

Rationale, Design, and Performance of mHealth in the RURAL Cohort Study

Apurv Soni

`apurv.soni@umassmed.edu`

University of Massachusetts Chan Medical School

Jesse Hsu

University of Pennsylvania

Vik Kheterpal

CareEvolution (United States)

Eric Schramm

CareEvolution (United States)

Matheus Montenegro

University of Massachusetts Chan Medical School

Ziyue Wang

University of Massachusetts Chan Medical School

Edwin Van De Heuvel

Boston University

Shawn Ballard

University of Pennsylvania

Megan Evans

University of Alabama at Birmingham

Binoy Shah

University of Massachusetts Chan Medical School

Corby K. Martin

Pennington Biomedical Research Center

Stephanie D. Boone

University of Louisville

Stephanie Broyles

Pennington Biomedical Research Center

Shelicia Morton-Ford

University of Alabama at Birmingham

Ervin Fox

University of Mississippi Medical Center

Lindsay Pool

National Heart Lung and Blood Institute

Suzanne E Judd

University of Alabama at Birmingham

Ramachandran S. Vasan

The University of Texas at San Antonio

David D. McManus

University of Massachusetts Chan Medical School

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Abstract

Rural communities in the Southeastern United States bear a high burden of cardiovascular disease yet remain underrepresented in longitudinal research. The Risk Underlying Rural Areas Longitudinal Heart and Lung Study incorporated a mobile health (mHealth) core to extend follow-up for 6 months after baseline study visits using a smartphone application, remote coordinator support, and a wrist-worn wearable device. Among 3,563 participants enrolled in the mHealth component across the first eight counties, 47.0% were Black; 3,119 (87.5%) contributed wearable data; 3,122 (87.6%) completed at least one survey; and 3,027 (85.0%) contributed both. Survey completion exceeded 80% across follow-up waves, with > 90% completion at 24 hours, 7 days, and 1 month, and > 70% at 6 months. Interrupted time-series analyses showed more favorable completion trajectories in later protocol periods, particularly for 24-hour and 6-month surveys. These findings support the feasibility of extending cohort follow-up in rural populations using a hybrid mHealth model.

Introduction

Cardiovascular disease (CVD) mortality has declined in the U.S. in recent decades, but rural communities—especially in the Southeastern United States—continue to experience disproportionately high CVD death rates.^{1,2} These rural populations face elevated cardiometabolic risk yet have been historically underrepresented in research, due in part to relative geographic isolation and limited access to study centers. Social determinants of health (SDOH) such as poverty, limited healthcare access, and educational disparities further exacerbate rural health inequities, underscoring the need for innovative approaches to engage these communities to understand and reduce CVD burdens.^{3–5} Traditional epidemiological cohorts have relied on periodic in-person visits, which are logistically difficult for rural residents, and recent electronic cohorts (often comprised of tech-savvy volunteers) may not generalize to rural, older, or lower-income populations.^{6,7}

Mobile health (mHealth) technologies offer a promising strategy to bridge research gaps in hard-to-reach (‘last mile problem’) populations by enabling remote data collection and participant engagement. Digital health platforms can deliver surveys and collect sensor data from participants in their homes, potentially overcoming barriers related to travel and access.^{8,9} However, the adoption of mHealth in rural research settings remains low and has not been well characterized.¹⁰ To date, few large cohort studies have successfully enrolled rural participants using mobile health technologies, and little is known about long-term adherence to wearable devices and app-based surveys in these rural communities.^{11,12} This gap in current knowledge calls for evidence on how mHealth can be implemented to improve research participation among rural people.

The Risk Underlying Rural Areas Longitudinal (RURAL) Heart and Lung Study was designed to address these challenges through a hybrid approach combining a mobile examination unit (MEU) for baseline in-person visits with an mHealth extension for remote follow-up. In this report, we present the rationale, overall methods, and preliminary performance results of RURAL’s mHealth component, which augments the in-person study examination with 24-hour, 7-day, and 1-, 3-, and 6-month follow-up waves that are delivered using a smartphone, a smartphone app, and a wearable device (worn on the wrist). This report highlights four key contributions of the mHealth core: **(1)** a multi-component core encompassing six essential functions, **(2)** an extended follow-up protocol that schedules longitudinal surveys up to 6 months post-baseline with high onboarding success, **(3)** an agile implementation that evolved through four iterative phases to optimize participant enrollment and retention, and **(4)** robust follow-up adherence outcomes resulting from continuous protocol refinement. We describe these features in detail and compare them with prior digital cohort approaches and traditional cohorts, underscoring the feasibility of a rural-focused mHealth extension when paired with structured participant support.

Results

Participant Characteristics and Follow-Up Completion

Between February 2021 and March 2025, a total of 5,627 participants from the first 8 of the 10 target counties were rostered by the RURAL team, 3,465 completed a visit in the RURAL MEU, and 3,563 enrolled in the mHealth program by downloading the RURAL mHealth app (Fig. 4). Across mHealth enrollees, 3,119 participants contributed any Fitbit data (87.5%) and 3,122 contributed any survey data (87.6%), with 3,027 contributing both (85.0%) (Table 1).

Table 1
Sociodemographic Characteristics

Characteristic	MEU Visits (n = 3465)	mHealth Enrollment (n = 3563)	Fitbit Data Collected (n = 3119)	Survey Data Collected (n = 3122)	Fitbit & Survey Data Collected (n = 3027)
Sex					
Male	1128 (32.6%)	1158 (32.5%)	1008 (32.3%)	990 (31.7%)	963 (31.8%)
Female	2337 (67.4%)	2405 (67.5%)	2111 (67.7%)	2132 (68.3%)	2064 (68.2%)
Race (4 levels)					
White	1806 (52.1%)	1822 (51.1%)	1738 (55.7%)	1742 (55.8%)	1714 (56.6%)
Black or African American	1594 (46.0%)	1675 (47.0%)	1322 (42.4%)	1321 (42.3%)	1256 (41.5%)
Other	31 (0.9%)	31 (0.9%)	30 (1.0%)	29 (0.9%)	28 (0.9%)
Unknown or Not Reported	34 (1.0%)	35 (1.0%)	29 (0.9%)	30 (1.0%)	29 (1.0%)
Assignment type:					
Non-BYOD	524 (15.4%)	555 (15.7%)	402 (13.0%)	379 (12.3%)	362 (12.1%)
BYOD	2884 (84.6%)	2978 (84.3%)	2691 (87.0%)	2714 (87.7%)	2639 (87.9%)
Missing	57	30	26	29	26
Sampling county					
Dallas	510 (14.7%)	632 (17.7%)	461 (14.8%)	444 (14.2%)	435 (14.4%)
Wilcox	432 (12.5%)	428 (12.0%)	254 (8.1%)	265 (8.5%)	238 (7.9%)
Oktibbeha	758 (21.9%)	748 (21.0%)	678 (21.7%)	700 (22.4%)	658 (21.7%)
Panola	628 (18.1%)	628 (17.6%)	612 (19.6%)	607 (19.4%)	595 (19.7%)
Assumption	460 (13.3%)	453 (12.7%)	445 (14.3%)	442 (14.2%)	438 (14.5%)
Franklin	373 (10.8%)	373 (10.5%)	368 (11.8%)	368 (11.8%)	367 (12.1%)
Breathitt	76 (2.2%)	76 (2.1%)	76 (2.4%)	75 (2.4%)	75 (2.5%)
Perry	228 (6.6%)	225 (6.3%)	225 (7.2%)	221 (7.1%)	221 (7.3%)
MEU: Mobile examination unit. mHealth: mobile Health. BYOD: bring-your-own-device					

Among mHealth enrollees, 2,405 (67.5%) were women and 1,158 (32.5%) were men (Table 1). Race was reported as White for 1,822 (51.1%), Black or African American for 1,675 (47.0%), other for 31 (0.9%), and unknown or not reported for 35 (1.0%). Most participants used their own smartphones to participate (bring your own device, BYOD): 2,978 (84.3%) used BYOD, and 555 (15.7%) were assigned a study-provided smartphone; assignment type was missing for 30 participants.

As of this analysis, participant enrollment was not complete (Table 2). County or parish representation among mHealth enrollees included Oktibbeha County, MS (21.0%), Panola County, MS (17.6%), Dallas County, AL (17.7%), Wilcox County, AL (12.0%),

Assumption Parish, LA (12.7%), Franklin Parish, LA (10.5%), Perry County, KY (6.3%), and Breathitt County, KY (2.1%). Participant enrollment began in KY in December 2024; no participants were enrolled from Boyle County, KY, or Garrard County, KY, at the time of analysis.

Table 2

The predicted cumulative completion rates of surveys over time by periods of survey deployment are estimated by piecewise regression models; i.e., interrupted time series models with multiple (3) interruptions. The analysis is completed by the gls function of R's nlme package (version 3.1.167).

Parameter	24H		7D		1M		3M		6M	
Parameter	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
(Intercept)	0.98575 (0.97665, 0.99484)	< 0.01	1.00017 (-4.65816, 6.65849)	0.73	1.00028 (-4.92906, 6.92962)	0.74	1.00037 (-5.84661, 7.84735)	0.77	0.94201 (0.91644, 0.96759)	< 0.01
day	-0.00008 (-0.00011, -0.00004)	< 0.01	-0.00017 (-0.00037, 0.00003)	0.11	-0.00028 (-0.00049, -0.00007)	< 0.01	-0.00037 (-0.00061, -0.00013)	< 0.01	-0.00071 (-0.00082, -0.00060)	< 0.01
ind_period2	-0.00503 (-0.00843, -0.00162)	< 0.01	-0.00392 (-0.00761, -0.00023)	0.04	-0.00364 (-0.00750, 0.00023)	0.07	-0.00343 (-0.00789, 0.00104)	0.13	-0.00136 (-0.01098, 0.00827)	0.78
day_since_period2	0.00003 (-0.00004, 0.00010)	0.42	0.00004 (-0.00025, 0.00033)	0.78	0.00015 (-0.00015, 0.00046)	0.32	0.00023 (-0.00012, 0.00058)	0.20	0.00067 (0.00048, 0.00087)	< 0.01
ind_period3	-0.00035 (-0.00677, 0.00607)	0.91	-0.00066 (-0.00823, 0.00690)	0.86	-0.00043 (-0.00835, 0.00750)	0.92	-0.00028 (-0.00943, 0.00887)	0.95	-0.00070 (-0.01885, 0.01745)	0.94
day_since_period3	0.00015 (0.00004, 0.00027)	< 0.01	0.00027 (-0.00011, 0.00065)	0.16	0.00036 (-0.00004, 0.00076)	0.08	0.00041 (-0.00005, 0.00087)	0.08	0.00059 (0.00028, 0.00091)	< 0.01
ind_period4	-0.00025 (-0.00490, 0.00441)	0.92	-0.00005 (-0.00511, 0.00501)	0.98	-0.00002 (-0.00532, 0.00528)	0.99	0.00004 (-0.00608, 0.00615)	0.99	0.00224 (-0.01092, 0.01540)	0.74
day_since_period4	-0.00009 (-0.00018, 0.00000)	0.05	-0.00013 (-0.00047, 0.00021)	0.45	-0.00021 (-0.00057, 0.00015)	0.25	-0.00024 (-0.00066, 0.00017)	0.25	-0.00048 (-0.00073, -0.00023)	< 0.01

Overall, survey completion rates exceed 80% across all survey waves, indicating excellent adherence to the app-based questionnaires throughout the 6-month study follow-up. At 24 hours post-enrollment, > 90% of participants completed their initial survey. Completion remained high at 7 days (> 90%) and 1 month (> 90%). At 3 months, > 80% of participants completed the surveys. By the 6-month mark – the end of the follow-up – >70% of participants had completed the final surveys. We observed that waves 1 and 2 were associated with lower survey completion rates, with downtrends, while waves 3 and 4 were associated with continuous improvement in adherence (Fig. 5).

We observed a gradual decline over six months for collection of any physical activity (> 0 steps) and any sleep data (> 0 minutes); however, adherence was found to be significantly greater in the later period (4) of implementation and with a slower rate of attrition at a comparatively compared to earlier periods 1–3 (Fig. 6).

Discussion

In this report, we describe the rationale, design, and early performance of an mHealth core within the RURAL Heart and Lung Study. Among 3,563 participants enrolled in the mHealth component, 3,027 contributed both wearable and survey data (Table 2). The cohort includes substantial representation of Black participants (47.0%) across multiple rural counties in the Southeastern United States (Table 2). Interrupted time-series analyses suggested that survey completion dynamics varied across protocol periods, with evidence that later protocol refinements were associated with improved trends for selected survey waves, particularly the 24-hour and 6-month

surveys (Fig. 5; **Table 3**). These findings support the feasibility of extending follow-up in rural cohort studies using a smartphone app and a wrist-worn wearable when paired with structured onboarding and operational monitoring.

Survey adherence exceeded 80% at each of the four scheduled survey waves, with over 90% of participants completing the baseline questionnaire and the majority still responding to surveys administered at 3- and 6-months after enrollment. Likewise, wearable device usage was sustained over the 6-month follow-up: participants contributed step-count and sleep data on most days of the 180-day period (Fig. 6). These adherence metrics are higher than those reported in prior longitudinal cohort studies, including the electronic Framingham Heart Study.^{12,20} Other landmark cardiovascular cohort studies, such as the Jackson Heart Study (JHS), Multi-Ethnic Study of Atherosclerosis (MESA), and Coronary Artery Risk Development in Young Adults (CARDIA) studies, have been pivotal in understanding CVD risk factors, but they relied on periodic in-person clinic visits and telephone follow-ups, which pose logistical hurdles for rural populations.^{21–23} In contrast to our study, Framingham study investigators reported a 76% enrollment rate among FHS participants invited to enroll in the electronic Framingham substudy (eFHS), and only 59% of those who enrolled completed a 3-month follow-up survey.²⁴ In comparison, RURAL's mHealth uptake and 3-month survey completion rates were higher than those seen in the eFHS. Notably, enrollment and adherence rates appear significantly higher in both the RURAL and eFHS, which used in-person enrollment, as compared with studies that enrolled participants over the internet, including the Health-eHeart and MyHeart Counts studies (both studies report survey completion rates below 50%).^{23,25,26} The high engagement in RURAL approaches or surpasses the 60–80% follow-up rates seen in traditional cohorts over the years, despite those studies' intensive retention efforts. Moreover, RURAL is unique in focusing on rural communities, including predominantly African American and lower-income communities historically underrepresented in research, whereas Framingham and other studies mostly enrolled urban or suburban populations.²⁷ Our 6-month retention rate is especially notable given the anticipated barriers in rural settings. These comparisons suggest that a carefully designed mHealth program that reduces digital connectivity barriers can achieve cohort retention comparable to, or even better than, that of conventional methods, even in an underserved rural context.

Several practical takeaways emerged from the iterative implementation of the mHealth core. *First*, provisioning devices to participants who lacked them was essential to ensure inclusion of all RURAL participants. Approximately 15% of RURAL participants did not own a compatible smartphone or elected to use a study-provided smartphone. *Second*, onboarding and training of participants (whether via remote or in-person) proved critical to success. Each RURAL participant underwent a one-on-one “setup” to ensure that the study apps were installed properly, to configure the wrist-based wearable, and to answer questions. Study coordinators helped even those participants who lacked familiarity with these technologies to gain confidence with the study tools. This intensive upfront support led to nearly universal onboarding – in all but one county, over 90% of those completing a baseline RURAL exam joined the mHealth follow-up. In Wilcox County, pandemic-related staffing shortages and a decoupled remote mHealth onboarding process led to only 55.1% of participants collecting Fitbit and survey data. *Third*, a system of automated and telephone reminders, coupled with active monitoring of study participation using a study dashboard, was effective in rescuing a high proportion of participants and sustaining engagement throughout the 6-month study period. The study used a dose titration approach to study reminders. First, the study app issued an automated reminder notification for incomplete surveys. Next, an automated email reminder was sent and, if they did not respond, a call from an mHealth study coordinator was made. Our mHealth team was highly effective at bringing non-adherent participants back into the survey and wrist-based wearable adherence (40% of participants were successfully rescued). The RURAL mHealth reminder strategy was predicated on the fact that our team monitored incoming data from participants, and then used it to engage participants promptly to prevent prolonged periods of non-adherence. High survey completion rates and device adherence rates throughout the study attest to the success of this intensive monitoring and reengagement process. *Fourth*, agility in the face of technical and operational challenges was paramount. The mHealth protocol evolved through four phases, during which we confronted issues such as app outages and firmware bugs. Rather than static procedures, we continuously refined our engagement tactics based on interim data – for example, when early cohorts showed a dip in 3-month survey completion, we adjusted the scheduling and added mid-study encouragement messages, which contributed to improved adherence among participants enrolled later in the cohort (Fig. 5; **Table 3**). Finally, we recognize that *natural attrition* occurs despite best efforts. Even with strong overall metrics, participation tended to wane slightly by the 6-month mark for survey responses and wearable device adherence. This pattern is common in longitudinal studies. Our experience suggests that additional strategies, such as gamification, incentive refreshers, or providing participants with more interactive feedback on their data, could be used to sustain and increase engagement over longer follow-up periods.

This study has limitations. First, these results describe early operational performance from the first 8 of the 10 counties and may not generalize to subsequent recruitment waves or to other rural settings. Second, follow-up in this report was limited to six months, and

longer-term adherence was not assessed. Third, we focused on operational outcomes and did not evaluate clinical endpoints or associations between wearable-derived measures, survey responses, and health outcomes. Finally, sustaining a monitoring and support infrastructure requires resources, and future analyses should evaluate scalability and cost effectiveness.

In conclusion, the RURAL study's successful strategy for deploying and supporting a mobile health examination may serve as a blueprint for other contemporary studies involving rural or historically marginalized populations. Researchers aiming to supplement traditional follow-up visits with remote data collection may draw on our RURAL experience. The RURAL study shows that by providing participants with user-friendly technologies, robust onboarding and training, and prompt technical support during the follow-up period, researchers can achieve high 6-month follow-up rates across multiple waves. As mobile technology becomes increasingly ubiquitous and mHealth research methods advance, mobile examinations have the potential to enhance large-scale cohort research by making it more inclusive, efficient, and scalable.

Methods

The RURAL study is a collaboration between the National Heart, Lung, and Blood Institute (NHLBI) and 16 academic institutions in the US. Participants are recruited from 10 rural counties across four Southern states: Alabama, Kentucky, Louisiana, and Mississippi. Participants are included in this study if they are: (1) aged between 25 and 64 years; (2) current residents in one of the ten rural counties of recruitment for the past two years and plan to reside at the residence for the next two years; (3) not currently incarcerated or institutionalized; and (4) not currently in hospice care and no terminal illness with less than 6-month life expectancy. The study protocol was reviewed and approved by the Institutional Review Boards of all 16 institutions (Fig. 1).¹³

mHealth core and responsibilities: The University of Massachusetts Chan Medical School serves as the mHealth core for the RURAL study and oversees a list of responsibilities as outlined in Fig. 1: 1) design and maintenance of the RURAL mHealth smartphone app, 2) identification, procurement, and management of the inventory of smartwatches and smartphones for participants who do not have a smartphone and require a 'loaner' phone from the study to enable their six months-long participation, 3) remote coordinator support for onboarding of participants to the mHealth app and promoting adherence with study surveys and wearable device, 4) data curation and submission to the Study Data Coordinating Center, 5) performing periodic quality-assurance and quality-checks on mHealth data, and 6) supporting ancillary studies. The core enabling technology of the RURAL mHealth component is the RURAL mobile application, a customization of a smartphone application called MyDataHelps produced by CareEvolution, LLC (Ann Arbor, MI) (Fig. 2)¹⁴. The smartphone app features a user-friendly interface that lists all activities participants are requested to complete as part of their mHealth study. It also allows for dynamic scheduling and delivery of surveys, reminder notifications, and SMS or email messages. The application programming interfaces (API) also automatically and passively pull data from participants' wearable devices and push it to the centralized RURAL study database. The app also provides a summary of wearable device data to the participants.

Participant recruitment and mHealth onboarding: Potentially eligible participants were identified by one of two methods: 1) a response to a mailed invitation from randomly selected households identified through purchased mailing lists are identified based on census data from the respective counties or 2) by providing information on a volunteer interest portal among those who learned of the study through various community engagement, outreach, and recruitment methods (Fig. 3). Participants are subsequently screened for eligibility via a telehealth call by the trained research staff and 'rostered' for participation in the RURAL cohort study. Participants are then scheduled for a baseline visit in the MEU where they are consented, survey data on medical history, lifestyle, and health-related factors are collected, and a comprehensive examination evaluating heart and lung health is performed.^{15–17} The RURAL mHealth study design integrated mHealth study onboarding into the main MEU visit. However, during the COVID-19 pandemic, the mHealth research team modified its protocol to reduce the time spent by participants in the confined space of the MEU. During this first phase of the study, the research team conducted an asynchronous mHealth study onboarding of participants as they scheduled their MEU study examination (Phase 1: February 19, 2021 – February 14, 2022). This phase of the study was followed by a reduction in MEU staff, necessitating an asynchronous mHealth onboarding effort decoupled from MEU visit scheduling (Phase 2: February 15, 2022 – January 04, 2023). A third phase of the study reintegrated mHealth onboarding into the main MEU study visit (Phase 3: January 05, 2023 – June 05, 2023). The fourth phase of the study continued mHealth onboarding during the MEU and added new automated reminders and retention efforts (Phase 4: June 06, 2023, onwards to date).

Study wrist-based wearable device and study application: Participants in the mHealth portion of RURAL received a Fitbit Inspire 2 device on enrollment and were instructed on how to download the MyDataHelps and Fitbit apps. The decision to select the Fitbit

device was informed by community advisory boards representing each county assembled by the parent RURAL study, as well as technical advantages. The Fitbit wrist-based wearable was selected due to its: (1) compatibility with the Android software and Apple iOS, (2) common usage as a wrist-monitor capable of both heart rate and activity monitoring, (3) proven accuracy in step monitoring, and (4) a relatively long (5–7 days) battery life.^{18,19} For participants who received an mHealth ‘setup’ call, participants were prompted to log in to the Fitbit app on their smartphone and were instructed on the proper use of the Fitbit and the MyDataHelps smartphone application. Participants were allowed to use their own smartphone (classified as ‘Bring Your Own Device’ (BYOD) participants) or were provided a study smartphone (classified as non-BYOD participants). The decision to select phones and data plans was informed by community advisory boards convened by the parent RURAL study. The community advisory boards were also consulted on the original study application design, which helped with co-design and building trust between the research groups and the community representatives. Participants are offered optional televideo or live phone call visits by the mHealth core staff to help with the onboarding into the RURAL mHealth study and to provide technical support (for example, for device syncing). Participants could select a preference for the type and timing of automated study notifications.

Data collection

Table 1 lists the schedule of data collection events via the smartphone app. To avoid missing data in key mobile health survey data, the RURAL study coordinating center at the University of Texas Health Science Center at San Antonio gave each survey a priority ranking. Those surveys that were deemed to have the highest priority were issued at earlier timepoints. Surveys were issued at baseline and in waves, with progressively longer intervals between issuances. Participants are notified when surveys are available, when they are due within 48 hours, and when they are overdue. Participants receive a short message service (SMS) notification and an email notification if surveys are overdue by 48 hours. Participants receive a phone call from the mHealth core if the surveys are overdue by two weeks. Similarly, participants receive a notification if the mHealth core has not received wearable device data for more than 5 days and receive a call if the mHealth core has not received wearable device data for more than 2 weeks. There was a five-call limit per participant per survey, after which they were not contacted for the overdue survey. Standard operating procedures were developed to guide participants through re-syncing Fitbit. Data are transferred daily from the smartphone app to the RURAL data coordinating center at the University of Pennsylvania. Wearable device data are synchronized in near real time via the Fitbit API. During the first four years of the RURAL study, to verify that data was fully captured through the API, a redundant data capture pipeline was established using Fitabase (a data management platform for wearable device research) for the first 30 days of mHealth participation. After four years, MyDataHelps was used to capture all Fitbit data, following an analysis that showed concordance between Fitabase and MyDataHelps-derived data elements (data not shown). All data collected through the MyDataHelps app and wearable devices is securely encrypted both in transit and at rest, in compliance with HIPAA regulations. Participant data are available only to authorized study personnel for remote coordinator support, and access is via a password and multi-factor authentication platform.

Data analysis: Data analysis was performed using R (currently version 4.3.2; <https://cran.r-project.org/>). Descriptive analysis was conducted to report participant characteristics. Continuous data were reported using mean and standard deviation. Categorical data were reported using absolute counts and proportions. Cumulative survey completion over the four defined periods was visualized using line graphs. The predicted cumulative completion rates of surveys over time by periods of survey deployment were estimated using piecewise regression models; i.e., interrupted time series models with multiple interruptions. The analysis was completed by the gls function of R's nlme package (version 3.1.167).

Declarations

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Author Contribution

Conceptualization: AS, VK, RSV, DDM; Data curation: AS, JH, VK, ES, SB; Formal Analysis: AS, JH, MM, ZW, EVDH, BS, RSV, DDM; Funding acquisition: AS, JH, VK, ES, EVDH, SDB, SBr, EF, SEJ, RSV, DDM; Investigation: AS, JH, ZW, EVDH, ME, BS, CKM, SDB, SBr, SM, EF, LP, SEJ, RSV, DDM; Methodology: AS, JH, ZW, EVDH, BS, RSV, DDM; Project administration: AS, VK, ES, MM, SB, BS, SDB, SBr, SM, EF, LP, SEJ, RSV, DDM; Resources: AS, VK, ES, SB, LP, SEJ, RSV, DDM; Software: AS, VK, ES, DDM; Supervision: AS, MM, EVDH, ME, CKM, SDB, SBr, SM, EF, LP, SEJ, RSV, DDM; Validation: VK, ES, ZW, EVDH; Visualization: AS, JH, ZW, EVDH, SB, DDM; Writing – original draft: AS; Writing – review & editing: AS, JH, VK, ES, MM, ZW, EVDH, SB, ME, BS, CKM, SDB, SBr, SM, EF, LP, SEJ, RSV, DDM

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Data Availability

De-identified data from the RURAL Cohort Study will be shared in accordance with the study's External Data Sharing Policy and participant informed consent. Phenotypic data will be available through NHLBI BioLINCC and genomic data through dbGaP, subject to applicable approvals and data access requirements. Geospatial data are not publicly shared because of re-identification risk. Further information is available from the Coordinating Center (rural@bu.edu).

Ethical Declaration

This study was conducted in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the University of Alabama at Birmingham Institutional Review Board (UAB IRB; Federalwide Assurance #FWA00005960; protocol IRB-300005225), which serves as the IRB of record for the RURAL Heart and Lung Study. Written informed consent was obtained from all individual participants included in the study.

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28. mHealth Rural Methods

Figures

mHealth Rural Methods

Figure 1: Organizations involved in the Risk Under Rural Areas Longitudinal (RURAL) study and scope of mHealth core at UMass Chan Medical School



Figure 1

See image above for figure legend.

Figure 2: Screenshots of customized MyDataHelps smartphone application for the RURAL study. Onboarding process includes entering RURAL project code (left), different surveys due are displayed as a dynamic checklist which changes based on survey availability and completion (middle), and a participant dashboard (right) displays wearable device connectivity, survey completion status and other features including remote mHealth support number (right)

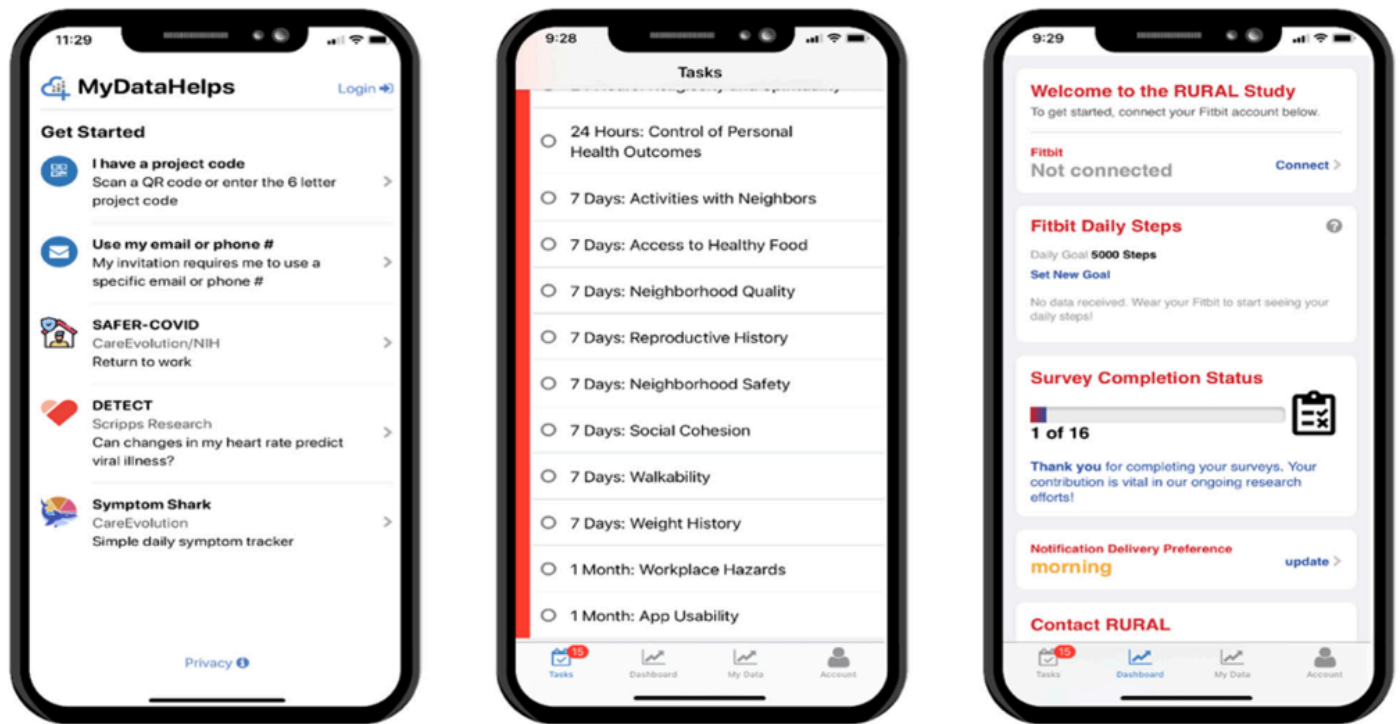


Figure 2

See image above for figure legend.

Figure 3: Participant recruitment flow for the RURAL cohort study and different phases of mHealth core implementation of onboarding process (blue boxes) over time

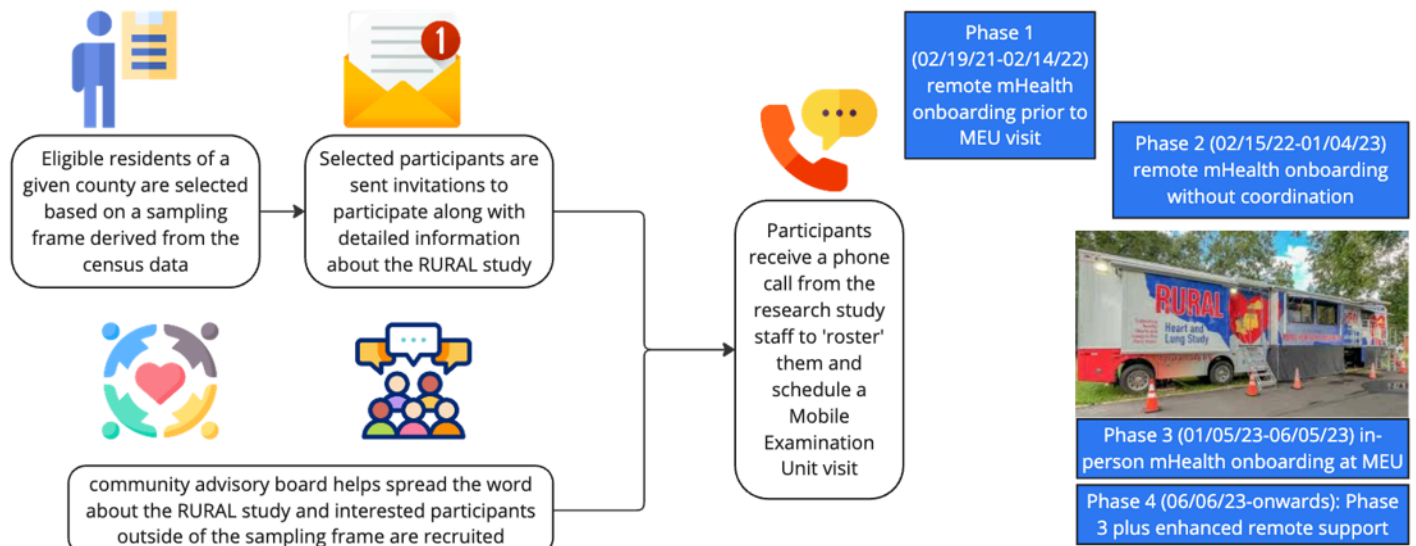
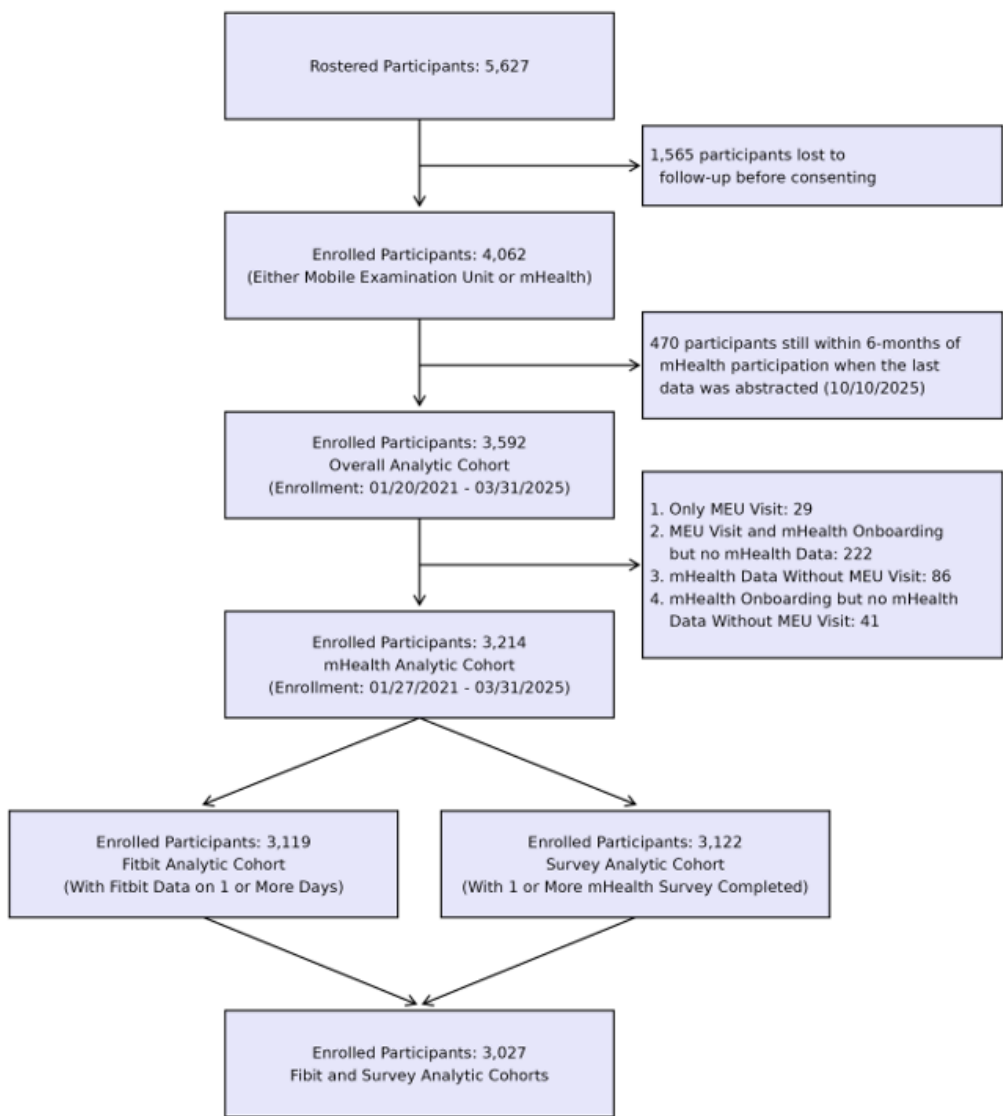


Figure 3

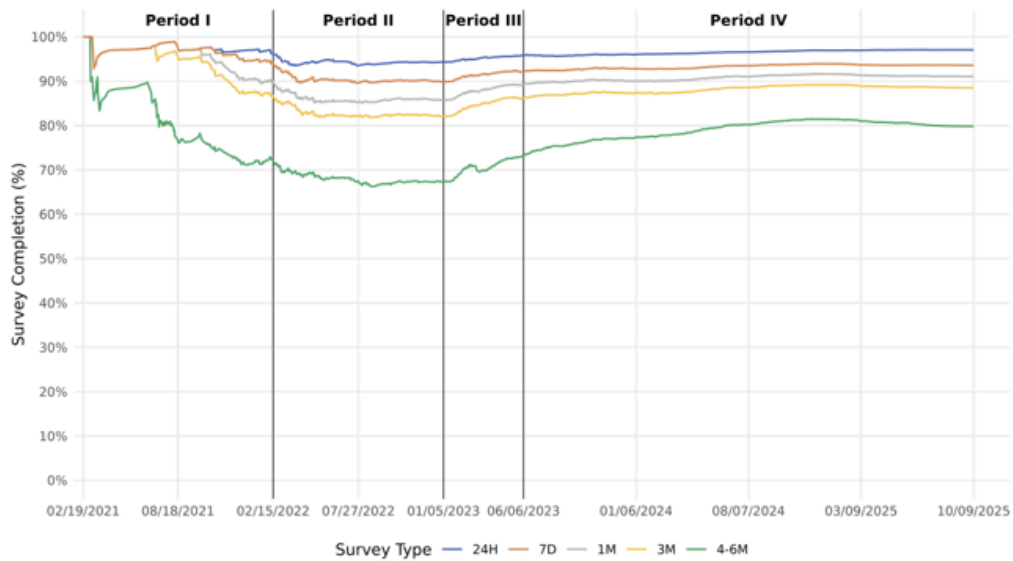
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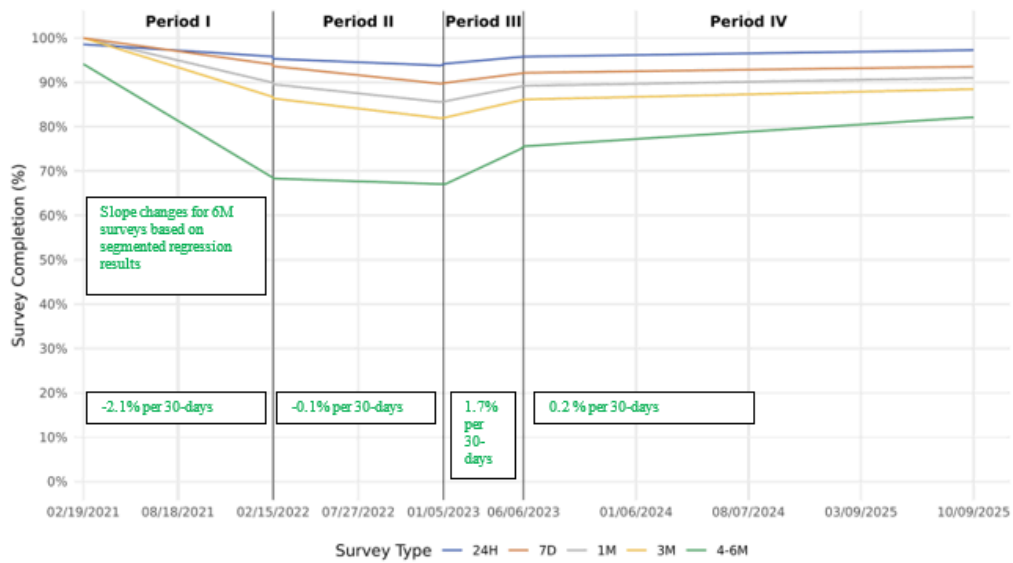
CONSORT Diagram for Participants Used in the Analysis of Mobile Health (mHealth) Core Performance in the RURAL Cohort Study

Figure 4

CONSORT Diagram for participants used in the analysis of mHealth core performance in the RURAL cohort study



Cumulative Completion Rate of Surveys Over Time by Periods of Survey Deployment



Predicted Cumulative Completion Rate of Surveys Over Time by Periods of Survey Deployment

Figure 5

Cumulative Survey Completion Rate

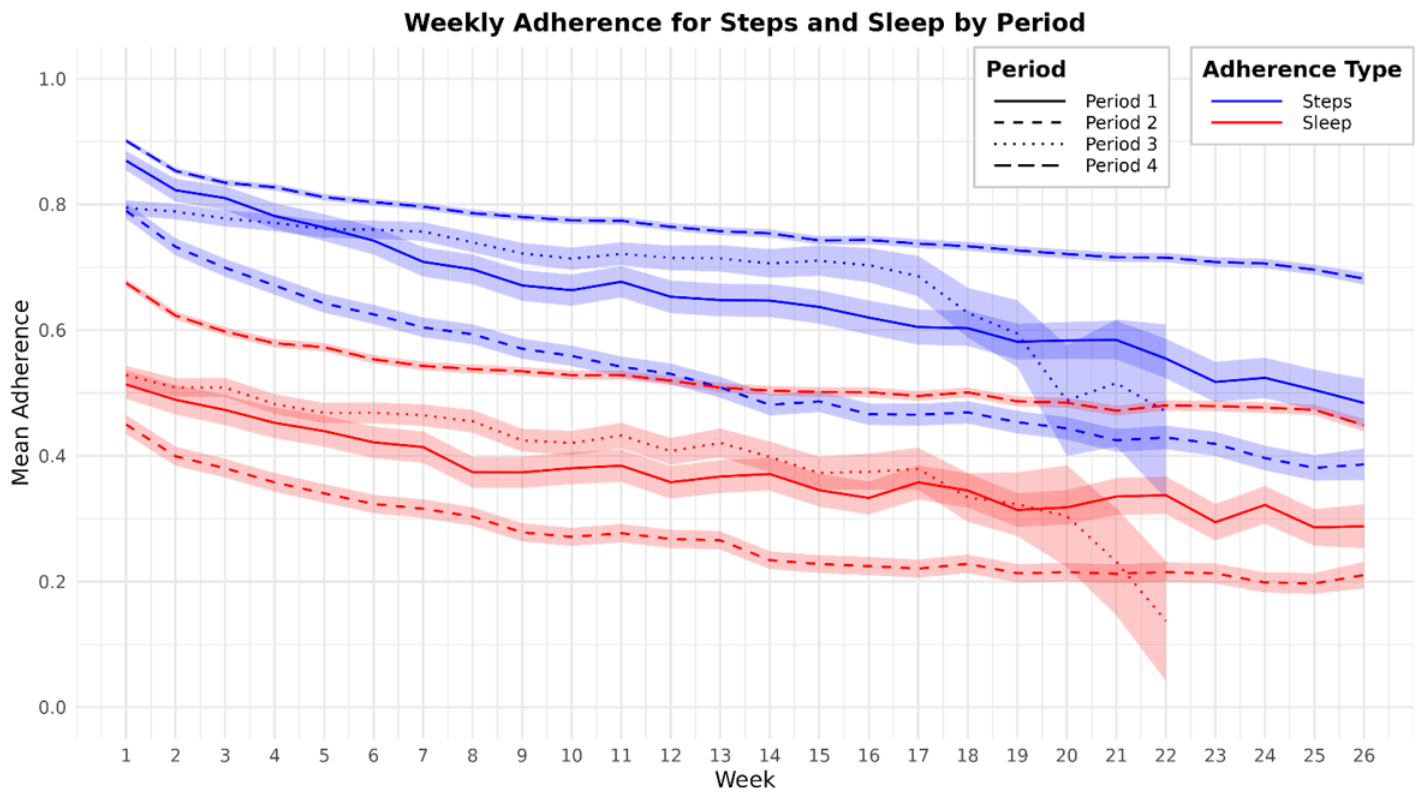


Figure 6

Weekly Adherence

Weekly Adherence for Physical Activity and Sleep

- Adherence for physical activity is defined as >0 steps in a day
- Adherence for sleep is defined as >0 minutes of sleep in a 24-hour period

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryTable1.docx](#)