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Brief Communications

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ABSTRACT

Despite smartphone ownership becoming ubiquitous, it is unclear whether and where disparities persist in experience using health apps. In 2 diverse samples of adults with type 2 diabetes collected 2017–2018 and 2020–2021, we examined adjusted disparities in smartphone ownership and health app use by age, gender, race, education, annual household income, health insurance status, health literacy, and hemoglobin A1c. In the earlier sample ($N = 422$), 87% owned a smartphone and 49% of those had ever used a health app. Participants with lower income or limited health literacy had $\geq 50\%$ lower odds of owning a smartphone. Comparatively, in the later sample ($N = 330$), almost all participants (98%) owned a smartphone and 70% of those had ever used a health app; however, disparities in health app use closely mirrored disparities in smartphone ownership from 2017 to 2018. Our findings suggest device ownership is necessary but insufficient for assuming people will use apps to support their health.

Key words: mobile phone, smartphone, applications, health disparities, type 2 diabetes, digital divide

LAY SUMMARY

Mobile health (mHealth) programs provide a convenient and effective approach to supporting health for people with chronic conditions like diabetes. We examined individual characteristics associated with smartphone ownership and health app use in 2 separate samples of adults with type 2 diabetes, collected a few years apart (2017–2018 and 2020–2021). In the earlier sample ($N = 422$), 87% owned a smartphone and among those, 49% had used a health app. People with low income and people with limited health literacy had 61% and 50% lower odds of owning a smartphone, respectively. Comparatively, in the later sample ($N = 330$), almost all participants (98%) owned a smartphone and 70% of those had used a health app. However, older people (≥ 60 years old), people with a high school degree or less education, and people with limited health literacy had 78%, 58%, and 66% lower odds (respectively) of having used a health app. Our findings support thoughtful consideration of how and to whom apps are presented in both research and clinical contexts to avoid worsening health disparities. Smartphone access is not the only prerequisite for use of mHealth tools.

INTRODUCTION

Smartphone applications (apps) designed to support type 2 diabetes (T2D) self-management have proliferated in recent years and continue to develop at a rapid pace.[1–3] Although specific features and components vary widely, most apps share basic functions that include providing education, alerts and reminders, self-monitoring, and/or communication for self-management support.[4,5] Evidence is accumulating that apps can improve self-care and glycemic management.[6–8] Moreover, research has advanced on identifying the functions that contribute to an app's effectiveness.[9] However, understanding who has access to and experience with using apps has implications for who can ultimately benefit.[10]

The term "digital divide" has been used to describe the gap in Internet and mobile phone access across different sociodemographic groups. Recent reporting suggests disparities in access that have persisted for decades are narrowing.[11–13] For example, smartphone ownership among US adults is becoming more common across different economic, educational, and racial/ethnic backgrounds.[14] From this closing of the digital divide, the conclusion often follows that more people are using health apps; however, it is necessary to critically examine usage by individuals' characteristics to understand whether and where disparities persist.

Previous research has examined sociodemographic factors associated with smartphone and app use, but there are notable limitations. First, the data in most studies were collected at least 5 years ago[15–18]; with technology access rapidly evolving, recent data are necessary to understand current trends. Furthermore, while many studies have examined bivariate associations between individuals' characteristics and mobile phone use, fewer have adjusted for key confounders.[15,17,19] Lastly, limited research has specifically examined smartphone and health app use among people with T2D, for whom racial/ethnic minorities and persons with lower socioeconomic status (SES) disproportionately experience worse health outcomes and stand to benefit considerably from this technology.[20]

Objective

We examined predictors of smartphone ownership and health app use in 2 separate samples of adults with T2D. Data for one sample were collected between May 2017 and December 2018 and the other between April 2020 and October 2021. We examined predictors of mobile phone use, including sociodemographic and clinical characteristics in each sample separately.

MATERIALS AND METHODS

Study participants

We used participant-reported data collected as part of 2 randomized controlled trials (RCTs) evaluating effects of mobile phone-delivered interventions for diabetes self-management.[21,22] Both interventions used only basic mobile phone technology (ie, phone calls and texts) and participants were required to own a mobile phone and be able to text after training with a research assistant. The 2017–2018 sample was recruited from community health centers and academic medical center primary care clinics in and around Nashville, TN. The 2020–2021 sample was recruited from the academic medical center primary care clinics only. For both studies, potential participants were identified with electronic health record (EHR) data, mailed a letter describing the study, and then patients who did not opt-out were contacted by phone calls from study staff to assess interest and complete eligibility screening. For both samples, eligible participants were English-speaking adults diagnosed with T2D, prescribed at least one daily T2D medication, and had a recent elevated hemoglobin A1c (HbA1c) value or the absence of an HbA1c value in the EHR. Interested and eligible participants completed consent, a survey, and HbA1c test. Surveys were completed in-person or by phone with a research assistant, online with an emailed link, or via a mailed paper copy, per participant preference. The Vanderbilt University IRB approved all study procedures for both RCTs.

Measures

All participants self-reported sociodemographics including age, gender, race, ethnicity, years of education, income, and insurance status. We assessed health literacy with the Brief Health Literacy Screen (BHLS)[23–25] which asks: "How often do you have someone help you read hospital or clinic materials?" and "How often do you have problems learning about your medical condition because of difficulty understanding written information?" scored $1 =$ never to $5 =$ always, and "How confident are you filling out medical forms by yourself?" scored $1 =$ not at all to $5 =$ extremely. The first 2 items are reverse coded. In both the 2017–2018 and 2020–2021 sample, the BHLS had acceptable internal consistency ($\alpha = .71$ and $\alpha = .66$, respectively). HbA1c was collected via venipuncture or point-of-care by patients' clinic or using a mail-in HbA1c kit provided and analyzed by CoreMedica Laboratories (Lee's Summit, MO). Participants were asked whether they owned a smartphone: ("Some cell phones are called 'smartphones' because they let you access the Internet and have a touchscreen. For example, an iPhone is a smartphone. Is your cell phone a smartphone?"). If participants responded yes, they were asked whether they had ever accessed a health app ("Have you ever used a health 'app'? It is a program that you can download on your phone that may help you track or monitor things such as your diet, exercise, or sleep."). Response options for both items included Yes, No, Don't know, and Refused.

Statistical analyses

All analyses were performed using SPSS Version 24. For either sample, we only analyzed data among participants who responded either yes or no to the smartphone question. Accordingly, 10 and 5 participants were excluded in the 2017–2018 and 2020–2021 sample, respectively. We calculated summary statistics using mean and standard deviation or percent. Then, for meaningful contrasts, we dichotomized characteristics to examine group differences in mobile phone use variables. For age, we compared participants who were <60 and ≥ 60, based on prior literature examining disparities in technology adoption[26–28] and to achieve a near equal distribution of participants across categories. For race, we compared participants who were Non-Hispanic Black and Non-Hispanic White. For income, we compared participants who had an annual household income of $<\$35\,000$ and $\geq\$35\,000$ based on prior research.[14] For insurance, we compared participants who were underinsured (public insurance only or uninsured) with those who were privately insured. For health literacy, we compared participants reporting adequate (all BHLS items with response >3) and limited health literacy (any BHLS item with response ≤ 3) based on prior research.[29,30] For descriptive purposes, we compared the samples on characteristics of interest using Chi-square tests of independence for categorical variables and Mann–Whitney U tests for continuous variables. All subsequent analyses used categorical variables.

We used multivariate logistic regression models to examine adjusted associations between participants' characteristics and mobile phone use. We confirmed our data met assumptions for logistic regression. Participants reporting a race other than Non-Hispanic Black or Non-Hispanic White or reporting as Hispanic were included in multivariate models, but coefficients are not reported because there were too few participants in those groups to draw conclusions. For any variable with ≥10 missing values, we included an indicator for missingness in the multivariate models. We used this approach because missingness on these variables (income and HbA1c) was likely not at random, and this approach ensures all participants are included in contrasts of interest for which they have data.[31]

RESULTS

Participant characteristics for both samples are detailed in Table 1. In the 2017–2018 sample, average age was 56.3 ± 9.6 years, about half (55%) were female, and about 40% were Non-Hispanic Black. In the 2020–2021 sample, average age was 56.8 ± 11.0 years, about half (48%) were female, and about one-third (28%) were Non-Hispanic Black. Characteristics across samples were similar with respect to age, gender, and HbA1c; however, the 2017–2018 sample had more participants who were Non-Hispanic Black and who had limited health literacy and lower SES (ie, education, income, health insurance status) (Table 1).

2017–2018 sample

When recruiting the 2017–2018 sample, only 3% (37/1244) of patients screened reported not owning a phone with texting capability. Most enrolled participants (87%; 365/422) said they owned a smartphone, and among those, 49% (180/365) said they had used a health app. One participant said they did not know if they had used a health app and was excluded from the model predicting health app use. Adjusted logistic regression results for the associations between participant characteristics and mobile phone use are reported in Table 2. Participants who had <$35K in household income or had limited health literacy, had 61% and 50% lower odds of owning a smartphone, respectively. Among those who owned a smartphone, participants with ≤12 years of education or <$35K in household income, had 49% and 42% lower odds of having used a health app, respectively.

Table 1. Participant characteristics

Characteristic	2017–2018 (N = 422)[a]	2020–2021 (N = 330)[b]	*P*-value[c]
Age, years	56.31 ± 9.55	56.79 ± 11.01	.48
<60	249 (59)	189 (57)	.66
≥60	173 (41)	141 (43)	
Gender[d]			
Female	231 (55)	155 (48)	.06
Male	191 (45)	171 (52)	
Race/Ethnicity			
Non-Hispanic White	198 (47)	204 (62)	<.001
Non-Hispanic Black	170 (40)	79 (24)	
Non-Hispanic Other race	25 (6)	22 (7)	
Hispanic	26 (7)	23 (7)	
Education, years	14.06 ± 3.10	15.31 ± 2.91	<.001
≤12	173 (41)	65 (20)	<.001
>12	243 (58)	259 (80)	
Annual household income, USD			
<$35 000	233 (60)	58 (18)	<.001
≥$35 000	154 (40)	261 (82)	
Health insurance			
Underinsured	207 (49)	64 (19)	<.001
Privately insured	212 (51)	257 (79)	
Health literacy (BHLS)[e]	13.04 ± 2.55	13.58 ± 1.89	.05
Limited	154 (36)	71 (22)	<.001
Adequate	268 (64)	259 (79)	
Hemoglobin A1c, %	8.63 ± 2.04	8.72 ± 1.69	.13
<8.5	214 (52)	161 (51)	.45
≥8.5	200 (48)	152 (49)	

[a]In the 2017–2018 sample, 3 participants did not provide race, 6 did not provide education, 35 did not provide income, 3 did not provide insurance, and 8 did not provide hemoglobin A1c data.

[b]In the 2020–2021 sample, 2 participants did not provide race, 2 participants did not provide gender, 6 participants did not provide education, 11 did not provide income, 9 did not provide insurance, and 17 did not provide hemoglobin A1c data.

[c]Mann–Whitney *U* tests used for continuous variables; Chi-square tests of independence used for categorical variables.

[d]Response options for gender included male, female, and prefer to self-describe. Two participants in the 2020–2021 sample indicated that they preferred to self-describe their gender; one wrote in their gender as non-binary and one wrote in their gender as Zim.

[e]Possible scores for the composite BHLS score range from 3 to 15 with higher scores indicating higher health literacy; participants with a score ≤3 on any item are categorized as having limited health literacy.

USD, United States Dollars; BHLS, Brief Health Literacy Screen.

Table 2. Participant characteristics independently associated with mobile phone use

	2017–2018		2020–2021[a]
	Owns smartphone (N = 422) AOR (95% CI)	Uses health app (N = 364) AOR (95% CI)	Uses health app (N = 321) AOR (95% CI)
≥60 years of age	0.600 (0.318, 1.131)	0.737 (0.457, 1.189)	**0.222 (0.120, 0.411)**
Gender (male)	0.925 (0.507, 1.685)	0.861 (0.548, 1.353)	0.795 (0.450, 1.406)
Non-Hispanic Black	1.002 (0.527, 1.905)	0.711 (0.438, 1.154)	0.899 (0.451, 1.791)
≤12 years of education	0.562 (0.302, 1.045)	**0.513 (0.319, 0.824)**	**0.424 (0.209, 0.858)**
<$35K annual income	**0.390 (0.175, 0.870)**	**0.578 (0.343, 0.976)**	0.722 (0.316, 1.648)
Underinsured	0.988 (0.511, 1.913)	0.777 (0.472, 1.279)	0.804 (0.394, 1.642)
Limited health literacy	**0.497 (0.274, 0.900)**	0.810 (0.508, 1.290)	**0.343 (0.181, 0.650)**
Hemoglobin A1c ≥8.5%	0.859 (0.466, 1.583)	0.731 (0.465, 1.153)	0.978 (0.542, 1.766)

Bold text indicates *P*-value ≤.05.

AOR, adjusted odds ratio; CI, confidence interval.

[a]We did not examine correlates of smartphone ownership in the 2020–2021 sample because almost all participants (98%) reporting owning a smartphone.

2020–2021 sample

When recruiting the 2020–2021 sample, only 1% (7/519) of patients screened reported not owning a phone with texting capability. Almost all (98%; 323/330) enrolled participants owned a smartphone and among those, 70% (225/323) said they had used a health app. Two participants said they did not know if they had used a health app and were excluded from the model predicting health app use. Because almost all participants reported owning a smartphone, we did not examine correlates of smartphone ownership. Among those who owned a smartphone, participants who were ≥60 years of age, had ≤12 years of education, or had limited health literacy had 78%, 58%, and 66% lower odds (respectively) of having used a health app (Table 2).

DISCUSSION

Mobile health (mHealth) programs are ideally suited for improving diabetes management in that they provide convenient and timely support to people in their daily lives, where self-management occurs. Apps are one form of mHealth which, while quickly growing in availability, may not be accessible to all people with T2D. We compared smartphone ownership and health app use across 2 samples of adults with T2D collected several years apart. In the 2017–2018 sample, we found independent disparities in smartphone ownership by participants' income and health literacy. Among participants who did own a smartphone (87%), those with less education or lower income had lower adjusted odds of having used a health app. Comparatively, in the 2020–2021 sample, almost all participants (98%) owned a smartphone; however, disparities in health app use closely mirrored the disparities in smartphone ownership from 2017 to 2018 (Figure 1).

The ubiquity in smartphone ownership, both nationally and in our most recent sample of adults with T2D, is encouraging news for mHealth researchers. However, our findings are consistent with other recent studies that show emerging evidence of a new type of digital inequality based on experience with using digital tools.[16,32] Despite owning a smartphone and having access to technology, individuals may be hesitant with using all its functions. Apps, in particular, require technical skills (eg, setting up an account, logging in, navigating the interface) which can be overwhelming for those who are less tech-savvy.[33] In addition, individuals from underserved pop-

ulations have expressed concerns over the privacy and security risks with transmitting their personal health information via digital devices.[16,34] Trust is another factor which may limit adoption of health apps considering historical mistrust of healthcare systems among minoritized groups.[33,34] Taken together, these findings suggest that device ownership or device provision is necessary but insufficient for assuming people will use apps to support their health.[35,36]

Several key design considerations can help ensure all individuals equally benefit from mHealth interventions. First, despite their capabilities, an app may not be the best choice for the intervention; rather, a phone could be leveraged for the functionality used by the most individuals.[37] Text messaging is ubiquitous across racial and socioeconomic groups and continues to be the most widely adopted and least expensive function on mobile phones.[38] In either RCT for the samples used in this study, less than 4% of all patients screened reported not owning a mobile phone with texting capability. Second, if an app is the necessary modality, user-centered and participatory design is key to ensure the tool is acceptable, appropriate, and meets end-users' needs.[34] Third, including technical support as part of the intervention is imperative.[34] As one example, Liu et al[39] improved mHealth adoption among low-income patients by having community health workers teach participants about the app at study enrollment. To provide this type of support more efficiently, a digital healthcare literacy screener could help identify those who require assistance, whether as part of a research study or in a healthcare setting.[40]

Our study has strengths and limitations with respect to generalizability. Data were collected from a single region in Middle Tennessee among adults with T2D and therefore our findings may not generalize to other regions and patient populations. While both samples were diverse, the 2020–2021 sample was more affluent than the 2017–2018 sample. However, the direction of this bias would have reduced our ability to detect disparities in the 2020–2021 sample and yet we identified similar disparities as in the 2017–2018 sample. Because participants in both samples signed up for an RCT examining diabetes self-management support delivered via mobile phones, they may not represent all adults with diabetes, but they do represent individuals interested in this type of support who would in theory be inclined to use health apps. We also acknowledge that dichotomizing our predictor variables may have reduced the power to detect associations between patient characteristics and mobile
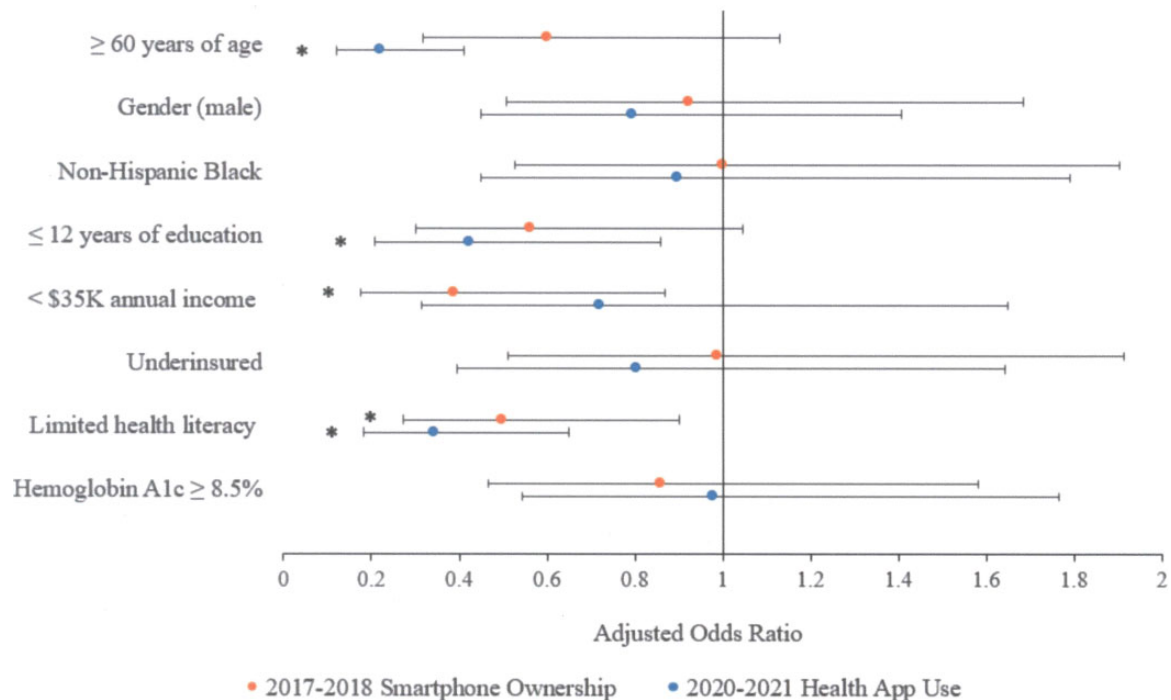
Figure 1. Participant characteristics associated with smartphone ownership in the 2017–2018 sample and health app use in the 2020–2021 sample. An asterisk indicates *P*-value ≤.05.

phone use; however, the categories were selected based on existing literature identifying meaningful disparities in technology use. Finally, our study focused on examining differences in mobile phone use and did not assess reasons why participants were more or less likely to use health apps. More mixed-methods work in this area is necessary to inform mHealth deployment and design.

CONCLUSION

Given the increase in access to mobile technologies recently seen in low-income and minoritized racial and ethnic groups, mHealth has been championed as a strategy for improving population health and reducing health disparities. Our results and those of similar studies, support thoughtful consideration of how and to whom mHealth apps are presented. Without concerted efforts to address disparities in app use, there is potential to exacerbate existing disparities in health.

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AUTHOR CONTRIBUTIONS

Authorship contributions according to the CRediT: LAN: Conceptualization, Formal Analysis, Writing—Original Draft, Writing—Review & Editing. SPA: Formal Analysis, Writing—Review & Editing. LML: Data Curation, Formal Analysis, Writing—Review & Editing. LSM: Conceptualization, Methodology, Investigation, Supervision, Funding Acquisition, Writing—Review & Editing.

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CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILAVILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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