WhatsApp-Based Group Intervention for Adolescent Mothers in the Dominican Republic: Experiences of Social Support and the Role of Engagement

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Abstract

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Social support is vital in particular for adolescent mothers, who, compared to adults, are more likely to have inadequate social support. While traditional interventions aiming to improve social support involve in-person meetings, mobile health (mHealth) is an increasingly popular approach. We recently completed a 12-week moderated WhatsApp group chat intervention with adolescent mothers in the Dominican Republic which aimed to improve maternal and infant health through increased social support and access to health information. This mixed-methods thesis analyzed previously collected data from the Strengthening Self-Determination of Adolescent Mothers (*Fortaleciendo la Autodeterminación de Madres Adolescentes* (FAMA)) intervention including WhatsApp group messages and post-intervention interviews (PII). We characterized the experiences and reports of social support exchanges in intervention groups, determined patterns of engagement with FAMA, and assessed associations between engagement in FAMA (as defined by our novel “Engagement Index” measure) and intervention outcomes. We found a significant association between Engagement Index and change in health knowledge survey score. In univariable regression, each 1-unit increase in the engagement index was associated with a 0.028-unit increase in health knowledge score (CI: 0.008-0.048, $p = 0.009$), out of a maximum of 11. This association remained statistically significant after adjustment for confounding variables. We found no significant

association between the Engagement Index and change in social support survey scores from pre to post in crude or adjusted analyses (unadjusted p-value = 0.63, adjusted p-value = 0.37), nor any significant association between the Engagement Index and contraceptive use at the end of the intervention study (adjusted RR = 1.0, 95% CI = 0.99-1.00, p = 0.97). In general, reports from PII were similar to social support exchanges observed in WhatsApp chats; importantly, group moderators played an important role in this intervention, as they not only provided informational messaging, but also both companionship and emotional support. These small community-based studies provide critical data for designing larger interventions to support often marginalized communities and ensuring their needs are met in early development. Further study is needed to determine the long-term effects of an intervention like FAMA, and also its cost-effectiveness for larger-scale implementation

Study Objective and Specific Aims

This thesis draws on data collected from a WhatsApp-based group intervention conducted with adolescent mothers in the Dominican Republic which aimed to improve maternal and child health.

The specific aims of this study are:

Aim 1.a.: To characterize the domains of social support exchanged among participants and with group moderators in three WhatsApp support groups for adolescent mothers.

A qualitative analysis of WhatsApp chats will be performed, identifying domains of social support exchanged. Support will be characterized by type (informational, emotional, companionship, instrumental)(1), source (moderator or participant), and content areas.

Aim 1.b.: To compare self-reported experiences of social support to those observed in WhatsApp chats.

A qualitative analysis of post-intervention participant interviews will be conducted, identifying domains and content areas reported to have been experienced by participants. These reported experiences with social support will then be compared to those observed in WhatsApp chats to determine any significant domain differences.

Aim 2.a.: To describe patterns of participant engagement in WhatsApp chats.

A quantitative analysis of patterns of participant engagement will be conducted, including use of emoji, media, and written messages. Participant engagement will be summarized as metrics of adherence (the proportion of days a participant sent the 'emoji of the day'), diligence (the proportion of group forum questions answered), consistency (the proportion of intervention days a participant sent any message), support (the proportion of messages in which a participant exchanged social support), and immersion (participants' total messages sent).

Aim 2.b.: To determine the association between participants' level of engagement by WhatsApp and health knowledge and postpartum health behavior.

Based on patterns of engagement assessed in Aim 2.a., an Engagement Index will be calculated for each participant. Association between this index and quantitative intervention outcomes will be assessed, including change in health knowledge and social support, and post-intervention contraceptive use.

Background and Significance

In the developing world (as defined by UN Population Division: Latin America and the Caribbean, Asia, and Africa, excluding Japan, Australia, and New Zealand), an estimated 10 million unintended pregnancies occur among adolescents ages 15-19 each year (2). Despite reductions in frequency of adolescent pregnancy over the last 15 years (3), pregnancies among 15-19-year-olds remain an important public health concern. Not only does pregnancy itself pose a series of health risks to the pregnant teen, but pregnancy and motherhood at this young age can have profound and life-long financial, emotional, and social effects (3). In fact, adolescent and young mothers are more likely than adult mothers to live in poverty and experience disproportionately low educational attainment (4). Additionally, while transition to motherhood at any age is a psychologically stressful time, during which mothers are susceptible to both prenatal and postpartum depression (5), adolescent mothers tend to have even higher levels of parental stress and depression (6). Maternal depression itself has been linked to negative health outcomes for infants, including preterm labor and delivery, low birth weight, and lower Apgar scores (7). Furthermore,

adolescent mothers are less likely to breastfeed their infants compared to adult mothers (8), despite evidence that exclusive breastfeeding of infants promotes development and protects infants against both infectious and chronic diseases (9). These early life experiences have a cascading effect in determining infants' future health outcomes (10). Infants born to adolescent mothers face increased risks of developmental delays, social and emotional problems, and increased mortality within the first year of life (6).

In the Dominican Republic, despite nearly a decade since sexual and reproductive health (SRH) education was mandated for all public schools, not all schools have implemented SRH curriculum. As a result, young Dominicans demonstrate limited knowledge of these vital topics (11). Adolescents age 15-19 additionally remain the age group with the highest unmet need for contraceptives in the Dominican Republic (27.3%) (12). Evidence suggests that there is a link between SRH knowledge and behaviors among adolescents—particularly in the use of non-use of contraception (13).

In this environment where access to SRH education and services is limited, adolescent pregnancy is common. In 2013, the age specific adolescent fertility rate for 15-19-year-olds was 89.3 per 1,000 (12), compared to the global average of 55.7 per 1,000 women (14). In all, 22.3% of births in the Dominican Republic between 2010-2015 were to adolescent mothers, and 20.5% of adolescents had either already given birth or were pregnant for the first time (12). Today, the Dominican Republic remains one of the top five Latin American countries with the highest number of adolescent pregnancies (15).

Although important for all individuals, social support plays a particularly significant role for members of stigmatized groups and those facing daunting challenges in their lives, such as adolescent mothers. Social support, or the extent to which an individual feels their social relationships are able to provide aid in times of need, has been shown to positively impact both physical and emotional health (1). Social support can be categorized into four key domains: instrumental (functional support such as providing transportation), informational (providing information or advice), emotional (support through empathetic listening, understanding, care) (1), and companionship (availability of someone with whom to share enjoyable leisure activities such as visiting, talking, celebrations, etc.) (16).

Social support is vital for new mothers, who represent one of the most socially isolated groups in their communities, often resulting in increased risks of negative mental and physical health outcomes for mothers and their families (17). Importantly, compared to adult mothers, adolescents are more likely to have inadequate social support (6). Support groups for new mothers can be beneficial to both mothers and infants, resulting from the social support created by the opportunity to build relationships and share experiences with other mothers (10). These social support groups for new mothers provide participants with important opportunities to access information, connect with other mothers, and get reassurance to normalize their own experiences (10).

Adequate social support, particularly peer support, has been shown to be a major factor in reducing the occurrence of both prenatal and postpartum depression in new mothers of all ages, including adolescents (5,18). In addition, the perception of social support is associated with improved knowledge about child development, particularly for vulnerable adolescent mothers (19). Furthermore, positive social support can both empower mothers to breastfeed and mitigate the challenges these mothers encounter with breastfeeding (20). Social support is even more important for adolescents who, during this stage of their lives develop a more pronounced reliance on peers (21). Peers in turn are often viewed as more trust-worthy and easily accessible sources for information, influencing both individual behaviors and decision-

making (21). Many interventions have capitalized on the role of peer educators and peer support. In fact, peer support and education has been shown to increase a number of breastfeeding indicators (22,23), alleviate emotional distress (24), and increase use of modern contraceptives (25).

While traditionally interventions aiming to improve feelings of social support involve in-person meetings and gatherings, mobile health (mHealth), the use of mobile phones to improve health, is an increasingly popular approach in public health (26). Globally, mobile phone use is dramatically increasing, especially among adolescents and young adults (26). This presents an opportunity to reach young people beyond the clinical setting and overcome barriers to in-person care experienced by adolescents (27). Some research additionally suggests that adolescents prefer online support groups over in-person groups (28). Importantly, studies suggest that mHealth interventions can be engaging and effective for a broad range of populations, including adolescents with early sexual debut and those with low parental support (29).

A worldwide social media and communication platform, WhatsApp is uniquely situated to serve as a basis for a variety of mHealth interventions (30). This platform provides end-to-end encryption of all messages to protect privacy, allows the formation of Group Chats of up to 256 members, and provides for use of Broadcast lists which allow users to separately send messages to saved lists of recipients (31). Today, WhatsApp is being implemented largely in clinical settings for information exchange between health care professionals, due to its low cost and ability to facilitate rapid clinical communications while preserving privacy (31). In addition to use for communication among medical professionals, WhatsApp has also been used in smoking-relapse prevention (32), self-help for hypertensive patients with type 2 diabetes (33), physical fitness interventions (34), and HIV prevention, testing, and engagement in care (35), aiming to capitalize on the use of social support, daily reminders, peer support, and important informational messages which are more easily facilitated through this platform (31,35)

We recently completed a 12-week moderated WhatsApp group chat intervention with adolescent mothers in the Dominican Republic which aimed to improve maternal and infant health through increased social support and access to health information. Some of the specific outcomes this intervention targeted were changes in health knowledge, changes in experiences of social support, contraceptive use, on-time vaccinations of infants, and monthly attendance to well-baby visits at the MAMI clinic. This intervention was undertaken with the financial support of Grand Challenges Canada and the Government of Canada, through Global Affairs Canada (GAC). In this analysis, we explore the domains of social support exchanged in this intervention, as compared with self-reported experiences of social support in post-intervention interviews with group participants. In addition, we describe patterns of participant engagement with the intervention, and their association with experience of social support, health knowledge and postpartum health behaviors. This mixed-methods analysis seeks to provide insight on how interactions and engagement with peers and moderators on this social media and messaging application can be used to improve health knowledge and outcomes through social support.

Methods:

This mixed-methods thesis analyzed previously collected data. This data originated from the Strengthening Self-Determination of Adolescent Mothers (*Fortaleciendo la Autodeterminación de Madres Adolescentes* (FAMA)) intervention conducted by the Módulo de Adolescentes Materno Infantil (MAMI) in La Romana, Dominican Republic, in collaboration with Planned Parenthood of the Great Northwest and the Hawaiian Islands (PPGNHI) Global Programs. MAMI is a collaboration between the Dominican non-governmental organization Clínica de Familia La Romana and the provincial public hospital Hospital

Francisco Gonzalvo. The FAMA study, which aimed broadly to improve maternal and child health outcomes, began with a user-centered design component, wherein a group of Dominican adolescent mothers identified the topics and themes most important for them to learn more about as young mothers. This initial group also served as the pilot group for the WhatsApp-based intervention. The FAMA intervention consisted of three key phases: 1) an initial in-person meeting of group members and moderators to establish norms, distribute phones to participants, build an initial connection, and administer pre-intervention surveys, 2) a 12-week long WhatsApp chat group intervention in which daily informational messages were sent by a moderator regarding selected health-related themes of importance to new adolescent mothers, and participants and moderators were free to interact, ask, and answer questions related to these and other important health themes, and 3) an in-person closing group session to reflect together, administer post-intervention surveys, and conduct post-intervention interviews with those participants who agreed to be interviewed. After the finalization of the intervention, participants were allowed to keep their study phones and study phone number if they were able to provide a government-issued identification to register the number to themselves. Building upon previous analyses of FAMA acceptability and effectiveness conducted by PPGNHI, this study aimed to characterize the domains of social support exchanged within the FAMA WhatsApp groups, and to determine the association between engagement with the intervention on health knowledge, social support, and contraceptive use among participants.

STUDY PARTICIPANTS

Participants were recruited by study staff in the waiting room at the MAMI clinic. Participants were eligible for study participation if they were 14-19 years old, had at least one child, had given birth in the last 6 months, spoke Spanish, lived in La Romana, and received health services at the MAMI clinic. Informed consent to participate was obtained from all participants prior to data collection and start of intervention period.

FAMA INTERVENTION

Participants and moderators were added to the group shortly before the start of the 12-week intervention. Although the FAMA intervention was silently observed by various members of the study team who were added to the group chat before participants entered, only two moderators interacted with participants, taking turns so that one was always available on weekdays between the hours of 8 A.M. and 5 P.M. Throughout the 12 weeks, moderators sent daily informational messages related to the following topics: family planning, baby illnesses, growth and development stages, feeding baby, understanding baby, and breastfeeding. Two weeks of daily weekday messaging were devoted to each of the six topics. Participants were expected to participate at least once a day by sending the emoji of the day, confirming that they had received and read the information for the day. The selected emoji of the day was included at the end of each daily message along with a reminder to participants to send it once they had read the message. Moderators also sent forum questions every two weeks which aimed to spark discussion and engagement in the chat group related to that week’s topic. Participants were encouraged to respond with messages in the group, but not required to do so. In addition, participants were encouraged to ask questions, seek support, and engage with each other in relation to the topics discussed, the health of their babies, and their own health. Members were told that moderators were available to answer questions and participate in groups only from 8 A.M. to 5 P.M. on weekdays.

DATA COLLECTION

Post-Intervention Interviews

A convenience sample of participants were approached during the final in-person meeting and asked to participate in a one-on-one interview aimed to determine the acceptability of the intervention, gain participant perspectives, and receive feedback for improving future iterations of FAMA. In total, 27 post-intervention interviews were conducted with participants who attended the in-person group meeting at the end of the intervention period and agreed to be interviewed. These structured interviews were conducted in Spanish by study staff in the MAMI clinic. Verbal consent was obtained prior to the start of each individual interview, as interview participation was optional and not included in the initial consent process. Although interviews were intended to be linked with study participant identification numbers, one of the 27 interviews could not be linked with its corresponding participant number.

WhatsApp Chats

WhatsApp chats from the three FAMA groups were exported from a study team member's device as separate text files. Each text file was then opened in Microsoft Excel, and fixed width columns were applied to separate dates, times, senders, and message content into individual columns. Phone numbers were stripped from the files, replaced with participant identification numbers, and each text was then reviewed and adjusted in places where column content had not been separated accurately. Audio messages were individually transcribed, and transcriptions were added in a separate column as appropriate. Because this analysis was not part of the initial analysis plan, most media messages were not saved and their content could not be summarized for review. Photo and video message content was excluded from this analysis. "Sticker" media messages were saved and exported in their entirety, so the content of these messages was summarized as text and added in a separate column as appropriate.

Surveys

Paper surveys were administered in-person at the MAMI clinic during group meetings both before the start of the intervention, and after its completion. Surveys included a demographic survey, a health knowledge and literacy survey, and a social support survey.

The health knowledge and literacy survey was created for the FAMA study based on the key themes and informational messages provided in the intervention. The health knowledge and literacy survey was formatted as 14 multiple-choice or true-false questions. The first three questions of the health knowledge survey came from validated scales (36) which assess participants' ability to complete requested medical forms and to read and understand written medical information (health literacy). These questions used a Likert scale, and allowed for a range of scores from 3-15, with higher scores reflecting lower levels of health knowledge. The remaining 11 questions of the health knowledge and literacy survey covered topics such as: infant nutrition, family planning, breastfeeding, infant illnesses, infant growth and development, and other general infant care (health knowledge). Each correct answer was awarded one point, allowing for a range of scores on this portion of the survey of 0-11. For the purposes of this study we only focus on the health knowledge portion of this survey.

The social support survey was based on the NIH Toolbox Social Relations scales, using PROMIS tools which have been validated in Spanish and are based in Item Response Theory. This survey was divided into five scales of six questions each. The scales used here were: Emotional Support, Informational Support, Social Isolation, Means of Support, and Companionship. Each question had five possible responses using a Likert

scale, allowing for a range in total raw score for each section of 6-30, with higher scores indicating more perceived social support and interaction. Each score was then scaled using standardized conversion tables, changing each separate raw score into a T-score for each participant. This T-score converted the raw score into a standardized score with a standard deviation of 10.

Although these scales have only been individually validated, the present study combined scaled scores on all five to give a more complete understanding of each participant's experience of social support. Total scores from each of the five scales were summed, allowing for a range in raw score of 30-150, and a range in T-score of 108.1-336.7. For the purposes of analysis in this study, only T-scores were used.

Clinical Data

Clinical data for each participant was gathered by study team members who conducted a review of MAMI medical files. Information on participant use of contraceptive methods (oral, injectable, and other long-acting contraceptives) was recorded for each participant before, during, and after completion of the intervention.

ETHICAL APPROVAL

Ethical approval for this study was obtained from the Consejo Nacional de Bioética en Salud (CONABIOS) institutional review board in the Dominican Republic and the University of Washington Institutional Review Board. All participants provided written informed consent to participate in the intervention and allow study team members access to their personal medical records, and those of their infant. Participants were privately informed about the study, given an opportunity to ask questions and receive answers, and were assured that they could choose to leave the study at any time without any consequences. Verbal informed consent was later obtained for those participants who agreed to be interviewed after completing the intervention. Although some participants were under the age of 18, in accordance with Dominican law 136-03, adolescents under 18 who are pregnant and/or have a child are considered emancipated minors and are eligible to provide informed consent for participation in research.

DATA ANALYSIS

Qualitative Data

Qualitative data sources in this study include WhatsApp chats (messages, audio, media), and post-intervention interviews. Both sources of data were collected prior to this thesis and were not translated from their original Spanish in order to preserve their original meaning and full context. Post-intervention interviews were analyzed using Dedoose, and WhatsApp text was coded and analyzed in an excel spreadsheet format, including transcriptions of audio messages and descriptions of "sticker" media messages sent. Although the WhatsApp text had not been analyzed previously, post-intervention interviews were previously coded and analyzed as part of a previous report on the FAMA intervention.

Although some cross-over existed, the aims of this study are distinct from those of the initial analyses conducted. As such, this analysis used some parts of and expanded upon the previous codebook used to analyze post-intervention interviews. Qualitative analysis was used to inform Aim 2.A., which describes participant engagement, as coding included classification of different kinds of messages and message content. A codebook informed by Social Support Theory was developed prior to team coding and the same codebook was used to analyze WhatsApp messages and interview transcripts. A team coding strategy was

employed for coding and analysis of WhatsApp chat text and interviews. The team consisted of four bilingual (English and Spanish) coders. WhatsApp text was separated by intervention group, and then organized into week-long sections of text. Each week-long section was considered its own “selection of text” and was analyzed separately, but coders had access to the entire group chat in order to ensure the appropriate context was provided for each selection. The team coding process was conducted as follows: 1) Coders familiarized themselves with existing codebook and examples; 2) Each coder was given the same sections of text to code independently; 3) The coding team came together to compare code application and discuss any discrepancies; 4) This process (steps 2-3) was repeated until the coding team determined that an acceptable level of consensus had been reached; 5) Coders were assigned selections of text to code independently; 6) One coder coded each selection of text, but every sixth selection of text was double-coded (coded by two different coders independently) and then examined for agreement to ensure consistency throughout the coding process. After the coding process, data was organized and synthesized into a series of memos that reflected the most salient themes in the analysis. Memos were then interpreted and examined in order to generate a final report.

Quantitative Data

Quantitative data sources in this study included pre- and post-intervention survey scores and contraceptive use among participants. Surveys were conducted in-person at the MAMI clinic during initial group meetings to establish norms, and during closing group sessions. Contraceptive use was determined from clinical data gathered by MAMI staff.

In order to address Aim 2.A. and describe participant engagement in chats, descriptive statistics related to engagement within the WhatsApp chat were calculated and reported (Table 1). Many of these statistics were calculated using message categorization during the qualitative coding process about types and content of messages.

Aim 2.B. examines the association between messaging engagement and survey and clinical outcomes collected at study visits. Participant engagement in FAMA (the independent variable of interest) is represented by the following Engagement Index as a summary measure, adapted for use in this study based on a previously developed Engagement Index (37):

$$\mathbf{EI = \sum (A_i + D_i + C_i + S_i + I_i) * 100}$$

where EI is Engagement Index, A is Adherence Index, D is Diligence Index, C is Consistency Index, S is Support Index, and I is Immersion Index. All indices were calculated separately for each participant.

The *Adherence Index* for this study was calculated as the number of emojis of the day sent out of the total possible days in which informational messages were sent. This was the only compulsory response participants were expected to send to the group each day to confirm receipt of the informational message sent by the moderator.

The *Diligence Index* was calculated as the number of group forum questions answered out of total number of forum questions posed to the group over the 12-week intervention period. Although participants were not required to participate or respond to these forums, the questions posed offered participants an opportunity to reflect on the information presented to them and apply it to their own experiences. Forum question responses were identified during qualitative coding of chats.

The *Consistency Index* was calculated as the proportion of intervention days a participant sent any message containing text. This index demonstrates a consistent interaction with the group in addition to simply reading the informational message.

The *Support Index* was calculated as the proportion of total messages in which each participant demonstrates an exchange of social support (companionship, emotional, instrumental, informational). This could be either seeking support or offering social support to others.

The *Immersion Index* was calculated as the participants' percentile rank of the total number of messages sent throughout the 12-week period, divided by 100. Each participant's percentile rank was calculated among the members of their WhatsApp group to allow for differences in group dynamics.

To address Aim 2.B., linear regression was conducted using the Engagement Index (EI) as the independent variable and change between baseline and exit scores in the Health Knowledge (HK) and Social Support (SS) surveys as the responding variables. A Poisson regression with robust standard errors was additionally conducted using EI as the independent variable, and Contraceptive Use (CU) at end of intervention as the binary dependent variable of interest.. For all three analyses we first ran a univariate regression, and then multivariable regressions adjusted for *a priori* defined confounding factors: participant age, whether the participant is declared (a documentation of birth necessary to enroll in university, and participate in formal employment), whether the participant is currently in school, whether the participant has a partner. P-values and 95% confidence intervals are reported for all regression analyses. All data analyses were conducted in R version 3.5.1.

Results:

Participant characteristics

A total of 58 participants participated in the FAMA intervention, of whom 27 participated in post-intervention interviews. Table 2 summarizes participant baseline characteristics. The median age of participants in the intervention was 18 years (interquartile range [IQR] 17-18 years), with median infant age of three months (IQR: 1-5 months) at the start of the intervention period. Most participants had declared status (53, 91.4%), while over half had government-issued identification cards (36, 62.1%). Few were employed (2, 3.5%) and 23 (39.7%) were attending school. Most participants reported currently have a romantic partner at the beginning of the study period, and almost all were first time mothers (54, 93.1%). Characteristics of participants in post-intervention interviews were similar to those who participated in the intervention (Table 2).

Domains of engagement with the FAMA intervention were quantified as indices of adherence, diligence, consistency, support and immersion, and a composite engagement index was calculated combining all domains (see Methods). Engagement levels are summarized in Table 3. The median Adherence Index score across all participants was 0.4 out of a maximum of 1.0, meaning participants sent the emoji of the day a median amount of 40% of the days they were asked to for the FAMA intervention. The median Diligence Index score was 0.2 out of a maximum of 1.0, indicating that participants responded to 20% of forum questions posed by moderators during the intervention. The median Consistency Index score was 0.5 out of 1.0, meaning that participants sent one or more text messages 50% of the intervention days. The median Support Index score was 0.5 out of 1.0, indicating that 50% of the median participant's

messages involved some sort of social support exchange. The Immersion Index was a percentile measure calculated separately for each group, but the number of messages sent by participants varied from 3-1026 messages. Overall, the median Engagement Index score for participants was 44.5, out of a possible score of 500 points, which would have indicated perfect adherence, consistency, and diligence, and the participant would have had to send the most messages in her group, and only sent messages containing some kind of social support exchange. Scores for the Engagement Index ranged from 0.35 to 98.92.

Association between engagement in FAMA and contraceptive use

At the end of the intervention period, 42 of the 53 participants with data on contraception (79.3%) were using some form of contraception.

In univariable analysis, we found that the Engagement Index was not significantly associated with contraceptive use at exit (Relative risk = 1.00, 95% CI: 1.00-1.01, p = 0.81). In analysis adjusted for a priori confounders of participant age, partnership, school attendance, and declared status, we similarly found no significant association between the Engagement Index and contraceptive use at the end of the intervention study (RR = 1.0, 95% CI = 0.99-1.00, p = 0.97).

Association between engagement in FAMA and change in social support score

The range of possible compiled scores on the social support surveys was 108.1-336.7. Therefore, there was a potential for this score to increase or decrease up to 228.6 points. Summed social support survey scores had a median increase from pre to post of 8.30 points on a scale of 108.1-336.7. We found no significant association between the Engagement Index and change in social support survey scores from pre to post in crude or adjusted analyses (unadjusted p-value = 0.63, adjusted p-value = 0.37). In addition, we found that having a partner at baseline was individually associated with changes in social support survey scores. Having a partner at baseline was associated with a 21.3-point higher change in social support survey scores (95% CI: 1.42 – 41.12, p-value = 0.04).

Association between engagement in FAMA and change in health knowledge score

Because the health knowledge survey was scored on a scale of 0-11 points, change in health knowledge from pre to post-test had a potential range of -11 to +11. In this study, the median change in health knowledge was +1.00 points (IQR: 0.00-2.25 points).

We found a significant association between Engagement Index and change in health knowledge survey score. In univariable regression, each 1-unit increase in the engagement index was associated with a 0.028-unit increase in health knowledge score (CI: 0.008-0.048, p = 0.009), out of a maximum of 11. This association remained statistically significant after adjustment for confounding variables: similarly, each 1-unit increase in the engagement index was associated with a 0.028-unit increase (0.008-0.048, p = 0.012) in health knowledge. More practically, a 10% higher engagement index score was associated with participants increasing their health knowledge score by 1.4 points more from pre to post test. Since the maximum change in health knowledge score from pre to post is +/-11 points, this represents a 12.7% higher increase in score.

In analyzing the individual indices that make up the composite engagement index, we found that the Support Index and the Adherence Index were individually associated with a change in health knowledge survey scores. Before adjustment, a one unit increase in the Adherence Index was associated with a 2.87-

unit higher change in health knowledge score from pre to post. A 1-unit increase in the Support Index, however, was associated with a 5.69-unit lower change in health knowledge. After adjustment, both remained statistically significant: participants with an Adherence Index score one unit higher were found to have on average 2.89 higher changes in health knowledge scores, compared to those with lower Adherence Index scores (95%CI: 0.765 – 5.017, p-value = 0.011). In contrast, a one-unit higher Support Index value was associated with an average change in health knowledge survey score 5.98 units lower (95%CI: -10.436, -1.515, p-value = 0.012). Practically, this means that a participant who sent 75% of the emojis of the day compared to one who sent just 25%, would be expected to have a change in health knowledge score 1.45 points higher. In addition, a participant whose messages were classified as 75% exchanges of social support, compared to one with just 25%, would be expected to have an approximately 3 points lower change in health knowledge from pre to post.

FAMA intervention content areas

During user-centered design of the FAMA intervention, participants identified six key content areas that they wanted or needed more information about, for the WhatsApp group messaging intervention: *family planning, baby growth and development, breastfeeding, baby illnesses, feeding baby, and understanding baby*. Included in content area of *family planning* was information about women's health, reproduction, methods of contraception, and myths related to sex and pregnancy. Under *baby growth and development* was included information about the month by month development that babies usually undergo, vaccination schedules and reminders, and early stimulation activities for babies (gross, fine, motor, language, and social skills). The *breastfeeding* topic covered information about the importance of breastfeeding, potential positions in which to breastfeed babies, and information and advice about potential issues mothers could encounter when trying to breastfeed. *Baby illnesses* included information about common infections, constipation, vomiting, allergies, and diaper rash. The *feeding baby* topic included information about nutrition for the first year of life, including what foods can and cannot be given to infants based on age, and advice for how to introduce new foods. Finally, the *understanding baby* content area included information about how to interpret a baby's cry, how to calm a baby, sleeping patterns, and general baby hygiene (including umbilical cord, bathing, skin, ear, and nail care). Each content area was covered for two of the 12-week intervention.

During post-intervention interviews (PIIs), interviewees were asked about the importance of different content areas, and what they learned or will apply from these content areas as a result of FAMA. Participants mentioned all six topics in interviews. Interviewees most often mentioned *family planning*, mentioned by 21 of the 27 participants (78%). Even the least mentioned FAMA topic—*baby growth and development*—was mentioned by 13 interviewees (48%). Most participants talked about multiple topic areas being particularly helpful for them:

> *Entrevistadora: ¿Y tienes algún ejemplo de algo que realmente has hecho?*
>
> *Participante: Le sigo dando la leche materna a mi bebé, sé cuándo llora es por algo, y qué debo hacer cuando mi bebé está estreñido y la planificación familiar.*
>
> Translation:
>
> *Interviewer: Do you have any example of something you have actually done [because of FAMA]?*
>
> *Participant: I am still breastfeeding my baby, I know that when my baby cries it is for a reason, and what I should do when my baby is constipated, and family planning.*

- *Group 2 participant, age 18*

Analysis of the WhatsApp chats identified similar topics, although only 13.3% of total messages were coded as on-topic (Table 1). Messaging related to the six different content areas ranged from 0.3% of total messages (Understanding Baby in group 3) to 5.6% (Growth and Development in group 1). On average, each topic accounted for about 1.5-3.5% of total messages. Although family planning was the topic most commonly mentioned in the PIIs, it was actually the topic that made up the fewest number of messages exchanged (overall it accounted for just 1.5% of total messages across all three groups).

The role of group moderators

The FAMA intervention not only allowed for peer-to-peer exchanges, but also provided experienced and knowledgeable group moderators who were available during business hours to respond to participants and send informational messages and reminders.

In post-intervention interviews, a similar number of interviewees mentioned the role of moderators (20) and fellow participants (18) in supporting them. However, moderators were more often mentioned (48 times), as compared to fellow participants (32 times). Many interviewees reported that moderators provided most of the informational support exchange in the intervention, and some participants reported specific content areas the moderator supported them with. Fellow participants were less commonly discussed as sources of informational support and were never mentioned as providing support related to a specific topic.

> *Aja porque a mi bebé se me… él antes no vomitaba, ahora está vomitando y yo he preguntado a [la moderadora] y ella me dijo que tenía que venir al pediatra para ver qué es, y [la moderadora] me dijo que eso es como normal o que es por algo que estoy comiendo.*
>
> Translation:
>
> *Mhm because my baby…before he didn't vomit, but now he is vomiting and I have asked [the moderator] and she told me that I had to come to the pediatrician to see what it is, and [the moderator] told me that that is somewhat normal or it's because of something that I am eating…*
>
> - *Group 3 participant, age 16*

> *[Ellas] me ayudaba[n] en esas cosas que sabían ellas, me ayudaban a mí, y yo las ayudaba a ellas.*
>
> Translation:
>
> *[Fellow participants] helped me in things that they knew, they helped me, and I helped them.*
>
> - *Group 2 participant, age 18*

Interviewees additionally reported that moderators provided extensive companionship support by playing, joking, and making participants feel at home in the group. Companionship support, however, was mentioned slightly more often as being provided by fellow participants than by moderators.

> *De verdad me gustó el grupo, me gustó, me gustó, me gustó porque [las moderadoras] me hicieron muy feliz, muy feliz y de verdad que eso me ha puesto muy mal que ya no vamos a poder compartir, pero por cualquier cosa yo voy a tener su número y cualquier cosa yo le escribo.*
>
> Translation:

Honestly I liked the group, I liked it, I liked it, I liked it because [the moderators] made me really happy, really happy and honestly that has made me feel really bad that we won't be able to share anymore, but whatever I need I will have their numbers so whatever comes up I will write them.

- Group 3 participant, age 18

Ehhh mis cosas favoritas fueron el compañerismo que teníamos.

Translation:

Uhh, my favorite thing was the companionship we had.

- *Group 2 participant, age 18*

In WhatsApp group chats, moderators contributed an average of 20.9% of all group messages (group 1: 25.9%, group 2: 22.4%, group 3: 16.7%). Importantly, moderators sent over half of all informational support messages (group 1: 51.8%, group 2: 53.4%, group 3: 54.6%), and contributed between 17.3%-22.3% of all companionship messages in the different groups, with all other companionship messages coming from participants themselves. Moderators accounted for about one-third of emotional and instrumental support messages, and participants for approximately two-thirds (Table 1).

Social Support: someone to share with (companionship support)

Interviewees reported that the intervention provided them with an opportunity to exchange companionship support and build friendships. In PIIs, the second most commonly mentioned domain of social support was companionship. In total, exchanges of companionship support were mentioned 63 times by 24 of the 27 interviewees. Interviewees talked about their enjoyment of chatting—sending and reading messages in the group, and even sending pictures of their babies each week.

Bueno, yo me sentía más conectada con ellas porque yo hablaba con ellas cosas, uno se sentía divertido hablando con ellas, y hablaban cosas buenas.

Translation:

Well, I felt more connected with them because I talked about things with them, it was fun talking with them, and they talked about good things.

- *Group 2 participant, age 18*

Ehhh, me gustó mandar la carita del día, o sea el emoji del día, ehh, que hablábamos de los niños y los viernes que había que mandar foto de los niños, y eso me gustó.

Translation:

Uhh, I liked sending the little face of the day, I mean the emoji of the day, uhh, that we talked about the kids, and on Fridays we had to send a picture of the kids, and I liked that.

- *Participant (unable to be linked with demographic information)*

In addition, some interviewees mentioned that they now feel like as a result of FAMA they have more friends and people to share enjoyable activities with, not only through WhatsApp, but in-person as well.

> *Oh, conocí muchos, a muchas amigas, hablábamos de hacernos amigas, vamos a seguir saliendo.*
>
> Translation:
>
> *Oh, I met a lot, a lot of friends, we talked about becoming friends. We are going to keep going out.*
>
> - Group 1 participant, age 16

The WhatsApp chats themselves demonstrated that the intervention created a space where participants could connect with each other, share personal stories about their babies, commiserate and laugh about some of the difficult moments of motherhood, and even sometimes brag about their babies.

> *Tengo un bebé muy inteligente que si yo digo lo que ese niño ha echo y ese nadie me cree o me dicen mentirosa.*
>
> Translation:
>
> *I have a very intelligent baby, if I tell you what this baby has done no one believes me or they call me a liar.*
>
> - *Group 1 participant, age 18*

Even through simple things like daily check-ins and greetings, mothers were able to use the group chat to build friendships based on shared experiences.

> *Bueno días cómo está que Dios esté con cada una nosotras.*
>
> Translation:
>
> *Good morning, how are you? May god be with each one of us.*
>
> *-Group 3 participant, age 19*

Of the four social support domains, companionship support messages were the most commonly observed in the WhatsApp chats. Overall, message exchanges of companionship support accounted for 46.5% of all messages. Moderators contributed between 17.3%-22.3% of all companionship messages in the different groups. Fellow participants contributed the remaining 77.3-83.7% of messages. Although moderators exchanged companionship support with participants, the large majority of companionship support exchange was through messages sent by the participants themselves.

Social Support: someone to count on (informational support)

Participants also reported that FAMA gave them a place where they could turn with any questions, concerns, and doubts, without fear of judgement. Informational support was the most common domain of social support exchange to be mentioned during PIIs, mentioned by all but two interviewees (25/27). Many of the interviewees mentioned that the information shared during the FAMA intervention was particularly important for them because they were first time mothers and had little knowledge about how to care for their infants.

> *Como una madre primeriza, [FAMA] nos enseñó cómo atender a los bebés, cómo cuidarlos, cómo bañarlos, cómo ponerle ropa, cómo darle de comer, cuántas veces hay que darle comida y eso, eso fue.*
>
> Translation:
>
> *As a first time mother, [FAMA] showed us how to attend to our babies, how to take care of them, how to bathe them, how to put their clothes on, how to feed them, how many times you have to give them food, and that, that was it.*
>
> *- Group 1 participant, age 20*

According to interviewees, the informational support they received included not only important information about their babies, but also advice for how to take care of themselves. The informational support that the interviewees received often contradicted some of their long-held beliefs, exposing these beliefs as myths, which participants were proud to be able to contradict after the intervention.

> *Ese programa es muy bueno porque me ayuda a aprender muchas cosas, cosas que yo pensaba que eran verdaderas y son mitos de las personas.*
>
> Translation:
>
> *This program is very good because it helps me learn many things, things that I thought were true, and are actually peoples' myths.*
>
> - Group 1 participant, age 16

In addition, various interviewees mentioned that they were able to provide informational support for their peers (both inside and outside of the study), partners, and even their own mothers as a result of what they learned in FAMA.

> *Oh, con mi esposo un ejemplo, me siento más… o sea yo le digo cosas que él piensa como se le puede hacer al niño y le explico que sí se puede, se le puede dar su comidita, cómo se le puede dar su comidita al niño y él lo hace cuando él se queda con él, con mi mamá, y antes le daba y que té de anís y de orégano, y yo dije: "No, eso no se le puede dar", y me dijo: "Okey", y le expliqué.*

Translation:

Oh, with my husband for example, I feel more…well I tell him things that he thinks he can do to the baby, and I explain to him that yes he can, he can give the baby food, how he can give food to baby, and he does it when he stays with him. With my mom, before she gave him anise and oregano tea, and I said: "No, you can't give him that," and she said "Okay," and I explained it to her.

- *Group 1 participant, age 16*

Participants' accounts in PIIs regarding informational support were consistent with observations from the WhatsApp chats themselves. Participants in FAMA not only reported receiving informational messages each day but reported that they could ask any question in the group and get the response they needed. Participants used the group chat to ask about specific concerns.

Otra pregunta, si yo tengo, no sé, fiebre, dolores del cuerpo, y ese tipo de cosas, ¿a la bebé se le puede pasar a través del seno?

Translation:

Another question, if I have, I don't know, fever, body aches, and that type of thing, can I pass it to my baby through breastfeeding?

-Group 3 participant, age 18

Informational support messages were the second most common in WhatsApp chats overall, accounting for 7.9% of all messages across the three groups. Here, moderators played an important role, sending over half of all informational support messages (group 1: 51.8%, group 2: 53.4%, group 3: 54.6%), correcting erroneous beliefs and providing medical advice.

Ese es otro mito de las personas que nos rodean. Por eso queremos que estén bien informadas, hay veces que la leche del seno sabe salada, sin embargo no hace daño al bebé, lo único que hay que hacer es sacar un poco para sacar esa primera leche. Luego será dulce.

Translation:

That is another myth of the people who surround us. Because of that we want you to be well-informed, there are times where breastmilk will taste salty, but it doesn't harm the baby, the only thing you have to do is take out a little to get out that initial milk. Then it will be sweet.

- *Moderator in group 3*

Se recomienda que se desparasite a los niños a partir de los dos años, y en zonas de escasos recursos o poca salubridad, la prevalencia de parásitos es mayor y se recomienda desparasitar a los niños desde los 12 meses (1 año).

Translation:

It is recommended that children are dewormed starting at two years of age, and in zones with limited resources or poor health, where the prevalence of parasites is higher, it is recommended that children are dewormed starting at 12 months (1 year).

– Moderator in group 1

Importantly, moderators were not the only ones providing advice and information, but WhatsApp chats included participants themselves often offering their own pieces of advice or sharing relevant experiences with the hopes of supporting each other.

Participante del grupo 2, 17 años: Los vómitos no te preocupes que si vomita mucho es para engordar.
Participante del grupo 2, 19 años: No mi amor para engordar no es, porque mi hija va a tener casi un mes vomitando, que todo lo que le llega al estómago lo vomita, mi niña no come, no quiere nada de comer, ella está muy delgadita, no es porque ella va a engordar, ella tenía gripe y la gripe se le quitó, lo único que no se le quiere quitar es los vómitos.

Translation:

Group 2 participant, age 17: Don't worry about vomiting, if baby vomits a lot they will get fatter.

Group 2 participant, age 19: No my love, it does not make babies get fatter, because my daughter has been vomiting for almost a month, everything she eats she vomits, she doesn't eat, she doesn't want anything to eat, she is very skinny, it's not because she is going to get fatter, she has a cold and she got over her cold but the only thing she hasn't gotten over is the vomiting.

Ay tu tienes que tener cuidado con eso, llévala al médico.

Translation:

Oh, you need to be careful with that, take her to the doctor.

-Group 2 participant, age 17

Social Support: someone to turn to (emotional and instrumental support)

According to PII interviewees, emotional and instrumental exchanges occurred less frequently than either companionship or informational support. Participants more often described emotional support as being provided by moderators than fellow participants.

He tenido muchos problemas con mi relación con el papá del bebé, [las facilitadoras] me han ayudado mucho.

Translation:

I have had a lot of problems with my relationship with the father of my baby, and the moderators have helped me a lot.

- *Group 2 participant, age 18*

In terms of emotional support, participants in PIIs talked about how moderators assured participants that they could reach out with whatever they needed via private messages, and that even after the study was over, they would be available to participants.

> *Muy bien, son muy simpáticas las dos [facilitadoras] y cuando necesitaba una ayuda en privado siempre estaban ahí para mí, cualquier momento, cualquier situación.*
>
> Translation:
>
> *Very good, both [the moderators] are very nice, and when I needed any private help they were always there for me, at any time, in any situation.*
>
> - *Group 1 participant, age 16*

According to PII interviewees, both moderators and fellow participants were involved in the exchange of instrumental support, though these exchanges were rarely reported.

> *Bueno…fue algo muy bonito. Participé mucho, me dieron mucho apoyo cuando se me quemó mi hogar, compartieron conmigo, enviaron cosas, son muy buenas todas, [las facilitadoras] también nos apoyaron. Yo me sentí muy bien y apoyada, hasta el autoestima me subió, que fue algo muy bonito.*
>
> Translation:
>
> *Well…it was something very beautiful. I participated a lot, they gave me a lot of support when my home burned down, they shared with me, they sent things, they're all good people. The moderators helped us too. I felt very supported, even my self-esteem increased. It was a very beautiful thing.*
>
> - *Group 3 participant, age 18*

Each of the three WhatsApp intervention groups similarly demonstrated clear examples of participants who turned to the FAMA group during a particularly difficult moment in their lives. From experiences with post-partum depression, to the loss of a family member, to even the loss of a home and belongings to an accidental fire—participants turned to this group for both instrumental and emotional support. However, emotional and instrumental support messages made up relatively small proportions of total messaging (emotional:1.7%, instrumental: 0.5%).

> *Ay sí mija, yo estoy destrozada porque ahora se quemó todo de la niña, todo de lo mío, todo, yo no tengo ahora nada, ni donde sentarme, nada se me quemó todo, yo estoy destrozada.*
>
> Translation:
>
> *Oh yes, I am shattered because now all my girl's things have burned, all of my things, everything, I don't have anything now, not even a place to sit, nothing. Everything was burned, I am shattered.*
>
> - *Group 3 participant, age 18*

Moderators accounted for about one-third of both emotional and instrumental support messages, with participants sending the other two-thirds of these messages.

> *Todas las que puedan, pueden traer lo que le van a dejar a [la participante] aquí en el MAMI, y este, yo te voy a llamar [participante] para que venga a retirar lo que te tengo mientras tanto, pero en la semana, o sea desde esta tarde a mañana yo te consigo más cosas, al menos pampers vas a tener y alguna otra ropita.*
>
> Translation:
>
> *All who are able, you can bring what you are going to give to [the participant] here at MAMI, and I, I will call you [participant] so you can come and pick up what I have for you in the meantime. But during this week, starting this afternoon until tomorrow I will get you more things, at least you'll have some pampers and some other clothes.*
>
> *-Moderator, group 3*

Discussion

mHealth interventions are increasingly used, as access to mobile phones continues to expand on the global scale, in particular among adolescents and young adults (26). Although mHealth techniques are being implemented and tested in a variety of areas, including maternal and child health, this study is one of few utilizing the group chat feature in the WhatsApp application to allow for peer interaction (38,39). Most mHealth studies focused on maternal and child health to date have used other applications and SMS messaging to deliver interventions(38).

In this study we found that adolescent mothers were able to use this intervention not only to get advice and information needed for their own health and the health of their babies, but they also spent time sharing experiences, jokes, and even commiserating with fellow mothers. Although most of their messages were not explicitly tied to the selected six key content areas, participants reported gaining important knowledge, learning new skills, and even being able to dispel common health-related myths prevalent in their communities as a result of this intervention. The most common FAMA topic discussed in the groups was that of *baby illnesses*—largely due to instances where participants would reach out for help, advice, or even emotional support when their babies were ill. Interestingly, *family planning* was the topic mentioned most during PIIs, but least discussed in the WhatsApp chats themselves. This could indicate that although this was a powerful and important topic to cover for these new mothers, they might have felt less comfortable talking about this particular content area in a group chat.

Moderators played an important role in this intervention, as they not only provided informational messaging, but were also available to participants no matter what issues or questions they had. Having access to knowledgeable health professionals was particularly helpful for this group of largely new and unexperienced mothers who otherwise would have limited access to scientifically-sound advice. Moderators were not only vehicles of informational support in these groups, but were also able to connect, joke, and share other forms of social support with participants. Respondents also emphasized

that moderators were involved in providing companionship support and were more often the ones providing emotional support compared to fellow participants.

Despite having moderators present in groups, participants themselves often offered advice or answered questions for each other before moderators had a chance to respond. Sometimes, this advice was at odds with recommendations from moderators and they would gently but firmly correct myths and offer medically-sound advice. Often participants gave each other sound advice as well, and repeated things they had already learned during the intervention to each other. The main role of peers in this group, however, was in exchanging companionship support with one another. Largely, this support took the form of greetings, check-ins, general small talk, and sharing stories, experiences or even frustrations related to their experiences as new mothers. Because adolescent motherhood can be an isolating experience, having these virtual conversations with other women who could fully relate to their own experiences was a vital part of appeal of this intervention to participants.

In order to assess the clinical impact of the FAMA intervention, we evaluated the association between engagement and contraception use, change in social support, and change in health knowledge. We found no association between engagement and contraception use or change in social support. However, we found that engaging with the intervention was associated with improved health knowledge survey scores from pre to post test. This suggests that participants who were more fully engaged (as measured by our index) with the intervention, tended to increase their knowledge scores more than those who were less engaged.

Both the Adherence and Support Indices were statistically significantly associated with changes in health knowledge scores. More adherent participants—those who more often sent the required emoji of the day—were more likely to experience higher increases in health knowledge from pre to post test. Interestingly, this association was found for the Adherence, but not for the Consistency Index, which measured the proportion of days participants sent a text message. Although we posited that sending a text message involves more potential for engagement with the group and daily topics, it seems that sending the emoji of the day was a better predictor of changes in health knowledge.

The Support Index was negatively associated with changes in health knowledge. Although we had conjectured that those more involved in exchanging support with one another would benefit more from the intervention, we found the opposite association. In further study we hope to sub-divide the Support Index into the four domains of social support to ascertain if one particular domain drove the association with change in health knowledge.

Although engagement in this intervention with fellow adolescent mothers was not itself found to be significantly associated with changes in social support survey scores, having a partner at baseline was found to be positively associated. While the median change in social support survey scores from pre to post was just over 8 points, those who had a romantic partner at the start of the intervention on average experienced a 21-point higher increase from pre to post compared to those who did not. This finding suggests that romantic partnership may have a larger bearing on experiences of social support than the kinds of relationships developed in this intervention.

In addition, our Engagement Index was not significantly associated with contraceptive use at end of intervention. One potential explanation for this finding could be that because family planning was only one of six topics addressed in this intervention, its impact was diluted and did not result in significant

changes in contraception use. Also, considering the short duration of the intervention (12 weeks) and the fact that family planning was the last topic addressed during the intervention, it is possible that measuring contraception use right at the end of the 12-week period did not fully capture all those who began using contraception. Further study will aim to control for pre-intervention contraception use in order to isolate those who may have adopted the use of contraception throughout the study period. However, because these women were recruited from those attending the MAMI clinic, it is possible that a disproportionate number of participants were already using contraception at the start of the study, making contraception uptake from pre to post less likely.

A strength of this study was that it was conducted using mixed methods—both quantitative and qualitative analyses built upon each other to give a more holistic view of how participants engaged with this intervention, and how they talked about their experience. Because we were able to not only analyze post-intervention interviews but also the WhatsApp chat messages themselves, we were able to compare participants' reported experiences with those we observed in the group chat itself.

In addition, the FAMA intervention itself possessed a variety of strengths including its user-centered design, the use of an innovative platform in WhatsApp, and the way this intervention allowed conversations to be driven by both peers and moderators. This design allowed participants to get the information they needed and wanted through an app that most were already familiar with before the start of the intervention.

There were various limitations to this study, which arose both from the initial intervention itself, and limitations of the analysis proposed in this thesis project.

One limitation of the original FAMA study itself was that this intervention was only conducted with adolescent mothers from one clinic in the Dominican Republic. This, along with the relatively small sample size used in this study limits the generalizability of results to a broader population and limited our ability to control for potentially confounding factors. In addition, this intervention was not designed as a randomized control trial. This study therefore identifies associations but does not allow us to draw causal links between the intervention and observed outcomes.

While this was in part a limitation, the FAMA study was able to conduct this research with the relatively understudied population of adolescent mothers in the Dominican Republic. Few studies have focused mHealth interventions in the Latin American and Caribbean region, and fewer still on adolescent mothers—despite widespread access to mobile phones. This study provides an important first step in expanding the accessibility of evidence-based services to these populations.

Another limitation was the significant amount of missing data. Some media messages from the group chats were not downloaded along with other messages. Images and videos available were limited by the storage capacity of the study team member device. Because analysis of these messages was not an initial aim of the project, this data was not stored. As a result, images and videos were not available and their content could not be analyzed for the purposes of this study. This likely results in under-reporting of exchanges of social support and FAMA topic-related messaging.

Multiple participants also had incomplete demographic information, contraceptive use data, and even missing values for both health knowledge and social support survey scores. This further limited this study as the full sample size could not be analyzed for many of the quantitative analyses. This could have

affected the outcomes of this study as those whose information was incomplete were likely those least engaged with the intervention and this may have resulted in the presence of residual confounding. Despite these limitations however, we were able to adjust for a variety of potential confounders.

Within the analysis conducted for this thesis, one limitation arises from the fact that I, along with the other members of the study and coding team, do not share many of the intersectional identities of the participants in FAMA. Although the members of the coding team are all bilingual Spanish and English speakers, none share the unique experiences of project participants as Dominican adolescent mothers, and there may be important differences in Dominican Spanish and slang not easily understood by coders unfamiliar with Dominican Spanish. While qualitative texts have not been translated into English in order to preserve as much of their original meaning as possible, it is likely that these differences in identity will cause some nuances of participant perceptions and experiences to be lost.

Another important limitation to this analysis is that in all three of the WhatsApp chat groups, some members decided to make another, separate chat group just for the participants to talk—with no rules and without the participation of the moderators. This limits our ability to assess how social support was exchanged and how participants engaged within these groups as we only have access to the moderated intervention chat groups.

Additionally, some limitations arise with the analysis of WhatsApp chat data itself. As a relatively new area of study, there is little guidance from peer-reviewed sources or established literature on how to analyze this kind of data. Similarly, there is even less information on how to use WhatsApp chat data to evaluate intervention engagement. This lack of established methodologies has allowed for the development of a unique engagement metric to fit this particular intervention but may also pose a limitation as the selected metrics have not been validated.

As mentioned above, some of the metrics we used have not been validated. In particular, the social support survey scales have all been individually validated but using a sum of scores of these five areas of social support has not. Additionally, the measure we use to represent engagement has not been empirically validated and may not fully account for the broad range of possible engagement styles. For example, we have no data on time spent in group chats. Therefore, we cannot know which participants were taking the time to actively read and think about messages unless they actually sent a message in response. Similarly, even if a participant did send a response, we do not know that they took time to read and understand the message, all we know is that they responded. While this is a limitation to our study, to our knowledge it represents the first attempt at quantifying engagement in a WhatsApp-based intervention. Because WhatsApp does not have a built-in system for collecting para data, other metrics for measuring participant engagement must be developed. As WhatsApp is a broadly used application among global youth, it is likely that future interventions will seek to capitalize on this free platform and will need mechanisms for measuring participant engagement. This study may provide a starting point for future WhatsApp-based interventions aiming to understand the ways participants engage.

Despite the limitations present in this study, interventions such as FAMA have the potential to play an important role in supporting young mothers in low-resource communities. In particular, these kinds of interventions have the potential to connect mothers to each other, and to the information they need as they navigate motherhood. In addition, interventions such as FAMA may play a role in expanding health knowledge, yet more randomized control trial evidence is needed to support this. Although few of our results showed traditional statistical significance, we recognize the limitations of the use of the cut-off

point of $p < 0.05$ in trivializing important work conducted with small sample sizes. These small community-based studies provide critical data for designing larger interventions to support often marginalized communities and ensuring their needs are met in early development. For this particular intervention it was clear that an increase in health knowledge was associated with more engagement in participants, yet we could not detect associations between contraception use or social support and participant engagement. Further study is needed to determine the long-term effects of an intervention like FAMA, and also its cost-effectiveness for larger-scale implementation. In the field of mHealth, there is a need for further study of the different ways in which participants may interact and engage with maternal and child health interventions.

Table 1:

Descriptive statistics from WhatsApp chats

Statistic	Group 1	Group 2	Group 3	Overall
Number of Participants	16	20	22	58
Number of Intervention Days	82	85	85	252
Total Messages	4458	5915	7335	17708
Total Moderator Messages (%)	1156 (25.9%)	1322 (22.4%)	1224 (16.7%)	3702 (20.9%)
Total Participant Messages	3389	4593	6111	14093
Average Messages Per Participant	278.6	295.8	333.4	305.3
Average Daily Messages	54.4	69.6	86.3	70.3
Audio Messages Total (%)	160 (3.6%)	324 (5.5%)	406 (5.5%)	890 (5.0%)
Media Messages (%)	205 (4.6%)	109 (1.8%)	151 (2.1%)	465 (2.6%)
Emoji Messages (%)	1247 (28.0%)	1662 (28.1%)	1317 (18.0%)	4226 (23.9%)
Text Messages (%)	3533 (79.3%)	4530 (76.6%)	5741 (78.3%)	13804 (78.0%)
Family Planning Messages (%)	118 (2.7%)	41 (0.7%)	108 (1.5%)	267 (1.5%)
Breastfeeding Messages (%)	124 (2.8%)	146 (2.5%)	111 (1.5%)	381 (2.2%)
Baby Illnesses Messages (%)	192 (4.3%)	321 (5.4%)	145 (2.0%)	658 (3.7%)
Growth and Development Messages (%)	249 (5.6%)	169 (2.9%)	151 (2.1%)	569 (3.2%)
Feeding Baby Messages (%)	132 (3.0%)	159 (2.7%)	54 (0.7%)	345 (2.0%)
Understanding Baby Messages (%)	138 (3.1%)	118 (2.0%)	24 (0.3%)	280 (1.6%)
On-topic Messages (%)	996 (22.3%)	674 (11.4%)	687 (9.4%)	2357 (13.3%)
Other Content Messages (%)	1303 (29.2%)	1893 (32.0%)	2620 (35.2%)	5816 (32.8%)
Companionship Support Messages Total (%)	1788 (40.1%)	2618 (44.3%)	3832 (52.2%)	8238 (46.5%)
Moderator Companionship Support Messages (%)	398 (22.3%)	579 (22.1%)	664 (17.3%)	1641 (19.9%)
Emotional Support Messages (%)	92 (2.1%)	88 (1.5%)	114 (1.5%)	294 (1.7%)
Moderator Emotional Support Messages (%)	48 (52.2%)	29 (33.0%)	34 (29.8%)	111 (37.8%)
Informational Support Messages (%)	492 (11.0%)	476 (8.0%)	425 (5.8%)	1393 (7.9%)
Moderator Informational Support Messages (%)	255 (51.8%)	254 (53.4%)	232 (54.6%)	741 (53.2%)
Instrumental Support Messages (%)	15 (0.3%)	14 (0.2%)	54 (0.7%)	83 (0.5%)
Moderator Instrumental Support Messages (%)	10 (66.7%)	9 (64.3%)	12 (22.2%)	31 (37.4%)
Forum Response Messages (%)	62 (1.4%)	45 (0.8%)	49 (0.7%)	156 (0.9%)
Adherence Index Average	0.374	0.392	0.402	0.391
Diligence Index Average	0.344	0.2	0.227	0.25
Consistency Index Average	0.543	0.466	0.406	0.464
Support Index Average	0.483	0.48	0.576	0.517
Immersion Index Average*	0.5	0.5	0.498	0.499
Engagement Index Average	39.242	40.829	41.874	40.788

* calculated as per-group percentile

Table 2: Participant baseline characteristics

	Intervention participants (N=58)		Post-intervention interview participants (N=27)	
	Total (N)	**n (%) or median (IQR)**	**Total (N)**	**n (%) or median (IQR)**
Participant Age (Years)	58	18.0 (17.0-18.0)	25	18.0 (17.0-18.0)
Infant Age (Months)	57	3.0 (1.0-5.0)	25	4.0 (1.0-7.0)
Declared Status	58	53 (91.4%)	25	23 (92.0%)
Government-Issued ID	58	36 (62.1%)	25	12 (48.0%)
Attend School	58	23 (39.7%)	25	13 (52.0%)
Highest Grade Level	58	9.0 (8.0-11.0)	25	9.0 (8.0-11.0)
Partner	58	46 (79.3%)	25	22 (88.0%)
Partner Duration (Years)	46	2.0 (1.0-3.0)	22	2.0 (1.0-3.0)
Legally Married	46	2 (4.4%)	22	2 (9.1%)
Employed	58	2 (3.5%)	25	0 (0.0%)
Number of Children	58	1.0 (1.0-1.0)	25	1.0 (1.0-1.0)
Contraceptive Use	53	33 (62.3%)	24	16 (66.7%)
Health Knowledge score	44	7.0 (7.0-8.0)	25	7.0 (6.0-8.0)
Social Support score	39	255.6 (239.1-266.7)	20	258.7 (243.3-270.1)

Table 3: Participant characteristics at end of intervention

	Total (N)	n (%) or median (IQR)
Post-intervention Contraceptive Use	53	42 (79.3%)
Change in Health Knowledge Survey Score	44	1.0 (0.0-2.3)
Change in Social Support Survey Score	39	8.3 (-11.4-17.5)
Adherence Index	58	0.4 (0.1-0.6)
Diligence Index	58	0.2 (0.2-0.3)
Consistency Index	58	0.5 (0.3-0.7)
Support Index	58	0.5 (0.4-0.6)
Immersion Index	58	0.50 (0.2-0.8)
Engagement Index	58	44.5 (11.5-62.8)

Table 4: Correlates of contraception use at end of intervention

	N	No Contraception Use	Contraception Use	Unadjusted RR (95% CI)	Unadjusted p-value	Adjusted RR	Adjusted p-value
		n (%) or median (IQR)					
Participant Age (Years)	53	18.00 (17.50-19.00)	17.50 (16.25-18.00)	0.92 (0.80-1.07)	0.269		
Infant Age (Months)	53	2.00 (0.00-3.50)	4.00 (1.00-5.75)	1.03 (0.98-1.07)	0.246		
Number of Children	53	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.81 (0.44-1.48)	0.489		
Highest Grade Level		9.00 (9.00-10.50)	9.00 (8.00-11.00)	0.99 (0.91-1.06)	0.732		
Currently Attend School	53						
Yes	21	4 (19.05%)	17 (80.95%)	1.04 (0.81-1.33)	0.780		
No	32	7 (21.88)	25 (78.13%)	Ref			
Declared Status	53						
Yes	49	10 (20.41%)	39 (79.59%)	1.06 (0.59-1.89)	0.841		
No	4	1 (25.00%)	3 (75.00%)	Ref			
Government-Issued ID	53						
Yes	34	9 (26.47%)	25 (73.53%)	0.82 (0.64-1.05)	0.113		
No	19	2 (10.53%)	17 (89.47%)	Ref			
Current Partner	53						
Yes	41	8 (19.51%)	33 (80.49%)	1.07 (0.76-1.52)	0.689		
No	12	3 (25.00%)	9 (75.00%)	Ref			
Current Partnership Duration (Years)	41	2.00 (1.00-3.00)	2.00 (1.00-3.00)	1.00 (0.90-1.12)	0.973		
Adherence Index	53	0.49 (0.13-0.60)	0.44 (0.15-0.64)	1.05 (0.67-1.65)	0.822	0.98 (0.59-1.62)	0.943
Diligence Index	53	0.17 (0.17-0.25)	0.17 (0.17-0.46)	1.29 (0.85-1.95)	0.235	1.20 (0.74-1.95)	0.470
Consistency Index	53	0.46 (0.31-0.58)	0.55 (0.33-0.70)	1.37 (0.83-2.28)	0.222	1.27 (0.73-2.21)	0.391
Support Index	53	0.56 (0.51-0.65)	0.50 (0.43, 0.59)	0.56 (0.19-1.66)	0.298	0.72 (0.24-2.15)	0.560

Immersion Index	53	0.57 (0.25-0.68)	0.53 (0.25-0.78)	1.06 (0.67-1.67)	0.815	1.01 (0.62-1.65)	0.966
Engagement Index	53	51.30 (14.54-62.18)	46.08 (16.44-65.78)	1.00 (1.00-1.01)	0.813	1.00 (0.99-1.00)	0.952

N = 58 total, 53 with Contraception Use Data

Table 5: Correlates of change in health knowledge survey score

	Unadjusted coefficient	95% CI	Unadjusted p-value	Adjusted coefficient	95% CI	Adjusted p-value
Age	0.02	-0.430 - 0.47	0.928			
Infant Age	0.03	-0.16 - 0.21	0.794			
Number of Children	0.31	-1.10 - 1.71	0.670			
Declared Status	-0.50	-2.62 - 1.63	0.650			
Government-Issued ID	-1.11	-2.16 - -0.05	0.046			
Attend School	-0.16	-1.25 - 0.94	0.778			
Highest Grade Level	0.02	-0.19 - 0.23	0.840			
Partner	-0.27	-1.74 - 1.20	0.724			
Partner Duration (years)	-0.36	-0.80 - 0.08	0.114			
Adherence Index	2.87	0.83 - 4.90	0.008*	2.89	0.77 - 5.02	0.011*
Diligence Index	0.24	-2.12 - 2.60	0.845	0.19	-2.56 - 2.93	0.894
Consistency Index	1.69	-0.83 - 4.20	0.196	1.84	-0.88 - 4.55	0.193
Support Index	-5.69	-9.85 - -1.53	0.010*	-5.98	-10.44 - -1.52	0.012*
Immersion Index	0.87	-0.99 - 2.74	0.364	0.96	-1.04 - 2.97	0.352
Engagement Index	0.03	0.01 - 0.05	0.009*	0.03	0.01 - 0.05	0.012*

Table 6: Correlates of change in social support survey score

	Unadjusted coefficient	95% CI	Unadjusted p-value	Adjusted coefficient	95% CI	Adjusted p-value
Age	3.14	-2.80 - 9.08	0.307			
Infant Age	0.32	-2.37 - 3.00	0.817			
Number of Children	-3.37	-20.72 - 13.98	0.706			
Declared Status	-1.81	-33.63 - 30.02	0.912			
Government-Issued ID	8.75	-5.62 - 23.11	0.240			
Attend School	-1.16	-15.58 - 13.27	0.876			
Highest Grade Level	-2.24	-7.25 - 2.77	0.387			
Partner	21.27	1.42 - 41.12	0.043 *			
Partner Duration	39.60	-1.69 - 9.61	0.179			
Adherence Index	-7.13	-37.13 - 22.87	0.644	-13.82	-44.14 - 16.49	0.378
Diligence Index	-5.81	-37.58 - 25.97	0.722	0.86	-32.27 - 33.99	0.960
Consistency Index	-17.8	-53.59 - 17.95	0.335	-15.59	-51.23 - 20.05	0.397
Support Index	6.25	-51.82 - 64.32	0.834	16.68	-43.85 - 77.21	0.593
Immersion Index	-15.15	-38.79 - 8.48	0.217	-15.45	-39.19 - 8.29	0.211
Engagement Index	-0.07	-0.37 - 0.22	0.630	-0.14	-0.44 - 0.16	0.374

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