FINAL TECHNICAL REPORT_AMERICAN UNIVERSITY OF BEIRUT

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THE GAMIFICATION, ARTIFICIAL INTELLIGENCE AND MHEALTH NETWORK FOR

MATERNAL HEALTH IMPROVEMENT

* The GAIN MHI Project *

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The Gamification, Artificial Intelligence (AI) and mHealth Network for Maternal Health Improvement (GAIN MHI) is a 3-year project that aims to improve maternal health and enhance the uptake of antenatal care services among disadvantaged and refugee pregnant women through the employment of an innovative contextualized multi-component digital health intervention including mHealth, gamification for development of health professionals, and artificial intelligence. The project also aims to improve the quality of care provided to the pregnant women, by their specialized healthcare providers (HCPs) (mainly OBGYN specialists), and midwives.

This project is a community trial including a total of 19 Primary Healthcare Centers (PHCs) of which 9 PHCs have been designated as intervention sites and 10 PHCs served as control sites. Among the intervention sites, 5 PHCs are operatd by the United Nations Relief and Works Agency (UNRWA) serving solely Palestinian refugees in Lebanon, and 5 PHCs were non-UNRWA PHCs were affiliated with the Lebanese Ministry of Public Health (MOPH) and serving both disadvantaged Lebanese and non-Lebanese patients (Syrian, Iraqi, etc.). Similarly, among the control sites, 5 PHCs were UNRWA centers and the 5 others were MOPH PHCs.

The project started in April 2020 and was concluded in September 2023. Throughout the implementation phase of the project, data from 5352 pre-intervention and 4772 post intervention charts were collected. As part of the intervention, 1977 pregnant women, 1000 spouses, and 15 HCPs were enrolled to receive weekly gestational age specific educational messages (pregnant women and spouses) and use a professional development mobile application based on artificial intelligence and gamification (healthcare providers). A post intervention satisfaction survey was conducted with around 1023 pregnant women, 487 spouses and 12 HCPs.

Through leveraging mHealth technology, the GAIN MHI project provided equitable access to reliable information for both pregnant women and their HCPs and is currently evaluating its success through data on maternal health outcomes. Focusing on disadvantaged settings, the project fostered a positive health-seeking behavior by engaging both pregnant women and their spouses, recognizing the challenge of changing deep-rooted cultural norms. Additionally, the GAIN MHI mobile app served as a platform for HCPs to access updated, evidence-based information, facilitating continuous learning and professional development. One scholarly article titled 'Maternal Health Outcomes in the context of fragility: A Retrospective Study from Lebanon' reflecting baseline maternal health outcomes in PHCs prior to the initiation of the intervention was published in Journal of Conflict and Health. Other data from the study is currently being analyzed to generate additional articles and dissemination material in alignment with the project objectives.

THE RESEARCH PROBLEM

THE RESEARCH PROBLEM

The Middle East and North Africa (MENA) region, marked by persistent conflicts in many countries, has seen a significant influx of refugees, with Lebanon hosting the highest per capita. This ongoing refugee crisis places the Lebanese healthcare system in a situation of fragility with insufficient infrastructure and lack in availability of skilled health human resources in place, leading to sub-optimal service delivery and limited access to care especially in disadvantaged communities and low-resource settings. Access to antenatal care (ANC) for pregnant women, including Palestinian and Syrian refugees, has been a challenge with pregnancy-related complications being prevalent, especially among Syrian refugees.

GAIN MHI as a mHealth intervention, aimed to address these challenges by improving maternal health outcomes and access to ANC among pregnant women. Such intervention aligns with global maternal health goals, including engaging men in maternal health, improving healthcare worker support through mHealth, and using gamification and AI to enhance professional development.

The challenges included:

1. **Knowledge gaps towards maternal health among disadvantaged Lebanese pregnant women and refugees**: The project through the Knowledge, Attitudes, Practices (KAP) survey at time of recruitment of pregnant women and through the follow up at the end of the intervention period will assess the behavioral outcome indicators of pregnant women. The assessment will include cognitive antecedents of ANC visits to assess changes in cognitions due to the intervention. These include attitudes towards ANC visits, perceived social norms about ANC visits, and intention to attend/continue attending ANC visits.
2. **Suboptimal access to ANC visits:** Due to the limited availability of recent data concerning the health outcomes of pregnant women in Lebanon, particularly within disadvantaged communities, this study has examined the maternal health outcomes of disadvantaged Lebanese and refugee pregnant women who sought ANC services at PHCs in Lebanon. Consequently, this study has established a baseline for evaluating any subsequent enhancements in maternal health outcomes that might arise from interventions implemented in this domain.
3. **Gender inequity's impact on maternal health:** From a gender perspective, research has shown that gender inequity negatively affects maternal health, and access to and utilization of maternal healthcare services in several ways. With men considered as the key-decision makers, they often control women's access to economic resources and therefore, affect women's access to ANC and obstetric outcomes. Given the importance of the familial support during pregnancy, this project aims to highlight on main gender dynamics among studied population and underline the effect of engaging spouses in mhealth interventions on information uptake and health outcomes of pregnancy women.
4. **Inequitable access to reliable and up-to-date information and guidelines for practice:** Pregnant women encounter barriers in accessing information related to their health and well-being, leading to disparities in knowledge and awareness. This lack of access can impede their ability to make informed decisions about maternal health, which was targeted by the GAIN MHI project through the weekly gestational age specific informative messages.

5. **Resource constraints including limited continuing education programs and career development, shortage in healthcare professionals and disparities in geographic distribution of providers:** Healthcare providers face obstacles in being aware of the latest guidelines and best practices due to disparities in resource allocation, training opportunities, or information dissemination. The project through the GAIN MHI App has assessed the satisfaction and acceptability of healthcare providers with a novel mLearning tool for their professional development.

OBJECTIVES

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The GAIN MHI research project was guided by five (5) questions:

1. Do targeted mHealth interventions affect access to ANC services and pregnancy outcomes among refugees and disadvantaged women?
2. Is the engagement of spouses in mHealth interventions act as an enabler for ANC services uptake and favorable health outcomes among refugees and disadvantaged women?
3. Does the integration of gamification and AI in the professional development of care providers increase information uptake and enhance evidence-based practice?
4. What is the return on investment of using mHealth interventions among refugees and disadvantaged populations and their care providers?
5. How does the use of a Human Rights-Based Approach to Data (HRBAD) and the establishment of a data governance council influence data governance dynamics and opportunities for upscaling?

To address the research questions above, a conceptual framework was developed over a duration of three (3) years targeting the following objectives:

1. Investigating the effects of targeted mHealth interventions on access to maternal health services and pregnancy outcomes among refugee and disadvantaged women in Lebanon.
2. Evaluating the effect of engaging spouses in mhealth interventions on information uptake and health outcomes of pregnancy women.
3. Assessing the effects of integrating gamification and AI in professional development interventions on enhancing the knowledge and practice of maternal health care providers.
4. Assessing the return on investment (ROI) of mhealth interventions in the intervention groups.
5. Assessing the utilization of a HRBAD, with a particular focus on the experience with establishing a data governance council and suggesting ways for optimizing upscaling while safeguarding the human rights of the target population.
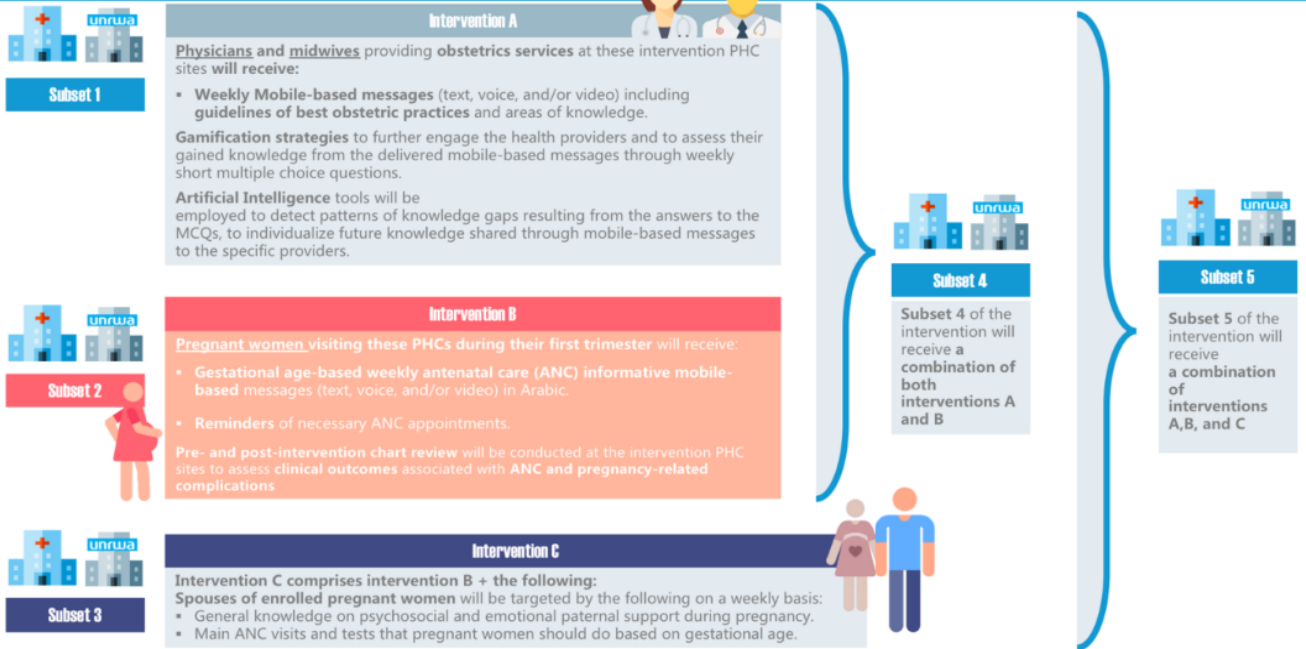
METHODOLOGY

METHODOLOGY

INTERVENTION SITES

5 UNRWA PHCs serving Palestinian refugees
5 non-UNRWA PHCs serving disadvantaged Lebanese and refugees of all nationalities

Subset 1

Intervention A

Physicians and midwives providing obstetrics services at these intervention PHC sites will receive:

- **Weekly Mobile-based messages** (text, voice, and/or video) including **guidelines of best obstetric practices** and areas of knowledge.

Gamification strategies to further engage the health providers and to assess their gained knowledge from the delivered mobile-based messages through weekly short multiple choice questions.

Artificial Intelligence tools will be employed to detect patterns of knowledge gaps resulting from the answers to the MCQs, to individualize future knowledge shared through mobile-based messages to the specific providers.

Subset 2

Intervention B

Pregnant women visiting these PHCs during their first trimester will receive:

- **Gestational age-based weekly antenatal care (ANC) informative mobile-based** messages (text, voice, and/or video) in Arabic.
- **Reminders** of necessary ANC appointments.

Pre- and post-intervention chart review will be conducted at the intervention PHC sites to assess **clinical outcomes** associated with **ANC and pregnancy-related complications**

Subset 3

Intervention C

Intervention C comprises intervention B + the following:
Spouses of enrolled pregnant women will be targeted by the following on a weekly basis:
- General knowledge on psychosocial and emotional paternal support during pregnancy.
- Main ANC visits and tests that pregnant women should do based on gestational age.

Subset 4

Subset 4 of the intervention will receive a combination of both interventions A and B

Subset 5

Subset 5 of the intervention will receive a combination of interventions A,B, and C

This study is a community trial including a total of 19 PHCs of which 9 PHCs were assigned as intervention sites and 10 PHCs were assigned as control sites. Among the intervention and control sites, 5 PHCs were governed by the United Nations Relief and Works Agency (UNRWA), and 4 were governed by the Ministry of Public Health (MOPH) in Lebanon. As for the control sites, 5 PHCs were UNRWA centers and the 5 others were MOPH PHCs. This study included pregnant women, both Lebanese and non-Lebanese (mainly refugees of Palestinian and Syrian nationalities), who have access to a mobile phone and who seek antenatal care services at the selected PHCs within their first three months of pregnancy.

The intervention centers were assigned to different components of the proposed mHealth intervention, targeting different target populations (the pregnant women, their health providers, and their spouses) and were divided as represented in the figure and as described below:

- 2 intervention PHCs (1 MOPH and 1 UNRWA) were assigned to the mHealth intervention specific to physicians and midwives (i.e. professional development mobile application through the use of gamification and artificial intelligence)
- 2 intervention PHCs (1 MOPH and 1 UNRWA) were assigned to the mHealth intervention targeting pregnant women only (i.e. weekly gestational age specific informative messages and reminder messages).
- 2 intervention PHCs (1 MOPH and 1 UNRWA) were assigned to the mHealth intervention targeting both pregnant women and their spouses.

- 2 intervention PHCs (1 MOPH and 1 UNRWA) were assigned to the mHealth intervention components targeting both pregnant women and their health providers (i.e. physicians and midwives)
- 2 intervention PHCs (1MOPH and 1 UNRWA were assigned to the full-fledged mHealth intervention targeting all 3 target populations (pregnant women, their health providers, and their spouses).

As for the control groups, pregnant women visiting the 10 control PHC centers received standard care provided by the physicians and midwives at these centers.

The plan of analysis is to compare every intervention arm with its matched control arm, and other subset of the intervention arm.

About the intervention

The different components of the mHealth intervention consisted of the following:

1) **mHealth intervention targeting physicians and midwives**

Physicians and midwives providing maternal health services at 6 PHCs were targeted with an innovative mobile application developed by AUB GHI that is founded on the concept of gamification and artificial intelligence: the GAIN MHI App. Gamification involves applying game principles and design elements, such as a 'trivia-like' concept, monthly recognition (Most Improved Player (MIP) and Most Valuable Player (MVP)), and monetary incentives. AI algorithms identify knowledge gaps based on providers' incorrect answers, tailoring subsequent questions to individualize learning. The app covers five categories related to maternal health, employing a randomized spin wheel for category selection. Users have a monthly limit of 30 attempts to answer questions, each accompanied by explanations and access to a Knowledge Resource Center (KRC). The app communicates with users via automated WhatsApp messages, providing feedback on scores, answers, remaining attempts, monthly performance, and rewards. Available in both English and Arabic, the GAIN MHI App represents an innovative approach to advancing healthcare provider education and maternal care.
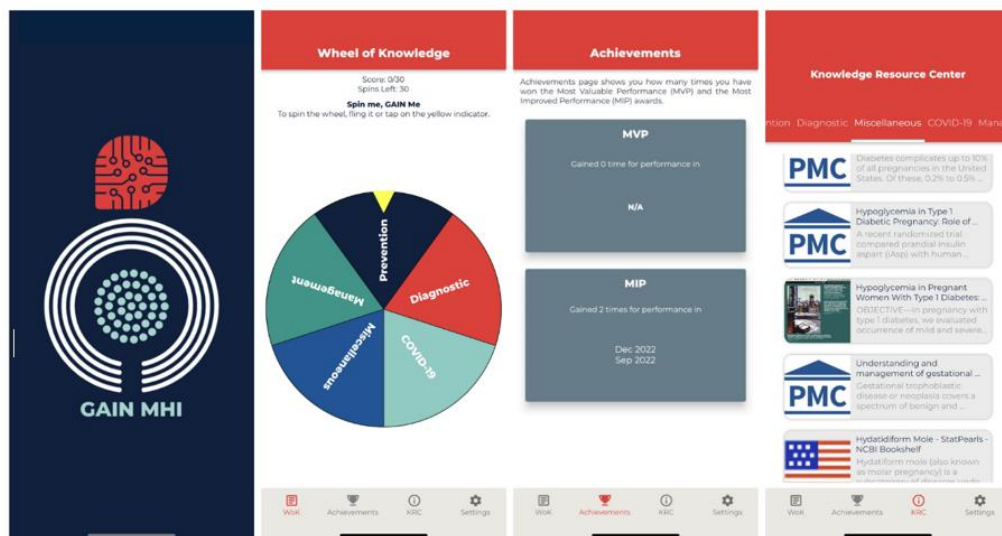
2) mHealth intervention targeting pregnant women

Pregnant women (Lebanese and non-Lebanese (refugees)) presenting during their first trimester of pregnancy to 8 of the intervention PHCs (as stated above) and having access to a mobile phone will were targeted with mobile-based messages in Arabic, consisting of the following:

a. Weekly informative messages: Enrolled pregnant women received weekly gestational age-specific educational messages in Arabic, that were sent to the mobile phone numbers provided by the women. These messages covered pregnancy education, including nutritional recommendations and supplementation, as well as pregnancy danger signs. Postpartum educational messages were delivered for 6 months after labour, to encourage postpartum visits, breastfeeding, contraception, maternal mental health and infant vaccinations.

b. Reminder messages: Reminder messages were sent to participants to notify them of their next ANC visits or required vaccinations, tests and medical examination.

3) mHealth intervention targeting spouses pregnant women

In 4 out of the 8 intervention centers where pregnant women were receiving the mHealth intervention, the spouses of the enrolled pregnant women were targeted by the intervention in order to examine the role of gender dynamics on enhancing the effectiveness of mHealth applications targeting women. The spouses received weekly mobile-based informative messages including knowledge on psychosocial and emotional paternal support during pregnancy.

Ethical Approval

Ethical approval was sought and obtained from the Institutional Review Board (IRB) at the American University of Beirut and the respective ethical committees at MOPH and UNRWA.

Theoretical Framework and Approach

The GAIN MHI project was based on the conceptual model of women empowerment. Based on this framework, the proposed mHealth intervention, leveraged institutional structures and tangible and intangible resources provided by the PHCs, aiming to improve the sense of agency among the target population, hence increasing their empowerment, a dynamic process of change. Based on the social ecological framework, the GAIN MHI project framework included the following elements: individual factors (e.g. attitudes towards ANC), intrapersonal factors/social norms (e.g. perceived support from the spouse to attend ANC visits); organizational factors (e.g. lack of skilled health providers, which affects the intention to attend ANC); societal forces/social determinants (e.g. cultural norms, discrimination); and public policies (e.g. presence of policies supporting free ANC visits). The mHealth intervention implemented as part of the GAIN MHI project was grounded on the Theory of Planned Behavior (TPB), a theory that has been utilized to describe ANC, or health-related behaviors whereby the intervention is aimed at influencing the beliefs and attitudes towards ANC, perceived social norms and control and self-efficacy of the target group towards ANC.

Recruitment Strategy, Population and Sample Size

➢ **Pre-Intervention Chart Review**

Prior to the implementation of the project's interventions, data from medical charts of pregnant women (Lebanese, Syrian and Palestinian refugees) were collected from July to December 2021 across 20 PHCs in five governorates of Lebanon, including Beirut, Bekaa, North Lebanon, Mount Lebanon, and South Lebanon. The study included pregnant women who attended one of the selected PHCs for ANC during their first trimester (up to 12 weeks of gestation) between August 2018 and August 2020, and continued their visits until delivery or termination of the pregnancy. In cases of multiple pregnancies within the specified period, only data from the most recent pregnancy meeting the eligibility criteria were considered.

Trained personnel from the PHCs, including nurses and midwives supervised by the research team, conducted the data collection. Information was abstracted in either English or Arabic. The collected data encompassed various categories: (1) demographic details like nationality, residency area, and age of pregnant women, (2) medical history, excluding Cesarean sections and Dilation and Curettage (D&C), (3) obstetric history, covering aspects such as number of gravidae, parities,, preterm deliveries, abortions, and C-sections, (4) antenatal details of the current pregnancy, including gestational age at the first visit, completed ANC visits, laboratory tests, ultrasound imaging, vaccines, and pregnancy-related complications, (5) outcomes of the current pregnancy, such as delivery onset, method, and complications during delivery, and (6) postnatal details of the current pregnancy, such as postnatal and neonatal complications, completed postnatal care visits, and breastfeeding practices.

The pre-intervention chart review data collection yielded a total of 5537 charts.

➢ **Recruitment of Pregnant Women and Spouses for mHealth Intervention**

Recruitment of pregnant women and their spouses commenced on September 1, 2021, at the Primary Health Centers (PHCs) where the intervention was implemented and concluded on December 31, 2022. Throughout the enrollment phase, a total of 1977 pregnant women participated, with 311 being Lebanese and 1666 non-Lebanese. Simultaneously, 1000 spouses of the enrolled pregnant women took part, comprising 257 Lebanese spouses and 743 non-Lebanese spouses. Research assistants (RAs) explained the study to eligible women at the intervention site, obtaining signed consent forms and assisting in completing the Knowledge, Attitude, and Practices (KAP) survey. Similarly, in sites targeting spouses, RAs explained the study either in person or via phone calls for those not accompanying their wives, obtaining signed consent forms. In cases where spouses were not physically present, they sent signed consent forms via WhatsApp. At the intervention's conclusion, both pregnant women and spouses were contacted for follow-up via phone by the research team to assess satisfaction with the intervention, perceived utility of the mHealth service, and changes in understanding resulting from the intervention.

➢ **Recruitment of Healthcare Providers for mHealth Intervention**

Initially, a total of 15 users/HCPs downloaded the GAIN MHI App, among whom 12 HCPs were active users, 2 were inactive, and one was opted out. In our results dissemination, we reported on the 12 active users including nine midwives and six obstetricians.

The research team coordinated with the selected PHCs' chief medical officer to circulate an invitation to participate in the study for health providers (i.e. physicians or midwives) alongside the consent forms. The health providers were asked to share back the signed copy of the consent via email or via WhatsApp. For providers who shared back the signed consent, the RA filled out a recruitment form, downloaded the application on their phone, and trained them on how to sign up and use it. If they did not wish to participate, their number and chat conversation in WhatsApp were permanently deleted from the phone. At the end of the intervention, assessment of health providers' satisfaction with the mHealth professional development program was carried out through a cross-sectional face-to-face survey.

➢ **Post-Intervention Chart Review**

Charts of pregnant women who visited the 19 PHCs (one of the PHCs was closed) throughout the 16 months of the intervention period (September 2021 – December 2022) were collected from March to June 2023. The post-intervention chart review was completed by data collectors who were either nurses, midwives, or data officers at the selected PHCs. Three (3) external data collectors were recruited to help in conducting the post intervention chart review. The collected data encompassed similar categories covered in the pre-intervention chart review.

The post-intervention chart review data collection yielded a total of 4,736 chart.

ACHIEVEMENTS

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The GAIN MHI project objectives remained unchanged throughout the project's timeline. In fact, their relevance has been reinforced during the project's implementation, as emerging evidence continued to underscore the importance of obtaining a more profound understanding of pregnant women's access to maternal health services, both through qualitative and quantitative data. Over the duration of the project, the research initiatives were related to a larger framework that encompassed partners engagement, effective communication strategies, and productive workshop sessions. This approach was designed to ensure that the research activities weren't isolated, but rather seamlessly integrated into the overall project strategy, aiming for upscaling while safeguarding the human rights of the target population.

➢ **Objective 1: Investigating the effects of targeted mHealth interventions on access to maternal health services and pregnancy outcomes among refugee and disadvantaged women in Lebanon.**

Pre- and post-intervention chart reviews were conducted to evaluate the impact of targeted mHealth interventions on access ANC services and pregnancy outcomes among refugees and disadvantaged women. One paper which is currently under the second round of review in the Journal of Conflict and Health, titled 'Maternal Health Outcomes Among Pregnant Women in Fragile Settings: A Retrospective Review from Lebanon' aimed to identify the maternal health outcomes of pregnant women in Lebanon and to highlight the existing gaps in the national health system. Another research paper will be generated in order to understand the effect of the GAIN MHI intervention on pregnancy outcomes based on postintervention chart review.

➢ **Objective 2: Evaluating the effect of engaging spouses in mhealth interventions on information uptake and health outcomes of pregnancy women.**

Comprehensive satisfactory surveys were conducted with pregnant women's spouses. These surveys aimed to understand the gender dynamics at play and how such interventions could enhance women's health through spousal engagement. The collected data will provide insights into the extent of spouses' understanding of maternal health information, their contribution to maternal well-being, and their involvement in decision-making. These findings will offer valuable perspectives on the potential benefits of engaging spouses in digital health initiatives for improved maternal health outcomes.

➢ **Objective 3: Assessing the effects of integrating gamification and AI in professional development interventions on enhancing the knowledge and practice of maternal health care providers.**

As for the integration of gamification and AI in professional development interventions and its role in enhancing the knowledge and practice of maternal HCPs, an assessment of the HCPs satisfaction with

utilizing gamification, AI and mhealth for the professional development of maternal care providers was conducted. Results were reported in scholarly article currently under review in JMIR Serious Games.

- ➢ **Objective 4:** Assessing the return on investment (ROI) of mhealth interventions in the intervention groups.
- ➢ **Objective 5:** Assessing the utilization of a HRBAD, with a particular focus on the experience with establishing a data governance council and suggesting ways for optimizing upscaling while safeguarding the human rights of the target population.

The ROI analysis and the assessment of the utilization of a HRBAD were not conducted throughout the period of the project life due to time limitation and unforeseen delays across different time points throughout the project. They are still expected to be conducted for the team to be able to share relevant results with researchers and the audience.

CAPACITY BUILDING ACTIVITIES AND WORKSHOPS

The GAIN MHI project included numerous capacity-building efforts during its implementation. Healthcare providers, particularly those in distant and underserved regions, encounter difficulties in accessing opportunities for professional development. The incorporation of the gamification component within the GAIN MHI App, enjoyed by 91.67% of participants, not only made the learning process engaging and enjoyable but also served as a motivation for 91.67% of users, fostering a 100% increase in interest in targeted areas. The AI component of the app effectively helped participants in identifying their weak areas with an agreement rate of 83.34%. Most of the HCPs participating in this research expressed a strong desire to endorse the GAIN MHI App to their peers. They also recommended its application in various medical domains, emphasizing the vital role of ongoing education that extends across diverse healthcare disciplines. Such recommendations underscore the app's capacity to function as a flexible and versatile platform, addressing the diverse learning requirements of HCPs across a broad spectrum.

Several capacity building workshops were held by the GAIN MHI team to empower the staff, research assistants, and stakeholders involved in the field-based implementation of the project to effectively execute project activities.

- ➢ **Training of Data Collectors to Conduct Pre-Intervention Chart Review**

In May and June 2021, the GAIN MHI team conducted four initiation workshops over two days for the directors and selected staff from the PHCs that were enrolled in the project. The centers were grouped into four groups (1 workshop per group) as follows:

- ▪ Group 1: 10 staff members from 5 UNRWA intervention PHCs (workshop held at UNRWA)
- ▪ Group 2: 10 staff members from 5 UNRWA control PHCs (workshop held at UNRWA)
- ▪ Group 3: 10 staff members from 5 MOPH intervention PHCs (workshop held at AUB)

- Group 4: 10 staff members from 5 MOPH control PHCs (workshop held at AUB)

➢ **Training of PHCs Staff to Conduct Post-Intervention Chart Review**

In March 2023, the GAIN MHI team conducted two initiation workshops over two days for the directors and selected staff from the PHCs that were enrolled in the project. The centers were grouped into two groups (1 workshop per group) as follows:

- **Group 1:** selected staff members and directors from 9 MOPH PHCs (control and intervention PHCs)
- **Group 2:** selected staff members and directors from 10 UNRWA PHCs (control and intervention PHCs)

The two workshops were conducted at AUB.

During all the workshops mentioned above, the project team explained to the attendees the study's objectives and the three phases of the study methodology: the pre- intervention phase, the intervention phase, and the post-intervention phase. The team also presented the data collection tool and the variables that will be collected by the centers' staff during the post- intervention phase. The staff involved in the data collection/chart review consisted of both women and men health workers including nurses, midwives, or medical record clerks. The selected staff were chosen by each PHC center's director.

➢ **Recruitment, Training, and Deployment of Research Assistants – Pre-intervention Phase**

A total of eight research assistants (RAs) joined the GAIN MHI team. Their main role was to recruit pregnant women (and their spouses when applicable) from the eight PHC intervention centers enrolled In the GAIN MHI study. Due to the sensitivity of the topic and for context-specific considerations, all RAs were meant to be women (pregnant women may not feel comfortable declaring pregnancy-related information to men). During the recruitment process, the team ensured that the recruited women had previous experience in data collection with a background in public health, social work, psychology, or other health and social sciences.

➢ **Training of Recruited Research Assistants (RAs) Data Collectors to Conduct Post-Intervention Chart Review**

During the training, the project team explained to the RAs the study's objectives and the three phases of the study methodology: the pre- intervention phase, the intervention phase, and the post-intervention phase. The team also presented the data collection tool and the variables that will be collected by the centers' staff during the post- intervention phase. The process of post-intervention chart review started effectively in March 2023.

VALIDATION AND FIELD-BASED MONITORING, & EVALUATION

➢ **Validation of the messages targeting the pregnant women**

In the formative phase, the research team engaged directly with refugees and disadvantaged Lebanese women (the group was established earlier as part of another project of the global health institute) to co-create the educational messages used as part of the GAIN MHI project to target pregnant women and enhance their access to antenatal health services offered at the PHCs. A message was created for each pregnancy week and up to 6 months post-delivery (total of 64 messages). The messages were created in Arabic, using terms that could be easily understood by a lay population, with a particular emphasis on contextualization. The messages were then validated, and pilot tested among another group of refugees and disadvantaged Lebanese women with the condition that these women should be either currently pregnant or have been pregnant at least once before. To complete the validation, a guide prepared by the research team was used. The guide included questions on whether the messages are easy to read and understand, whether the length of the messages were acceptable, whether the woman can relate to the content of the message, and whether the information provided through the message is new and adds to the knowledge of the responding woman. Women were also asked to provide any additional feedback on the message to enhance their clarity and readability. Based on the validation exercise, some of the messages were omitted and replaced by new one, and linguistic modifications were made. Women were also asked about their preferred format to receive the messages (voice or text); an equal number of votes was noted for each format. Accordingly, the research team recorded all messages in voice format to be coupled with the text format when the intervention is initiated.

➢ **Validation of the messages targeting the spouses of the pregnant women**

The exact same approach mentioned above was adopted to develop, contextualize, and validate the messages that are meant to target the spouses of the pregnant women in our intervention. However, it is noteworthy that, when asked about the preferred format, the spouses indicated their preference to receive voice notes compared to texts. Consequently, our team recorded the messages to create voice note versions.

➢ **Validation of the mHealth intervention targeting physicians and midwives**

The database for the GAIN MHI App was created by a medical consultant with expertise in obstetrics and gynecology. It was designed to include questions specifically tailored for OBGYN physicians and midwives, centering on antenatal and postnatal care practice guidelines. The questions were accompanied by relevant options, correct answers, detailed explanations, and references. To cater to Arabic-speaking healthcare providers, an Arabic version of the app was generated. Following this, a validation process took place, involving specialists in the same field who reviewed and confirmed the suitability of the questions for OBGYNs and midwives, ensuring alignment with the intended user base. After validation, adjustments were made to the intervention's components based on feedback and suggestions from participants. Subsequently, a testing phase was implemented to ascertain user satisfaction with the app's visual appeal, functionality, and overall usability. In response to user feedback, certain features of the app were improved and upgraded.

➢ **Monitoring and Evaluation**

Weekly/ monthly audit visits to PHCs and phone calls at daily basis were being completed to monitor the pre-intervention review process, the recruitment phase, and the post-intervention chart review process by each staff and recruited RA to identify any challenge/barrier during the project implementation. Follow ups with the directors of PHCs were also conducted on a regular basis to ensure that the center-based project implementation is in alignment with the PHCs' expectations.

Internal team meetings were held on a regular basis to evaluate the progress of the GAIN MHI project towards the targets and milestones, and to address any emerging challenge faced in data collection and/or recruitment.

ANALYSIS*

INTERVENTION PROGRESS IN NUMBERS

➢ **mHealth Intervention Targeting Pregnant Women and Spouses**

The intervention phase was concluded in December 2022. A total of 1977 pregnant women (311 pregnant women were Lebanese and 1666 pregnant women were non-Lebanese) and 1000 spouses of pregnant women (257 spouses were Lebanese and 743 spouses were non-Lebanese) were enrolled in the intervention.

➢ **Number Of Intervention Sites in the Study**

A total of nine (9) intervention sites, and ten (10) control sites took part of the study (intervention sites were originally 10, but 1 site was eliminated from the study as it was closed)

➢ **Enrollment of HCPs in the GAIN MHI Project**

Initially, a total of 15 users/HCPs downloaded the GAIN MHI App, among whom 12 HCPs were active users, 2 were inactive, and one was opted out. In our results dissemination, we reported on the 12 active users including nine midwives and six obstetricians.

➢ **Incentivization in Numbers**

Up till May 2023 (marking the end of this component of the intervention), a total of 39 monetary prizes were distributed to all MVPs (obstetricians and midwives). Among them, 21 prizes were distributed to obstetricians and 18 prizes were distributed to midwives. Similarly, a total of 38 monetary prizes were distributed to all MIPs (obstetricians and midwives). Among them, 19 prizes were distributed to obstetricians and 19 prizes were distributed to midwives. Informal discussions with the health providers revealed that these awards encouraged them to use the GAIN MHI App consistently and improve their performance from one month to another.

➢ **Data Collected in the Study**

12 FACE TO FACE FEEDBACK SURVEYS WERE COMPLETED WITH HCPS

5,352 CHARTS WERE INCLUDED IN THE PRE-INTERVENTION CHART REVIEW

4,736 CHARTS WERE INCLUDED IN THE POST INTERVENTION CHART REVIEW

1,024 FEEDBACK SURVEYS WERE COMPLETED WITH PREGNANT WOMEN

**488** FEEDBACK SURVEYS WERE COMPLETED WITH SPOUSES OF PREGNANT WOMEN

➢ **Quantitative Analysis:**

Among the 12 active users of the GAIN MHI App, 66.67% were midwives while 33.33% were doctors. 83.33% of the HCPs expressed satisfaction with no reported dissatisfaction. Gamification proved to be engaging and enjoyable for 91.67% of participants, motivating the same percentage, and stimulating interest in targeted areas for 100%. Notably, the incorporation of gamification significantly heightened participants' overall satisfaction with the learning experience, reaching 100%.

AI has targeted knowledge areas among 80% of the HCPs, explored knowledge gaps in 87% of the HCPs, and enhanced learning satisfaction among 87% of the HCPs. The personalization of the learning experience and the AI component successfully assisted the HCPs in pinpointing their areas of weakness, achieving an agreement rate of 83.34%.

Recommendations were robust, with 100% of respondents suggesting the app to their colleagues. The overall evaluation reached 87.18%, solidifying the effectiveness of the app, particularly through its gamification and AI components.
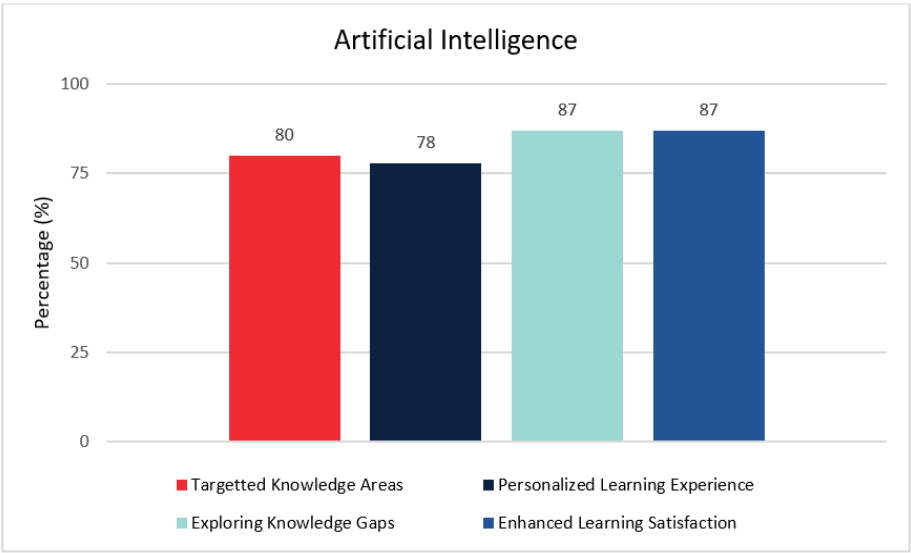
➢ **Qualitative Analysis:**

The feedback from interviewed healthcare providers underscores a positive response to the application. One provider mentioned, "The application was easy to use. I liked how it added to our knowledge and how it refreshed our memory, in addition to the diversity of the questions." Another provider echoed similar sentiments, stating, "The application was easy to use. I liked the subjects covered in the app and the way the app motivated us to learn more." Additionally, another healthcare professional suggested, "I suggest organizing workshops/conferences about the subjects raised in the app among others." This recommendation further emphasizes the value perceived by the providers and their interest in expanding discussions on the app's content through interactive events. Overall, the healthcare professionals

appreciated the user-friendly nature of the app, its contribution to knowledge enhancement, memory refreshment, diverse question content, and motivational aspects fostering a desire for further learning.

RESULTS FROM THE PRE-INTERVENTION CHART REVIEW

Considering the insufficiency of recent data on the maternal health outcomes of the pregnant women in Lebanon, the analysis of the pre-intervention chart review emphasized on three main outcomes: number of ANC visits, delivery type/outcomes, and delivery onset. Such data provided a baseline to evaluate potential future enhancements in the field among disadvantaged Lebanese, Syrian refugee, and Palestinian refugee pregnant women. The results of the analysis were disseminated in a scholarly article titled 'Maternal Health Outcomes in the context of fragility: A Retrospective Study from Lebanon' reflecting baseline maternal health outcomes in PHCs prior to the initiation of the intervention. The article was published in the Journal of Conflict and Health. The data from the article showed that women who underwent C-sections or had a history of abortion in their current pregnancy exhibited a suboptimal number of ANC visits. Conversely, complications during the latest pregnancy, multiple ultrasounds, and urinalysis tests were linked to a lower likelihood of suboptimal ANC visits.

INSIGHTS FROM THE RECRUITED PREGNANT WOMEN

During our field visits, the team engaged in informal reflection chats with the midwives at PHCs where the intervention targeting spouses was taking place. The midwives highlighted a new observation that had started a few months after the initiation of our intervention. They reported that more spouses were accompanying their wives to their ANC appointments. This raised the potential hypothesis that the educational messages sent to spouses about the importance of providing psychological support to their wives during pregnancy might have prompted this behavior. The midwives also observed an increase in the number of women inquiring about their ANC and PNC packages, as well as the subsidized services during their visits. Additionally, the research assistants at the PHCs noted positive feedback from enrolled pregnant women. These women expressed satisfaction with the text messages they received and indicated an improvement in their knowledge about their health and maternal health journey.

More details will be available upon completion of the data analysis.

Note: *Analysis of the data generated from the intervention has not been concluded throughout the project life and is still being currently conducted. The ESP team will share with IDRC all future research outputs featuring data from the GAIN MHI project.*

CHALLENGES AND UNFORSEEN DELAY

> **Challenges during the Project Implementation**

Throughout the project execution, multiple setbacks and delays have occurred. In the initial year of the project, various delays pushed certain project milestones into the second year. These included a delay in starting the chart review at the 20 PHCs, a holdup in recruiting and involving physicians and pregnant women in the intervention, and a delay in launching the intervention itself. The primary cause of these delays was the COVID-19 pandemic, which affected the review process of project documents by both the ethical review boards of AUB and UNRWA. Additionally, the pandemic placed a significant strain on Lebanon's healthcare system, with both the MOPH and UNRWA heavily involved in addressing this urgent health crisis. As a result, discussions with MOPH and UNRWA took longer than anticipated due to conflicting priorities. Besides the COVID-19, another factor that led to this delay was the upgrade of the mhealth intervention targeting the physicians and midwives into a mobile application, which was accompanied with intensive efforts towards the creation of the database of the questions and resources. This upgrade was seen useful for the enriching the professional development experience of the target individuals.

Due to the delays that have occurred in the year 1 of the project, some of the activities that are supposed to be implemented in year 2 were postponed to year 3. One of these activities was the assessment of health providers' satisfaction with the GAIN MHI mobile application.

> **Challenges during Recruitment of Pregnant Women and Spouses**

Around 2000 to 2400 pregnant women were planned to be enrolled in the intervention arms, yet a total of 1977 pregnant women were actually recruited. A delay in recruiting pregnant women and their spouses was experienced due to various factors, including the economic crisis in Lebanon, the COVID-19 pandemic, and stormy weather conditions in areas like Beqaa and North Lebanon, making it difficult for pregnant women to reach the PHCs. Additionally, most of women visiting the PHC were post their first trimester which obliged the team to amend the inclusion criteria to enroll women up to 16 weeks of pregnancy. As for the centers, 20 PHCs (10 MOPH and 10 UNRWA) were originally part of the study. Yet, one of the MOPH PHCs located in Beqaa has been shut down, marking then the end of our operations in that center.

As for the intervention targeting pregnant women and their spouses, the team encountered difficulties in maintaining contact with certain enrolled participants mainly due to changes in their contact information without prior notification to our team, resulting in attrition among this group. Additionally, a subset of pregnant women enrolled in the intervention experienced abortion or stillbirths during the course of the study, necessitating the discontinuation of their participation.

➢ **Challenges during the Pre- and Post- Intervention Chart Reviews:**

During the pre-intervention chart review phase, certain data was not available. This can be attributed to the implementation of the Primary Healthcare Network Information and Communication System (PHENICS), an electronic health record system, by MOPH PHCs in 2019. As a result, not all PHCs were able to transfer historical data from before this implementation, resulting in incomplete records.

To clarify, the incomplete data in both pre- and post-intervention phases can be attributed to several factors. First, some pregnant women missed certain antenatal or postnatal visits, resulting in gaps in availability of data. Additionally, some women who received care from private obstetricians in parallel to their visits to PHCs did not consistently share updates regarding their private visits, including test results and ultrasound findings, with the PHCs. Specific important variables such as prior surgeries, smoking and alcohol consumption habits, and breastfeeding practices were not consistently recorded during initial screenings conducted by midwives or nurses at the PHCs.

NEXT STEP

The next step of the project includes the dissemination of the results of the project in different papers. This process guarantees that the valuable outcomes and insights gained from the project are shared with a broader readership, and enrich the existing knowledge in the field. In order to inform policy and practice, a stakeholders' meeting will be held in late December. This will bring together various individuals and groups who were actively engaged in the project, allowing them to reflect on the project's outcomes and explore potential implications for policies and practices.

GENDER EQUALITY AND INCLUSION

GENDER EQUALITY AND INCLUSION

➢ **Empowering Women to Make Decisions about their Own Health**

The focus of this project on maternal health aims at enhancing the health and wellbeing of pregnant women during pregnancy and post-delivery. The design of the project considers women education and empowerment, irrespective of educational level and socio-economic status, as key enabler for women to make decisions about their own health.

Adopting a participatory approach allowed equal opportunities for members of the target communities to engage in focus group discussions and express their opinions. It is imperative to note that within our study, all women meeting the eligibility criteria were recruited without any form of discrimination related to race, nationality, ethnicity, religion, or any other pertinent characteristics.

➢ **Acknowledging the Role of Power and Gender Dynamics**

The engagement of spouses in the project is one of the gender-related considerations that were factored in the design of the study, based on the research team's understanding of the context and culture in the Middle East and North Africa (MENA) region. This component of the intervention did not only aim at educating men on the importance of maternal health but also at increasing their willingness to encourage and support their wives to seek antenatal care services. This is especially important in underprivileged populations where women often need the consent of their husbands to visit health centers, seek care, or buy necessary medication/supplement.

By actively engaging men partners in maternal health through weekly messages, traditional gender roles and norms were challenged, encouraging as such shared responsibility and fostering a sense of partnership in pregnancy care. This inclusive approach can lead to improved maternal health outcomes, as women receive enhanced support, reduce stress, and have access to additional resources. During the implementation of the project, the midwives at the PHCs highlighted a novel observation that emerged a few months after the introduction of our intervention. They noted an increase in the number of spouses accompanying their wives to antenatal care appointments. This suggests a plausible hypothesis that the educational messages directed at spouses may have played a role in encouraging this behavior. To evaluate this aspect and better understand the change in power and gender dynamics, a post-intervention satisfaction surveys with pregnant women and their spouses has been conducted with data being currently analyzed and prepared for dissemination.

PROJECT OUTPUT AND DISSEMINATION

PROJECT OUTPUT AND DISSEMINATION

Two scholarly articles presenting data from the GAIN MHI project have been finalized so far: one paper is published in journal of Conflict and Health and the other one is currently under review as outlined below:

- 'Maternal Health Outcomes in the context of fragility: A Retrospective Study from Lebanon' reflecting baseline maternal health outcomes in PHCs prior to the initiation of the intervention. **_Published in Journal of Conflict and Health._**

- 'Utilizing Gamification, Artificial Intelligence and mHealth for the professional development of maternal care providers: Assessing Providers' Satisfaction in Primary Healthcare Centers in Lebanon'. **_Under review in JMIR Serious Games._**

Other papers will be generated as part of this study to fulfill the objectives of the project once data analysis is completed including but not limited to:

- A paper describing the GAIN MHI model (the intervention components)
- A paper comparing the pre-intervention and post-intervention Chart Review Data in order to assess the impact of the GAIN MHI project on maternal health outcomes.
- A paper exploring which GAIN MHI intervention arm/component contributed to better maternal health outcomes.
- A commentary on power and gender dynamics based on observations from the project
- A paper assessing the satisfaction of the pregnant women and their spouses with the GAIN MHI intervention

As part of results dissemination, a podcast on 'Maternal Health and Family Planning in the Middle East: Gender and Power' featured the GAIN MHI project, as one of the digital maternal health and family planning initiatives in the MENA region. The GAIN MHI project was also described in a Blog on 'Context, Gender, Power, and Choices'.

It is also expected for the project team to present findings from the GAIN MHI project in the Global Digital Health Forum 2023 taking place in Washington DC, and to hold a stakeholders' meeting with representatives from MOPH, UNRWA and the community to discuss lessons learned and potential for scalability.

PROJECT OUTCOMES

PROJECT OUTCOMES

The GAIN-MHI project focuses on women empowerment, particularly during pregnancy, by providing pregnant women with access to accurate and trustworthy information about their health, which is a fundamental human right. Having said that, the team is currently investigating the extent to which the project has achieved the outcomes below:

➢ **Enhancing Access to Antenatal Care:** The primary objective of the GAIN MHI project is to enhance access of pregnant women to antenatal care services by providing them with the necessary and relevant health information. The extent to which our project has achieved this outcome is currently being investigated through data on maternal health outcomes and the change in the latter following the implementation of the intervention.

➢ **Equitable Access to Reliable and Up-to-Date Information and Guidelines for Practice:** The project leveraged mHealth technology to equip both the pregnant women and their HCPs with reliable and up-to-date information on pregnancy.

➢ **Positive Health Seeking Behavior:** The project acknowledges that changing health-related behaviors and practices can be challenging, especially in disadvantaged settings where cultural norms and practices may be deeply rooted. By engaging both pregnant women and their spouses, the project seeks to catalyze behavioral change within the targeted women. When spouses are informed and involved, they can encourage and support optimal health seeking behaviors among their wives during pregnancy.

➢ **Continuous Learning and Professional Development:** The GAIN MHI mobile App constituted a platform for HCPs to access a wide range of updated, evidence-based information, guidelines, and best practices.

OVERALL ASSESSMENT AND RECOMMENDATIONS

OVERALL ASSESSMENT AND RECOMMENDATIONS

Our collaborative engagement with the IDRC, as the project's funding partner, has played a pivotal role in facilitating the successful execution of our initiative. Our overarching objective focuses on the enhancement of maternal healthcare through the strategic deployment of mHealth interventions, targeting pregnant women, their respective partners, and healthcare professionals. The partnership with IDRC has enabled the adoption of a more comprehensive and multifaceted approach in addressing the intricate research problem at hand and effectively navigating the diverse milestones integral to this project. Throughout the project's preparatory and implementation phases, our recurrent dialogues and consultations with the IDRC team, in conjunction with the regular sharing of technical reports, have considerably enriched the research process. These interactions have provided a crucial platform for the receipt of constructive feedback, emanating from diverse expert perspectives. Such collaborative engagements have, in turn, significantly contributed to the refinement and rigor of our research efforts, ultimately enhancing the project's overall quality and comprehensiveness.

As previously mentioned, the project encountered various challenges and delays during its execution, which offered valuable lessons for future endeavors. Firstly, it underscored the necessity of developing adaptable strategies that rely on feedback and evolving circumstances to continuously enhance and evolve. Secondly, the importance of crisis preparedness became evident, emphasizing the need for contingency plans to mitigate disruptions, particularly unforeseen events like the COVID-19 pandemic, that may affect project timelines and goals. The project yielded additional insights, particularly the vital role of engaging the target community in designing interventions and creating content (such as weekly messages and the GAIN MHI App database) to foster their effectiveness. This effectiveness could be attributed to customizing intervention content to align with the cultural and literacy norms of diverse individuals within the target population. Lastly, robust evaluation and monitoring throughout various project phases emerged as crucial for obtaining valuable data to ensure a comprehensive assessment of the intervention's impact.

Considering the important role of the IDRC in this project, we recommend that it support similar projects focused on innovative technologies for healthcare improvement, especially in areas with limited resources. We also recommend that IDRC invest in the capacity-building of local researchers and healthcare providers to empower them to conduct such projects independently. Additionally, we suggest continuous support from the IDRC in the dissemination of such interventions to expand and maximize their benefits in a broader area. Finally, we acknowledge that the substantial investment of time, effort, and funding in this project is worth it. This project, focused on enhancing maternal health, may serve as a model for the implementation of technology in healthcare improvement and addressing related challenges.

LESSONS LEARNED AND SUPPLEMENTARY MATERIAL

LESSONS LEARNED

➢ **Participatory Approach**: the co-creation of messages content with the target audience (refugees and disadvantage Lebanese women) from one hand and the co-design of the GAIN MHI mobile App features on the other hand, made them more relevant and aligned with the need of the target audience. This highlights the importance of the continuous engagement (both at initial phase and during pilot testing and validation) of the target audience in designing digital health interventions and the role the latter plays in enhancing the effectiveness of these interventions.

➢ **Importance of Contextualization**: the adaptation of messages to the cultural and language of the target audience, boosted their involvement and understanding of the concept. This underlines the importance of tailoring digital health interventions to the context of application.

➢ **Considerations of Power & Gender Dynamics**: The implementation of the project highlighted the importance of closely considering factors related to gender and power dynamics at the time of the design and implementation of digital health solutions. This is to insure gender sensitive, equitable and inclusive interventions.

SUPPLEMENTARY MATERIAL

Please describe how the progress, lessons, outcomes, and achievements in your project speak to the conceptual framework linking sexual/reproductive health with data governance to support human rights and gender equality.

The GAIN MHI project has several key components that intersect with the conceptual framework linking sexual/reproductive health with data governance to support human rights and gender equality.

➢ **Inclusivity and Non-Discrimination:** The project's inclusion of both Lebanese and non-Lebanese pregnant women, without any exclusion based on ethnicity or nationality, reflects a commitment to non-discrimination and inclusivity. This approach acknowledges that access to sexual/reproductive health services should be a universal human right.
➢ **Gender Equality and Involving Partners**: Involving spouses in the intervention acknowledges the importance of gender equality in reproductive health decisions. By targeting both pregnant women and their partners, the project recognizes that family support is crucial for maternal health which reflects a gender-inclusive approach.
➢ **Quality of Care Enhancement:** The development of a database for the professional development mobile application for healthcare providers is an important aspect of the project. This aligns with the framework by recognizing that healthcare professionals' capacity and knowledge are essential for providing quality sexual/reproductive healthcare services.
➢ **Contextualized Considerations**: The project's intention to elucidate the digital health intervention model alongside context-specific considerations aligns with the framework's recognition that

healthcare solutions must be tailored to the unique sociocultural and economic contexts of the target population.

This conceptual framework helped the GAIN MHI team to adopt a more comprehensive and ethically-minded approach during the implementation of the project, emphasizing the interconnectedness of sexual/reproductive health, data governance, human rights, and gender equality. It encouraged the GAIN MHI team to consider the broader societal impact of the project while engaging with diverse stakeholders and adopting intersectional perspectives.

Please describe how matters of data governance have influenced your project to date. Have you shifted practices because of these considerations? Have you made recommendations based on your findings to your institution, to other researchers, to government? Please share specific reflections, lessons, and outcomes.

It is planned, once the situation in the MENA region becomes more stable, for our research team to hold a stakeholders meeting through which findings and lessons learnt about the project will be shared. During this meeting, feedback and recommendations for scaling up and replication of the GAIN MHI model to cover different health topics and broader populations are also planned to be discussed.

Please elaborate on how gender responsiveness and gender-intentional design, implementation and analysis have concretely influenced how research is conducted and produced for this project. Please include specific examples and the significance of the change in attitude, behaviour and/or practice.

The gender-responsive design employed in the development of educational messages within this intervention ensures that the messages are tailored to be relevant and effective for both pregnant women and their spouses. By specifically targeting spouses in this initiative, it signifies the recognition of the crucial role that men play in supporting and empowering their wives during pregnancy. This approach challenges traditional gender norms by emphasizing that involving partners can significantly contribute to improving maternal health outcomes. It underscores the importance of shared responsibility in healthcare decision-making between partners, acknowledging that the health and well-being of both the pregnant woman and her spouse are intertwined. It also reinforces the idea that women are supposed to be the primary decision maker about their health choices.

Collecting data separately from both pregnant women and their spouses serves several important purposes. Firstly, it allows for a comprehensive assessment of the intervention's impact on both groups, enabling researchers to evaluate how the messages and support provided through the intervention affect the knowledge and attitudes of both pregnant women and their male partners. This differentiation in data collection also enables the identification of potential disparities related to gender in terms of knowledge and attitudes concerning maternal health. By analyzing the data separately for each group, the GAIN MHI researchers can gain insights into the unique perspectives, needs, and experiences of pregnant women and their spouses, contributing to a more nuanced understanding of how gender dynamics influence maternal health outcomes and the effectiveness of the intervention.

During the conduct of the post-intervention survey with both pregnant women and their spouses, the research assistant noticed a high level of satisfaction among participants with the content of the messages. Pregnant women highlighted that their spouses became more supportive and engaged in their pregnancy journey after receiving messages. They said that their spouses reminded and accompanied them to their ANC visits, gave more attention to their medication intake, and accepted their mood swings more during pregnancy. Besides, spouses reported that they became more supportive and aware of pregnancy and its complications. Additional insights and outputs will emerge upon the conclusion of the data analysis phase.