities may be due to slow adoption, but could also speak to the long process of creating innovative curricula and resources, testing efficacy and effectiveness, and creating long-standing community relationships for dissemination. Go NAPSACC, SHAPES, and SAGE were programs that included many years of support and refinement before translation to web-based platforms.

Current: Opportunities in digital health modalities in ECE settings

Advances in digital technology provide the opportunity to reach ECE providers while also providing feedback to children and parents. Indeed, leveraging existing mHealth structure that focuses on provider and/or child behavior change, along with wearable technology to provide real-time feedback. Still, ECE providers face additional challenges compared to

the general population, and there are nuances of using screens and wearable devices with young children. Here, we detail the challenges and nuances to facilitate integration of these components to inform future digital interventions in ECE settings.

mHealth to reach and engage family childcare home providers in health behavior promotion—

Family childcare homes (FCCH) are underrepresented in healthy eating and PA research, as most efforts have occurred in center-based settings [31, 32]. FCCHs face unique challenges, as they are often run by a single provider or small staff, which must serve as educator, business owner, and perform all other functions of care (e.g. prepare/serve food and navigate CACFP). These additional duties and hours worked make it difficult to attend in-person professional development trainings [33]. Moreover, FCCH often care for a wide age range of children in a smaller home rather than center-based setting. FCCH providers often reside in communities that are low-income and may be more isolated from the social support of other providers. Digital health modalities, such as mHealth, may be an opportunity to deliver education and training to these providers using common devices like a tablet or cellphone. Translating CACFP training efforts to these modalities may also increase uptake of the program, which is associated with healthier child dietary quality in these settings [34]. FCCH providers often have health risk factors themselves, including having obesity/overweight, low fruit and vegetable intake, and lack of PA [35]. Anticipating this unique problem [36], the Keys to Healthy Child Care Homes created business practice and provider wellness modules delivered by a health coach via in-person meetings, workshops, and phone calls, which improved both child and FCCH provider's diet quality, and FCCH provider record keeping [37]. There is a great opportunity to use digital health modalities to reach more FCCH providers and deliver continuing education to support both provider and child health behaviors, but more research is needed to test these modalities in this setting.

Integrating wearable technology into PA promotion—Commercially available, wrist-worn activity trackers are becoming more common [38] and can serve as physical reminders of the importance of PA and provide PA data using low-cost technology with little participant burden. The increased availability and acceptability have spurred national PA surveillance efforts to move PA measurement devices from the waist to the wrist [39], including the US National Health and Examination Survey, which includes 3–5 year olds [40]. These national efforts complement international efforts to support potential creation of device-based PA guidelines [41, 42]. Like past PA efforts, the majority of ECE-based PA interventions included children wearing waist-worn research-grade devices for PA measurement and training teachers to lead PA or bringing in expert coaches [43, 44], which may not be effective amongst variable child device-wear compliance, teacher's numerous competing priorities, and high teacher turnover [44]. Wearable technology addresses these challenges by providing ECE teachers with information about their own and/or children's PA in real-time while reducing teacher workload and retraining for new teachers and improving device-wear compliance [39]. Moreover, these devices could allow parents and teachers to share access to the child's PA levels through a shared digital platform. Such devices may promote shared accountability in multiple settings and provide an opportunity for communication between parents and teachers. Early pilot studies

demonstrate effectiveness on improving child PA; these studies utilized a wrist-worn device (FitBit Flex) to monitor child PA [45, 46], and paired this device with an ECE teacher-based mHealth application to provide PA promotion strategies [45, 46]. Future iterations may consider more recent and cost-effective devices, context of behaviors, and streamlining teacher or parent platform usage for long-term adoption.

In summary, these opportunities illustrate the creative use of digital technology to support ECE provider and child health behavior while in the ECE setting. Integration of both or even one of these components may help advance current practices and support long-term behavior change.

Discussion

Research in ECE settings and digital health modalities have both advanced significantly in recent decades. Merging these efforts is now recommended for optimal benefit, with the renewed focus on digital health during the COVID-19 pandemic providing a perfect opportunity for this integration. In this section, a group of researchers among Healthy Eating Research and the Nutrition and Obesity Policy Research and Evaluation Network Early Childhood Work Group (<https://nopren.ucsf.edu/early-childhood>) provide implications for practice and future research based on these past efforts and special considerations. Here we document the multilevel considerations to expand the use of digital health in ECE settings that inform these implications, which include (i) macro-level: supporting digital capacity, (ii) micro-level: understanding of ECE setting capacity, and (iii) individual level: evaluating digital literacy and integrating families. We provide an overview of challenges and opportunities in Fig. 1.

First, macro-level factors such as access to reliable broadband internet and lack of assistance for ECE settings may impede local efforts to implement evidence-based practice digital health strategies. These factors impact technology adoption much like social determinants of health (SDOH) affect health behaviors. SDOH includes housing, education, employment, access to nutritious food, PA opportunities, and health literacy [47, 48]. Digital determinants, such as broadband access and up-to-date technology, also play a role [49]. For instance, lower-income individuals may reside in areas with poor internet access, limiting their engagement with digital health programs aimed at improving child health behaviors. Additionally, attitudes toward screen time and digital health may vary based on SDOH, potentially affecting the effectiveness of initial interventions [50]. This is another stark contrast to schools, who serve a larger number of children, and use digital technology in the classroom more frequently. Policy and infrastructure is needed to create equitable use and access to broadband, through improving bandwidth, and data volume support to all regions, and within a facility [49]. Even with policy and infrastructure support, private–public partnerships may further support adoption of materials and systems within ECE facilities. One way to support ECE providers, for example, is to provide reimbursement for purchasing up-to-date devices from local agencies. This reimbursement model may be applied to states and localities to enhance the use of digital health modalities to facilitate nutrition or PA training.

While there is a need to improve the macro-level context, it needs to be done in tandem with changes to the micro-level. Accordingly, numerous systematic reviews have highlighted contextual factors such as lack of resources (e.g. financial, infrastructure), leadership support, and staff turnover as barriers for ECE providers to enact healthy eating and PA strategies [51–53]. These contextual factors may impact consistent facility-level application of child screen time and digital health, including policies on child screen time and use of digital technology. As for local policies, ECE policies to limit screen time in older children (2–5 years of age) and disallow screen time in toddlers and infants are becoming more common as part of health promotion efforts [54]. It is unclear if these policies extend to using digital health modalities to deliver health promotion curricula to providers, or active play opportunities for children [55–57], or even wearable devices. For example, after a state policy on child screen time was enacted, some ECE providers in center-based care limited use of cellphones by teachers as cellphones were interpreted to be part of the state screen time policy [58]. These center-based care results are in contrast to screen time application in FCCH, who are usually governed by less restrictive child screen time policies [59]. Indeed, higher child screen time in FCCH was associated with greater child PA [55, 56], which may be due to teacher's using videos to facilitate music and additional activity. In context, these screen time moments may allow for additional child PA while the FCCH provider prepares lunch and potentially relieving staff burden [33]. Despite lack of consistency, screen time policies are important to parents; parents are more likely to know their ECE setting's screen time policy than PA policy [60]. As demonstrated in focus groups, parent's appreciated minimal child screen time in ECE settings, and if used, it is only for educational purposes [60]. Clarification of screen time guidance, for providers and parents, and tailored support to integrate digital health modalities into may help ECE efforts to adopt digital interventions, while ensuring parent concerns are met. In addition, a prepandemic survey of Australian ECE centers ($n = 390$) found the most frequently reported barrier to adoption of digital health interventions were changes in team interactions and existing daily routines (e.g. meal service or menu planning) to use the digitally delivered content [61]. Additional technical assistance will likely be needed to address these challenges and other trainings to digital modalities [24, 25].

Outside of macro- and micro-level factors, individual-level characteristics impact adoption of digital health innovations, including available time and digital literacy. In the SAGE studies [19, 20], many teachers anecdotally reported little time to review lessons in advance [62, 63]. A short-term solution to help jumpstart their use of the technology and curriculum may be brief (30–90 s) online videos providing an overview of the content and logistics. Digital literacy, a digital determinant of health itself, refers to the skills and abilities required to use, navigate, and understand digital devices [64]. The digital literacy of ECE providers is unknown, but we may speculate there is a spectrum of digital literacy based on the variable ages, experiences, and preferences of providers [57]. One area of future research is to assess the digital literacy within ECE providers, determine availability and accessibility of digital platforms and devices, and identify specific gaps in knowledge related to digital technology. These efforts may inform tailored digital training for providers and translate into a larger solution of providing digital literacy training, resources, and support as part of ECE providers continuing education.

ECE-based digital health interventions that include both providers and parents (e.g. shared mHealth app) may promote adoption of long-term change via consistent messaging. mHealth applications focusing on parents of preschoolers are effective at improving child health behaviors [65–67], but long-term behavior change is limited [68] and could likely be improved with integration of ECE providers. The preliminary successes of mHealth applications with parents of young children are promising, but these programs will need to be updated for the ECE provider role and interaction with children. MHealth applications such as ClassTag and bright-wheel that ECE providers use to interact with parents could be utilized to promote healthy eating and PA among children in both settings.

Implications for research and practice

To address these challenges across macro, micro, and individual levels, we propose the following research priorities below. We also highlight opportunities and challenges associated with these priorities to provide a balanced perspective.

1. **Assess the prevalence and determinants of digital health literacy in ECE providers.** Results from these estimates may help guide digital literacy training, which can be supported with public programs.
 - a. **Opportunities:** Identifies areas to improve digital literacy and design tailored programming.
 - b. **Challenges:** Does not address overarching SDOH, or other digital determinants of health that may also impact reach, implementation, or adoption of such digital programs.
2. **Translate existing evidence-based programs into digital health modalities to reach more providers.** Translating, then assessing the effectiveness of existing evidence-based programs may be the first step to using existing evidence-based programs to improve ECE settings and support provider's own health behaviors and practices.
 - a. **Opportunities:** Moves evidence-based curriculum more rapidly into settings, rather than beginning the lengthy research process of testing a new program.
 - b. **Challenges:** Indirectly precludes creation of other effective programs for ECE settings and does not account that existing evidence-based programs may still need tailoring to different areas and populations. Further evidence comparing digital vs. nondigital programs on provider's and child health behaviors is still required.
3. **Integrate implementation science methods and modalities for digital intervention and training programs in ECE settings.** Understanding organizational factors influencing use and uptake of programs in different kinds of ECE settings is needed for larger dissemination.

- a. **Opportunities:** Identifying such factors may help success within the program, potentially improving long-term implementation and maintenance.
 - b. **Challenges:** These factors may differ across ECE setting (e.g. center-based, FCCH), within settings themselves, and across classrooms. An individualized approach, like the approach of GoNAPSACC [15] and SHAPES [17], may be most appropriate but difficult to generalize.
4. **Continue and expand ECE community-research partnerships.** As modalities and training preferences evolve, it is critical for ECE providers and researchers to continue work together to develop, adopt, implement, maintain, and disseminate evidence-based programs for optimal nutrition and PA.
- a. **Opportunities:** This practice may strengthen existing community-research partnerships, allow for meaningful creation of content and programming, and allow input from the end user as programs are created.
 - b. **Challenges:** There is limited existing infrastructure (e.g. research grants or dedicated time) to support continued collaboration with the ECE communities. Staff turnover is a significant concern at the director level too, which may indirectly and directly impact continued collaboration.

Over the past decade, efforts in the ECE settings and digital health modalities have increasingly converged to enhance child health. By learning from previous eHealth initiatives, addressing the specific nuances of screen time for young children, and adopting a multilevel approach, we can advance these efforts further. Now is the crucial moment for the ECE field to fully embrace digital health and collaborate to promote the well-being of young children and their caregivers.

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Implications

Practice:

Efforts to disseminate and implement health behavior promotion strategies in early childhood education (ECE) settings should prioritize digital health as this has been a missed opportunity highlighted by the COVID-19 pandemic.

Policy:

Policymakers should support multilevel efforts to foster academic-community partnerships, improve ECE settings' digital capabilities, and facilitate dissemination of existing evidence-based programs to diverse ECE settings (e.g. family childcare homes).

Research:

Future research should incorporate digital health literacy and dissemination and implementation practices to expand use and understand effectiveness and reach of existing evidence-based digital interventions.

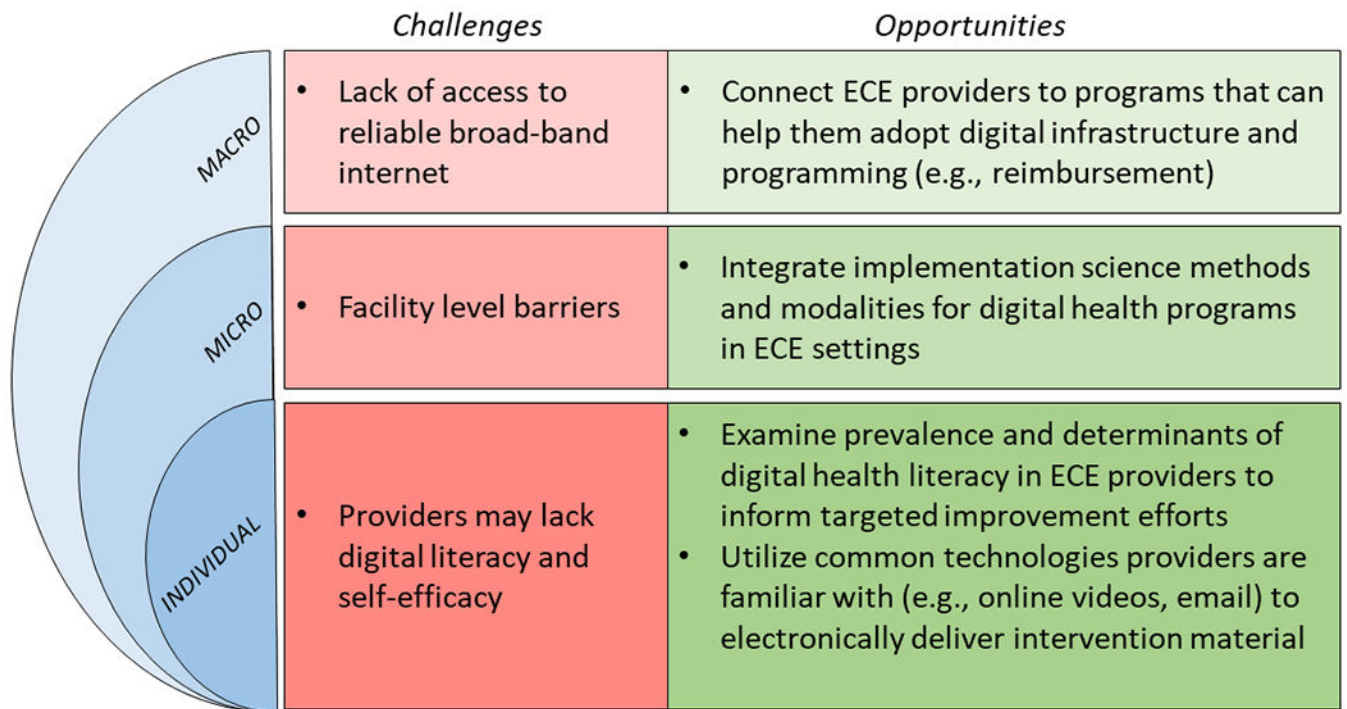


Figure 1. Multilevel considerations to expanding use of digital health in ECE settings. ECE, early childhood education