

Digital Reminders for Antenatal Care in a Refugee Population: A Quasi-Experimental Evaluation of a Mobile Health Intervention (HERA) in Türkiye

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Abstract

Background: Pregnant refugee women face intersecting barriers to antenatal care (ANC), including language, legal-entitlement, and access constraints. Digital health interventions, such as mobile reminder apps, may help improve continuity of ANC, but rigorous evaluations among refugees are rare and often complicated by implementation challenges.

Objective: To evaluate the association between a mobile antenatal reminder application (HERA) and ANC visit attendance among Syrian refugee women in Türkiye, and to document discrepancies between the planned randomized controlled trial (RCT) protocol and real-world implementation.

Methods: We conducted a quasi-experimental study at two migrant health centers in Istanbul, comparing pregnant Syrian refugee women with confirmed exposure to the HERA mobile reminder app ($n = 48$) to a retrospective baseline cohort identified from routine clinic records over the same period ($n = 949$). The intervention consisted of installing the HERA smartphone application, which provided push-notification reminders for upcoming antenatal visits and brief pregnancy-related information, alongside routine care; the study was originally planned as a three-arm randomized controlled trial, but incomplete recording of allocation and identifiers precluded an intention-to-treat analysis.

Results: Pregnant women who received reminders through HERA attended more ANC visits than those in the baseline cohort (mean 2.5 vs 1.9 visits), with consistent evidence of higher probabilities of achieving ≥ 2 visits across frequentist and Bayesian analyses.

Conclusions: A simple mobile reminder intervention was associated with increased ANC attendance among Syrian refugee women, despite substantial implementation barriers that transformed a planned RCT into a quasi-experimental evaluation. Our study highlights both the potential of digital health tools in humanitarian settings and the importance of robust identification and data-linkage strategies when designing digital health trials with refugees. Clinical Trial: NCT05094518 - <https://clinicaltrials.gov/ct2/show/NCT05094518>

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Original Manuscript

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Keywords: mobile health (mHealth); antenatal care; Syrian refugees; quasi-experimental study; digital health

Introduction

Refugee women confront an imposing intersection of vulnerabilities that substantially impede their access to essential reproductive, maternal, and preventive healthcare. In Türkiye, which hosts the

world's largest refugee population, [1] Syrian refugee women encounter language barriers, limited awareness of preventive services such as cervical cancer screening, and face cultural, educational, and legal-entitlement obstacles. [2, 3, 4] These obstacles are exacerbated during crises: during the COVID-19 pandemic, for example, attendance for antenatal and postpartum care among Syrian refugee women dropped sharply, home births increased, and contraceptive use declined substantially. [3] According to updated data from the Presidency of Migration Management, [5] there are 1,203,087 Syrian migrant women aged 18–64 living in Türkiye, and approximately half of them are of reproductive age.

Studies across Lebanon, Jordan, and Türkiye show that Syrian refugee women often have inadequate antenatal coverage, with some estimates suggesting only around 16% receive adequate ANC, leaving many at higher risk of preterm birth and other complications. [6] Systematic reviews of fragile and conflict-affected settings similarly highlight lower ANC uptake among refugees and migrants compared with host populations. [6]

The World Health Organization, recommends that a pregnant woman have at least eight contacts with healthcare providers throughout her pregnancy in order to reduce both fetal and maternal morbidity and mortality. Globally, 64% of women receive four or more antenatal care visits during pregnancy. [7] In Türkiye, preventive and primary healthcare services for Syrian migrants are provided through *Migrant Health Centers* (MHCs) established in areas with high migrant populations. These centers are affiliated with primary healthcare services. In addition to primary healthcare services, these centers provide internal medicine, pediatrics, obstetrics and gynecology, oral and dental health, and psychosocial support services. According to the Turkish Ministry of Health's *Antenatal Care Management Guidelines*, [8] at least four antenatal follow-up visits are recommended during pregnancy. According to the *Turkey Demographic and Health Survey (TDHS)* conducted in 2018—which is carried out every five years and includes data on migrant women—64% of Syrian migrant women received four or more antenatal care services, as recommended. [9]

Digital Health Tools

Digital Health tools hold promise in addressing such gaps by offering scalable, accessible means of bridging geographic, informational, and logistical barriers to accessing healthcare. Systematic reviews demonstrate that digital health tools—such as SMS reminders, smartphone applications, and interactive health platforms—can improve maternal health indicators, including antenatal care attendance, adherence to vaccination schedules, and health literacy, particularly in low- and middle-income settings. [10, 11] However, progress remains inconsistent, with challenges persisting in areas such as user engagement, cultural acceptability, digital literacy, and access to technology, especially in contexts of instability and displacement. [12] Few studies explicitly investigate how refugee women perceive and actually use digital health tools for maternal health; one qualitative study with Syrian refugee women in Turkey found that end-user design involvement, multilingual interfaces, and reminder features were valued, but concerns about data privacy, platform usability, trust and reliability, and offline functionality were frequently raised. [13]

The HERA platform is a digital health application developed to overcome barriers to healthcare access for refugee and migrant communities, by integrating appointment reminders, multilingual health information, electronic record-keeping, and navigational support into one mobile application, with a particular focus on Syrian refugees and female empowerment. [14] HERA, or Health

Recording App, with inspiration from strong female origins in Greek mythology, is a medical reminder intervention designed for the Syrian refugee population. The application enables users to receive healthcare appointment reminders, health information, centralize medical records, contact emergency services, and navigate the host country healthcare system in multiple available languages.

Building on prior qualitative work on the HERA app [14], this study set to evaluate whether app-based appointment reminders increased antenatal visit uptake among pregnant Syrian refugee women in Istanbul. In this paper, we (1) estimate the effect of confirmed HERA app exposure on the number of antenatal visits using a quasi-experimental comparison between application users and a retrospective baseline cohort, and (2) systematically document the discrepancies between the planned trial protocol and real-world implementation, with the aim of informing future digital health evaluations in refugee and humanitarian settings.

Methods

Study Design

This study was designed to evaluate the effect of sending digital appointment reminders on uptake of antenatal care appointments among Syrian refugee women in Türkiye, through a quasi-experimental comparison between an intervention group (women with confirmed app exposure) and a retrospective baseline control group derived from clinic records during the same time of the intervention.

Reporting follows the CONSORT 2025 checklist, CONSORT- EHEALTH as appropriate for quasi experimental studies and as far as relevant and incorporates elements from TREND guidelines for non-randomized evaluations. This trial was registered on ClinicalTrials.gov (NCT05094518; <https://clinicaltrials.gov/ct2/show/NCT05094518>).

Setting and Participants

The study was conducted at two *Migrant Health Centers* and/or *Extended Migrant Health Centers* in Istanbul, Türkiye, between [January 2023 – March 2023]. Eligible participants were Syrian refugee women between the ages of 18 to 49, in the first trimester of their pregnancy presenting for routine antenatal care. Exclusion criteria included: inability to consent due to being unable to read or write, lack of smartphone ownership or access, or being in a high-risk pregnancy and/or with a chronic medical condition requiring increased visit frequencies.

Planned Trial Protocol

According to the original protocol, participants were to be randomly assigned to one of three groups:

- Treatment arm – participants would receive access to the *HERA* app and reminder for their future antenatal care appointments;
- Informed control arm – participants aware of study participation but not provided with the app or reminders;
- Baseline control arm – participants not notified or interacted with directly, used to estimate background attendance rates.

Using GPower 3.1, we set our Type I error (α) to 0.05, our Type II error (β) to 0.10 and used f of 0.33 to determine the sample size per arm of our planned 3 group ANOVA. This yielded a value of 40. Accounting for a 20% follow-up loss rate, expected due to the transient nature of the refugee population, the sample size was increased by 25%, resulting in an anticipated 50 subjects per arm.

Actual Implementation and Deviations

Planned randomization procedures were applied inconsistently across recruitment days, and personnel occasionally omitted the allocation step due to time constraints. Identification data (names, phone numbers, unique IDs) were not consistently recorded for several participants, particularly in the ‘informed control’ and ‘baseline control’ arms. Consequently, only 48 intervention participants could be fully matched to outcome records, while allocation information for others was unrecoverable. Because the extent of loss of allocation data was substantial, the analysis proceeded as a quasi-experimental comparison of verified app users versus a retrospective baseline population.

Intervention

Participants in the treatment arm installed the *HERA* mobile health app on their smartphones at enrollment. The app provided push notification reminders for the next antenatal care appointments over a period of 6 months. Reminders were sent at the following intervals: 2 weeks before the appointment, 1 day before the appointment, and on the day of appointment. This reminder algorithm was used for each prenatal checkup for a total of four appointments: once in the first trimester, once in second trimester and two in third trimester, using the Turkish Ministry of Health prenatal checkup calendar. No financial incentives were provided. Clinic staff gave a 10 minute orientation session on application use and the study and consent process.

Outcomes and Data Sources

The primary outcome was the number of antenatal visits per participant during the study period, including the first visit, recorded through hospital records. Data from health records were

retrospectively reviewed to identify subsequent antenatal or postnatal visits up to 6 months after initial enrollment.

For the treatment arm, outcomes were matched to participant identifiers using name, age, date of first visit, and phone number. For the baseline group, outcomes were extracted for all eligible women visiting the same facilities within the study timeframe who were not identified as app users ($n = 949$). For analysis, we collapsed into our "control" arm any record that was not identified as a treatment subject and whose record did not indicate that this individual would have been excluded from the study. Missing outcome data for unmatched participants were not used for outcome analysis. Analyses were restricted to matched records (48 treated women and 949 baseline records).

Statistical Analysis

The final analysis compared two arms: treatment and baseline. Continuous outcomes were analyzed using Welch's two-sample t-test for unequal variances; non-parametric comparisons by Kruskal–Wallis test and distributional differences by G-test. A Bayesian multinomial model sensitivity analysis was also performed to obtain posterior probabilities of group differences. All analyses were conducted in R version 4.0.5.

Because only a small subset of participants in the originally planned randomized control arm could be matched to outcome records, the primary outcome analysis was restricted to the treated and baseline arms; information about those originally allocated to the randomized control arm was used only for baseline characteristic checks and descriptive comparisons.

Baseline comparability between the originally randomized treatment and control arms (93 participants per arm) was assessed for sociodemographic and obstetric characteristics including age, time in Türkiye, marital status, education, previous pregnancy outcomes, and chronic conditions. Differences in means were tested using Welch's t-test, and differences in proportions or categorical distributions using likelihood ratio tests. To account for multiple comparisons, a Bonferroni correction was applied to maintain a family-wise α of 0.05, and Cramer's V was calculated for selected categorical variables.

Ethical Considerations

This study was approved by the Acibadem Mehmet Ali Aydınlar University Medical Research Institutional Review Board (approval number: 2021-04/04). Written informed consent was obtained from all intervention-arm participants prior to enrollment. The retrospective baseline cohort was identified from routine clinical records under the same IRB approval, which waived the requirement for individual consent for deidentified records review.

Results

Sample Characteristics and Data Availability

Of 186 randomized participants (93 treatment, 93 control), 48 treatment participants and 15 control participants could be matched to the clinic records. In addition, 949 eligible baseline records with complete visit data were extracted from the hospital information systems for the study period. Because the matched control sample was underpowered, the primary analysis compared the 48 matched treated participants with the 949 baseline records, while the randomized control arm was used only for baseline characteristic checks and descriptive comparisons. (see randomization checks section). The flow of participants from randomization to inclusion in the analytic groups is shown in Figure 1.

Figure 1: Flowchart of Participant Recruitment and Analytical Sample

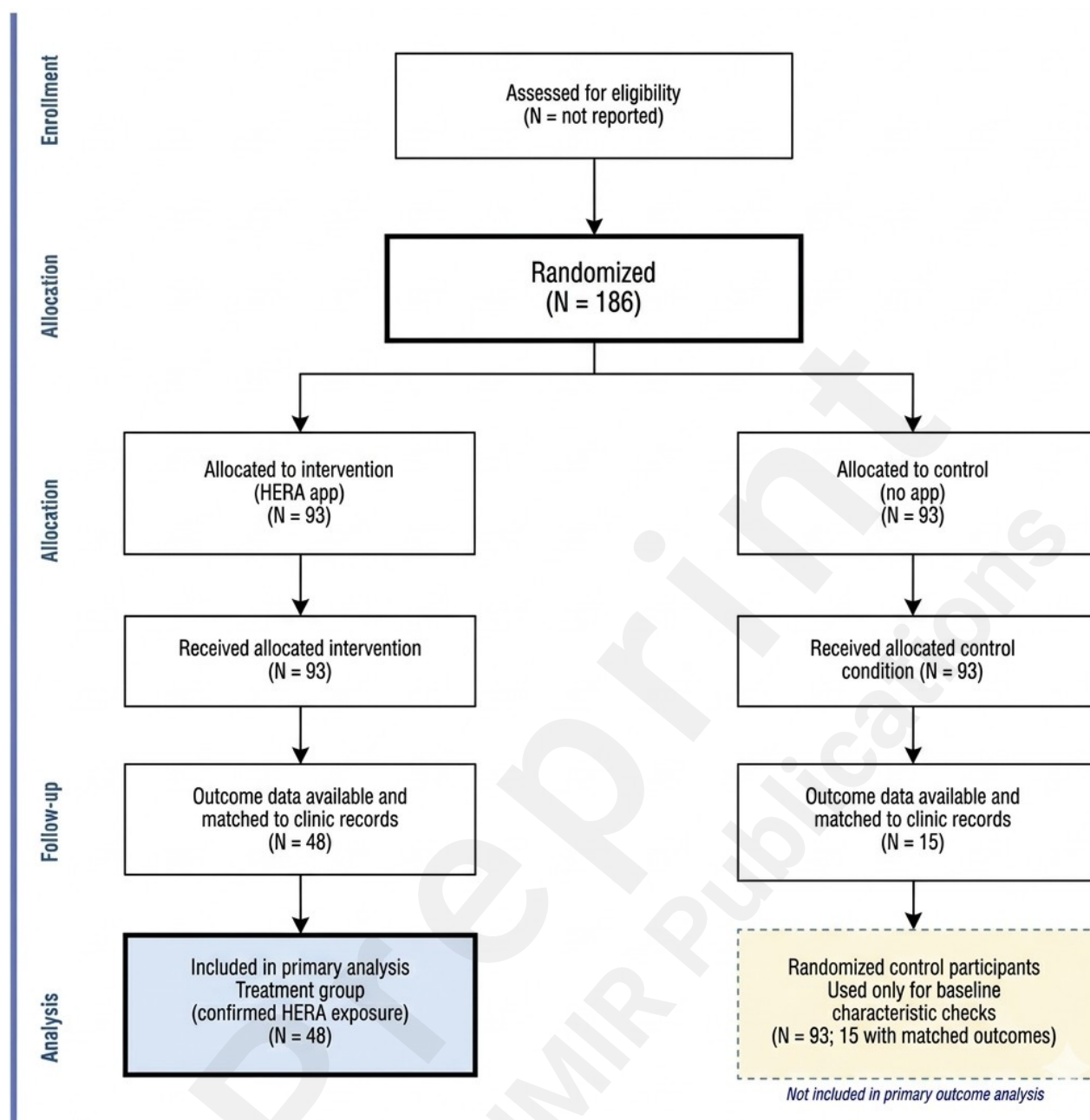


Table 1: The distribution of the number hospital visits for the baseline and treatment groups

Number of Visits	Baseline (n=949)	Treatment (n=48)
1	455	10
2	206	15
3	201	14
4	87	9

The mean number of antenatal visits (including the initial visit) was 1.9 (SE 0.03) in the baseline

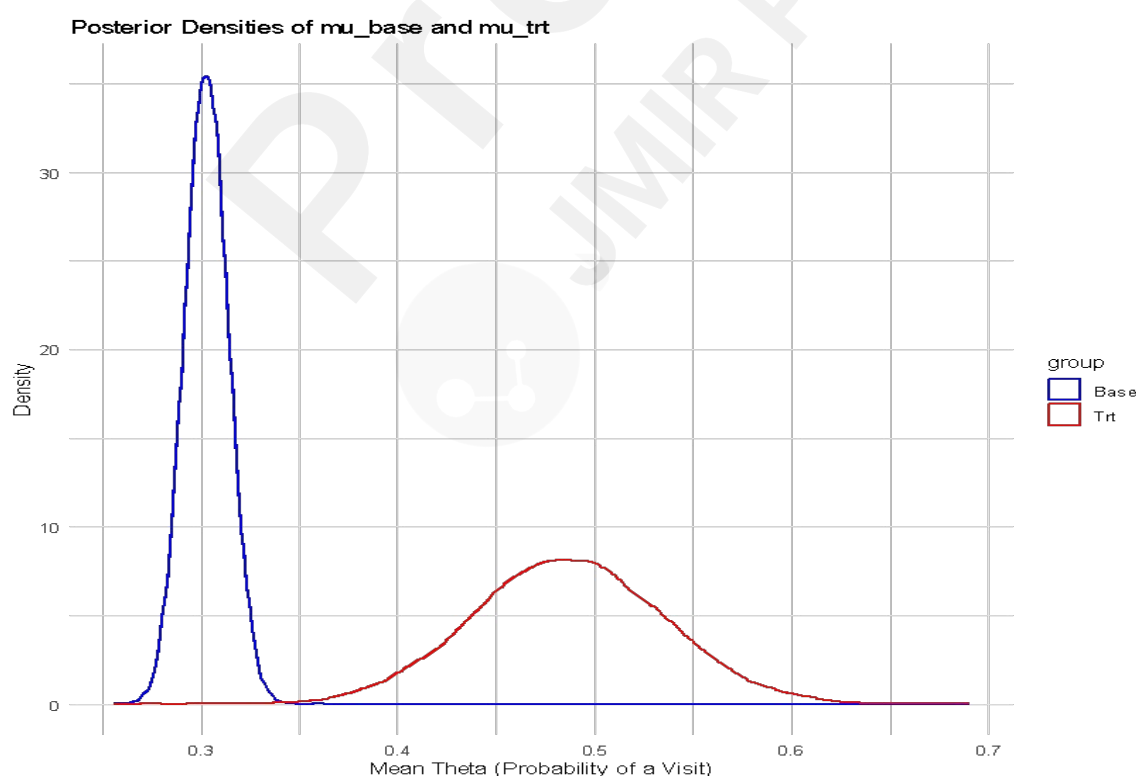
group and 2.5 (SE 0.14) in the treatment group, a difference of 0.6 visits. This difference was statistically significant across all tests applied (Welch t-test, Kruskal–Wallis, and G test; all $p < 0.01$), indicating that women in the treatment group attended more antenatal visits than those in the baseline group.

Table 2: Posterior probabilities of number of hospital visits

Number of Visits	Baseline	Treatment
1	0.48	0.21
2	0.22	0.31
3	0.21	0.29
4	0.09	0.19

Compared with the baseline group, the treatment group showed lower posterior probability of having only one visit and higher probabilities of having 2, 3, or 4 visits (see Table 2). In particular, the posterior probabilities that the treatment probabilities exceed the baseline for 2, 3, and 4 visits were 0.93, 0.89, and 0.98, respectively.

Figure 2. Posterior distributions of mean visit propensities for baseline and treatment groups



In this model (Figure 2), the probability that a randomly drawn woman from the treatment distribution has a higher visit propensity than a randomly drawn woman from the baseline distribution was 0.71, indicating a 71% chance that app users would attend more visits than non-users.

Randomization Checks

Among the 93 women originally allocated to each of the treatment and control arms, there were no statistically significant differences after Bonferroni correction (family-wise $\alpha = 0.05$) in mean age, time in Türkiye, marital status, prior miscarriages, prior child loss, history of stillbirth, long-term medical conditions, number of children, or overall education distribution. When examined without multiple-comparison adjustment ($\alpha = 0.05$), only education distribution approached significance ($p \approx 0.04998$), with Cramer's $V = 0.24$, suggesting a mild to moderate association between group membership and education level.

Baseline characteristics of the originally randomized treatment and control arms were broadly similar across sociodemographic and obstetric variables (Table 3). No statistically significant differences were observed after Bonferroni correction, with the exception that education level approached significance in unadjusted analyses (Table 4).

Table 3: Education level and number of children in randomized treatment and control groups

Section	Group	Mean	StdDev	Count	No	Yes	Statistic	df	p_value
Age	Control	26.3	6.3	91			t=1.62	174.0	0.11
	Treated	24.9	5.2	93					
Years Living in Turkey	Control	7.1	3.0	92			t=0		0.5
	Treated	7.1	2.7	93					
Miscarriage	Control			94	54.0	40.0	G=2.1	1.0	0.14
	Treated			93	62.0	31.0			
Has last child before	Control			93	89.0	4.0	G=2.0	1.0	0.16
	Treated			93	92.0	1.0			
Stillbirth ≥ 28 weeks	Control			93	86.0	7.0	G=1.7	1.0	0.19
	Treated			93	90.0	3.0			

Chronic medical condition	Control			92	83.0	9.0	G=0	1.0	0.98
	Treated			93	84.0	9.0			

Table 4: G-test statistics for education level and number of children in randomized treatment and control groups

Category	Level	Control	Treated
Education Level	Can not read	10	4
	Can read	10	5
	Elementary school	28	18
	Middle school	27	40
	High school	9	15
	Undergraduate	8	11
	Statistic	df	P value
	G=11	5.0	0.05
Number of Children	0	23	0
	1	17	0
	2	18	0
	3	18	23
	4	9	18
	5	4	20
	6	2	21
	7	1	13
	Statistic	df	p_value
	G=12.4	6.0	0.09

Discussion

Principal Results

In this study, we found that a digital health intervention (HERA App) was associated with an increased mean number of prenatal care visits amongst the Syrian refugee population in Turkey. We show a statistically significant increase of 0.6 in the mean number of visits between the baseline

group and treatment group, with higher posterior probabilities of achieving >1 prenatal care visit in the treatment group (Figure 2). As current WHO guidelines recommend at least 4 routine prenatal care visits for pregnant women to optimize pregnancy outcomes, this increase in actual visits attended is anticipated to confer clinically significant effect size in morbidity reduction for both women and infants.

Comparison With Prior Work

Although more studies are beginning to examine the use of text messaging in vulnerable populations, very few use experimental (quasi or randomized) trial designs. [15, 16] To our knowledge, this is one of the few studies designed to examine the effect of a digital health platform, specifically utilizing appointment reminders, to increase prenatal care visits in a refugee population. Furthermore, this digital health intervention was uniquely designed as a demand side intervention to provide behavioral influence to increase the uptake of already available host country public health services. It was not only designed as a medical tool, but also to facilitate female empowerment, ownership, and targeted learning for Syrian women in their pregnancy journey.

Conducting the study, however, required several adjustments to the original protocol. As evidenced by our experience, challenges with documentation in migrant health centers, particularly with shifting populations and sensitive identification data, remain an important deterrent to carrying out high quality randomized control design studies in refugee and migratory populations. Unfortunately, during study implementation, the research team encountered challenges in maintaining and verifying treatment allocation and participant identifiers due to incomplete and missing documentation over the study period. As a result of inconsistently recorded identification at the migrant sites for the control and baseline arms, the dataset could not preserve random assignment. This resulted in the main comparison for the analytic dataset to be quasi-experimental, to include women with confirmed HERA exposure versus a retrospective baseline drawn from routine clinic records. In constructing this baseline, we included all records from the period of interest that did not match treated participants and had no indication for exclusion, which likely created a superset of our planned control and baseline arms and allowed some misclassified treated women to remain in the baseline pool. This union and contamination would at worst lessen our sensitivity to detect differences between the treated and the new control arms as well as limit comparison of characteristics between these two arms.

Some challenges were specific to the project such as recruitment challenges but most reflected broader realities of refugee health research such as frequent relocation of participants, fluctuating contact information, and administrative delays at centers delivering refugee healthcare services. Hence, documentation is of extra value for future experiments. At the same time, the study illustrates how difficult it is to implement and rigorously evaluate interventions in humanitarian and refugee contexts for vulnerable populations, and specifically in highly politicized settings. High mobility, fragmented identification systems, competing clinical demands, and staff turnover all contributed to loss of allocation information and challenges in linking routine records, ultimately transforming a carefully planned randomized trial into a quasi-experimental analysis. These constraints are widely reported in refugee health research and underscore that disruptions to protocol fidelity, incomplete data capture, and context-driven adaptations are often the norm rather than the exception. [17]

Thus, given the quasi-experimental nature of the final analysis and potential misclassification of

some treated participants into the baseline group, these results should be viewed as evidence in support of a hypothesis for a causal effect rather than more definitive proof.

Our results are overall consistent with prior findings showing promise of digital health in increasing preventive care access, medication adherence, and chronic disease management.[18, 19, 20] For example, low-cost digital interventions are more widely being utilized in vulnerable populations and resourced-denied settings, including management of those living with tuberculosis and HIV. [21] Digital health applications have increasingly been used to improve availability of mental health resources and reduce depression symptoms of refugees and asylum seekers, with high burden of disease related to family separation. Through prospective data, we offer evidence for the value of a low-cost, high value intervention utilizing basic digital health infrastructure to build health literacy capacity and improve preventive care access in displaced populations historically susceptible to poverty, gender inequality, and poor pregnancy outcomes.

Strengths and Limitations

This study adds important evidence to a field where rigorous evaluations of digital maternal health interventions for refugees remain scarce. The design was strengthened by the inclusion of a non-notified baseline control group, which enabled us to separate the effect of the intervention from potential observation bias. Another notable design strength is the use of both frequentist and Bayesian methods. The convergence of results across these approaches provides reassurance that the observed differences are not artifacts of statistical choice but reflect a real and meaningful effect. By embedding the intervention within routine maternal and child health pathways, the study also demonstrated that digital reminders can be integrated with minimal disruption to clinic/health center workflow, and hold potential for scale-up within existing systems.

At the same time, several limitations should temper the interpretation of our findings. The study design, in contrast to the original planned protocol for a randomized trial, is quasi experimental. Challenges with recruitment and matching across different data sets meant that the treatment and original control group sizes were smaller than planned, which limited statistical power and prevented us from exploring heterogeneity by subgroups such as parity or comorbid conditions. The initial informed control arm, although conceptually valuable, ended up underpowered and was excluded from the main analyses. [23] Reliance on hospital records brought vulnerabilities, including incomplete matching and missing information for highly mobile participants. Our choice of outcome—visit frequency—was pragmatic but narrow. It captured continuity of care but not wider health outcomes such as maternal morbidity, patient experience, or cost-effectiveness. Without the statistical power to detect differences between the control group from the baseline and treatment groups, we cannot infer causality of the intervention. Furthermore, the study was confined to a metropolitan setting with relatively accessible clinic infrastructure, which may not reflect conditions in rural areas or other host countries. Finally, the short follow-up period also meant we could not assess whether improved attendance translates into lasting improvements in maternal and neonatal health.

Conclusions

This quasi-experimental study suggests that a mobile reminder intervention, HERA App, was

associated with improved follow-up visits among Syrian refugee women in Türkiye. Although the increase in visits was moderate, the direction of the effects were consistent across both the frequentist tests and the Bayesian modelling. The results show that even simple digital tools—when aligned with user needs—can shape care-seeking behaviour in populations facing substantial structural and social barriers.

Our experience highlights several priorities for future work. First, digital health and other service innovations for refugees should be designed with robust yet realistic procedures for assigning and tracking exposure, including simple identifiers and redundancy in data collection systems. Second, evaluation designs should anticipate implementation failure and incorporate analytic strategies—such as pre-planned quasi-experimental contrasts, sensitivity analyses, and explicit documentation of deviations—that can still yield informative evidence when ideal randomization and follow-up cannot be maintained. Looking forward, more advanced digital approaches including those involving artificial intelligence support may offer opportunities to build upon these results. Individualized analytics and risk-based models could help identify individuals at higher risk of disengagement and tailor outreach to specific needs. However, as promising as they are, such possibilities should be approached with caution in terms of equity, data protection, and usability to avoid reinforcing existing disparities among refugees.

In summary, this study contributes both empirical evidence and lessons learned. It shows that digital reminders may enhance follow-up in a marginalized population, while also illustrating the methodological and operational complexities that shape research in humanitarian contexts. Together, these findings point toward the value of context-appropriate digital interventions and highlight the importance of realistic pathways for integrating such tools into broader maternal and child health services in similar populations.

Acknowledgments

We used an AI assistant (Perplexity, powered by GPT-5.1) iteratively throughout the development of this manuscript, primarily as a writing and methods-clarification aid rather than for data generation or statistical analysis. Starting from an initial draft that described the study as a clean randomized controlled trial, we used the AI to reason through how loss of allocation and identification data affected internal validity, and to reframe the design and analysis transparently as a quasi-experimental comparison. The assistant helped us restructure the Methods and Results sections (e.g., distinguishing planned protocol vs actual implementation, clarifying construction of the baseline cohort, and tightening the description of statistical tests) and suggested CONSORT-EHEALTH- and TREND-aligned wording while we retained full control over analytic decisions and interpretation.

We also used the AI to edit and tighten the Introduction, Discussion, and Conclusion, including rephrasing overly causal statements, adding or refining transitions, and drafting initial versions of the abstract, participant-flow description, cover letter, and figure/table captions, which we subsequently reviewed and revised. All data analyses, statistical choices, and substantive interpretations were made by the author team, and all AI-generated or AI-edited text was checked, modified, and approved by the authors for accuracy, tone, and alignment with the study's actual procedures and findings.

Funding Statement

This study was supported by the Reproductive Health Working Group (RHWG) at the American University of Beirut (AUB). The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflicts of Interest

AS is the founder of HERA Digital Health, the organization that developed the intervention evaluated in this study. All other authors declare no conflicts of interest.

Data Availability

The datasets generated and/or analyzed during this study are not publicly available due to participant confidentiality considerations but are available from the corresponding author on reasonable request.

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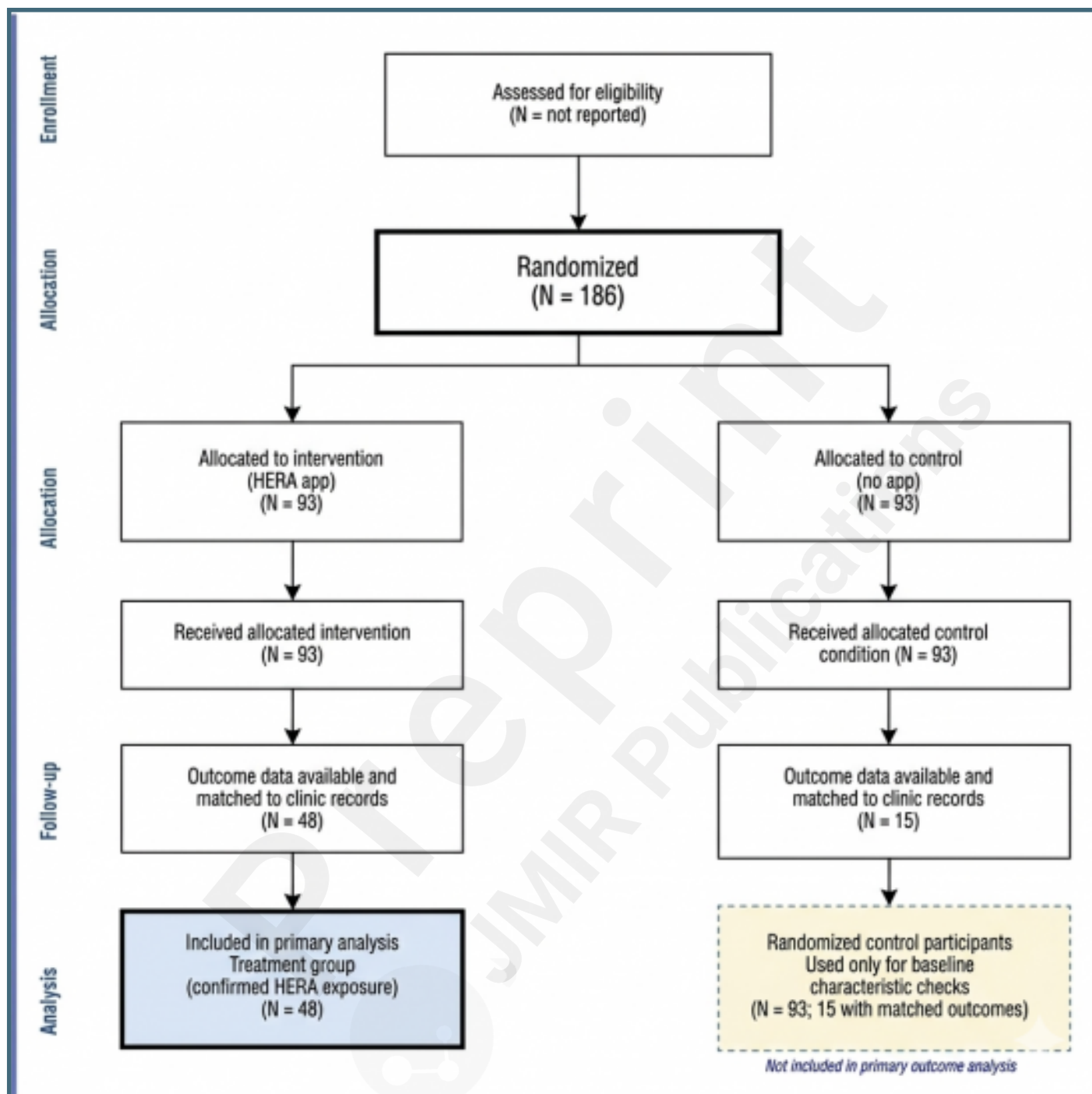
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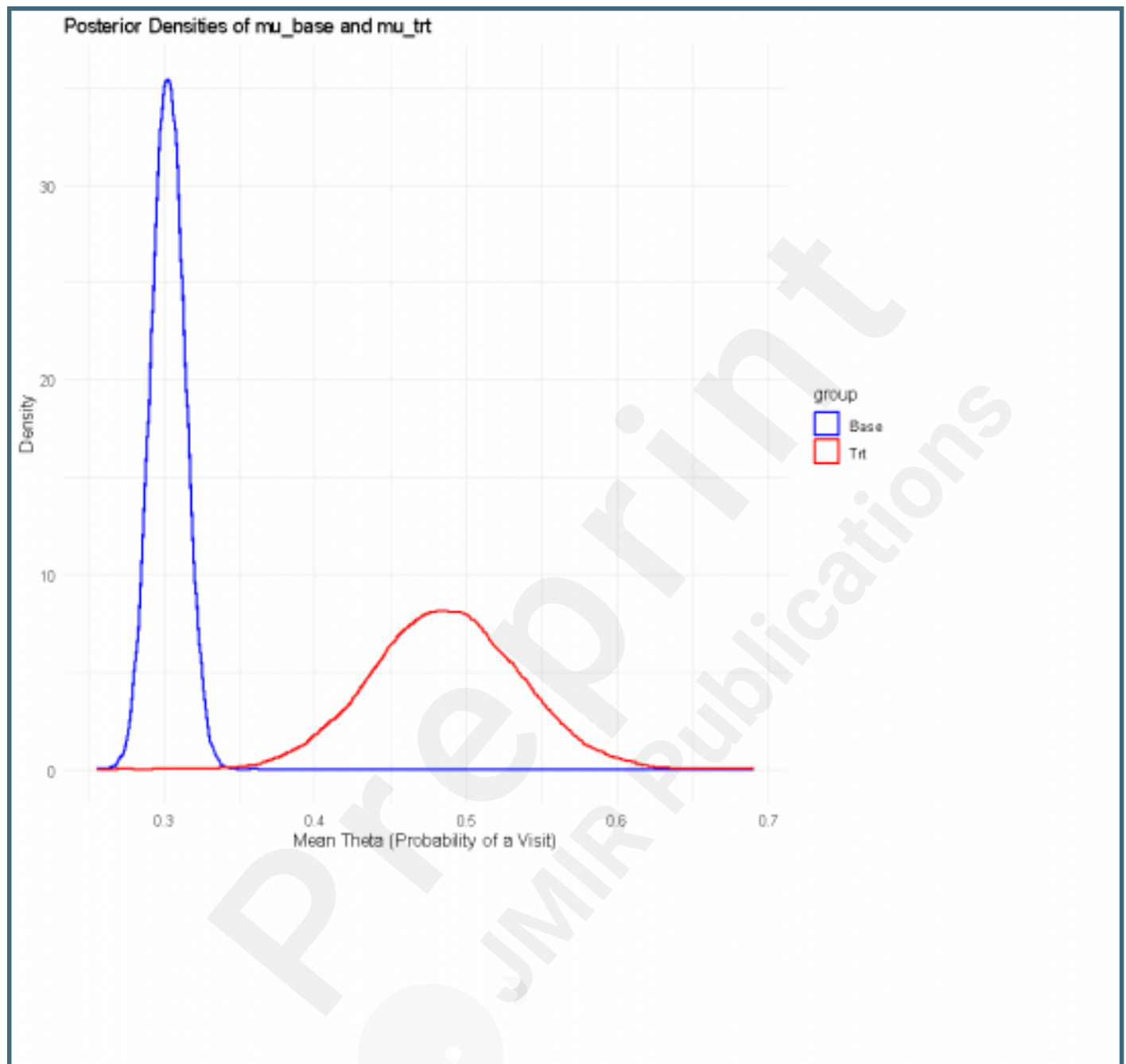
Supplementary Files

Figures

Flowchart of participant recruitment, randomization, and analytical sample.



Posterior distributions of mean visit propensities for baseline and treatment groups.



CONSORT (or other) checklists

CONSORT-EHEALTH V1.6.1 Reporting Checklist.

URL: <http://asset.jmir.pub/assets/d0cb862a009981d4cc42844b1d1071ce.pdf>

