

# Development of a targeted client communication intervention to women using an electronic maternal and child health registry: a qualitative study

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## Research article

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## Abstract

Background Targeted client communication (TCC) using text messages can inform, motivate and remind pregnant and postpartum women of timely utilization of care. The mixed results of the effectiveness of TCC interventions points to the importance of theory based co-design with users. The aim of this paper is to describe the planning, development, and evaluation of a theory based TCC intervention, tailored to pregnant and postpartum women and automated from the Palestinian electronic maternal and child health registry.

Methods We used the Health Belief Model to develop interview guides to explore women's perceptions of antenatal care (ANC), with a focus on high-risk pregnancy conditions (anemia, hypertensive disorders in pregnancy, gestational diabetes mellitus, and fetal growth restriction) and timely ANC attendance, issues predefined by a national expert panel as being of high interest. We performed 18 in-depth interviews with women and eight with healthcare providers in public primary healthcare clinics in the West Bank and Gaza. Following the results from the Health Belief Model, we used concepts from the Model of Actionable Feedback, social nudging and Enhanced Active Choice to compose the TCC content to be sent via SMS. We assessed the acceptability and understandability of the draft text messages through unstructured interviews with local health promotion experts, healthcare providers, and pregnant women.

Results We found low awareness of the importance of timeliness in attending ANC and the benefits of ANC for pregnancy outcomes. We identified knowledge gaps and beliefs in the domains of low awareness of susceptibility to, and severity of, such complications in pregnancy. We composed actionable text messages aiming to increase utilization of ANC, following recommended message framing models and iteratively improved the contents with users to bridge the identified gaps. We developed algorithms to trigger tailored text messages with higher intensity for women with a higher risk profile documented in the electronic health registry.

Conclusions We developed an optimized text message based TCC intervention underpinned by behavior change theories and co-designed with users following an iterative process. The electronic maternal and child health registry can serve as a unique platform for TCC interventions.

## Background

The introduction of information and communication technologies in the health sector is revolutionizing health information communication [1, 2]. Digital health applications, such as Short Message Services (SMS), are increasingly common, including in resource-limited settings [3-5]. Targeted Client Communication (TCC) via SMS is being used to improve people's knowledge and attitudes towards healthy behaviors and utilization of healthcare services [6-9]. Targeted Client Communication, in this context, is defined as transmission of unidirectional targeted health content (pregnancy related information and appointment reminders) tailored to individuals, based on static and dynamic information about recipients from a routine maternal and child health registry system (adapted from World Health Organization[3], and Agarwal et al[10]).

Well-informed clients have improved communication with their healthcare providers and are empowered to make informed health decisions [11]. Simple appointment reminders, alone or with health promotion content via SMS, have the potential to boost antenatal care (ANC), postnatal care (PNC) and newborn care service utilization [8, 12-16], but the effectiveness is mixed [17, 18].

Development of an effective TCC intervention is complex and requires careful design, implementation and evaluation [19]. Despite the growing number of TCC interventions via SMS [20], recent systematic review found that most of them are "*under-theorized, poorly specified and vaguely described*" [14], and the process of end-user

involvement is seldom reported [17]. TCC interventions are more effective if the assessment of the current behavior, the identification of gaps between the current and preferred behavior, and the approach to bridge these gaps are grounded on sound behavioral change theories [13, 14, 17, 18]. Theory based interventions are often specific and replicable due to the theory driven description of the design, development and implementation processes [21-23]. Behavior change theories, such as the Health Belief Model (HBM) [24] can be used to assess the context and guide development and evaluation of TCC interventions [22].

Message content, in most text message based TCC interventions, tends to be generic and is rarely tailored towards important individual characteristics [7, 8, 14], possibly due to on-demand recruitment through campaigns documenting a few background information, especially in low-and middle-income countries [3]. This recruitment process can limit the availability of information about the recipient, and thus make the development of individualized messages difficult. Furthermore, most digital maternal and child health interventions are without a focus on continuity of care [7]. Developing and sending TCC interventions from a longitudinal registry environment, that includes dynamic information over the course of pregnancy and delivery, to our knowledge, has not been reported previously. The national electronic maternal and child health registry (MCH eRegistry) in Palestine, built on the District Health Information System 2 (DHIS2) software [25], provides such an opportunity [26, 27]. Healthcare providers enter individual-level patient information into the eRegistry at the point of care. The systematic, uniform and longitudinally collected data generate algorithms that drive the eRegistry, including TCC via SMS, which can increase timely attendance and the quality of ANC and PNC [26].

Following Abroms' [28] recommendation of setting goals for TCC interventions, our goal was to encourage pregnant and postpartum women to attend the scheduled visits in a timely manner, and empower them to come with expectations, demand services, and make informed health choices. When well-informed clients participate in the decision processes of their own clinical care, they have the potential to improve the quality content of care. Therefore, by improving the utilization and quality content of ANC and PNC services, TCC influences the uptake (coverage) and quality components of effective coverage metrics [29, 30].

This paper presents a theory-driven process from conceptualization and contextual assessment, to development and evaluation of a tailored TCC intervention using individual background characteristics from the MCH eRegistry in Palestine. We used recommended steps for developing and evaluating text messages [28] and relevant components of mHealth related reporting checklists, such as mERA [31] and TIDieR [32] throughout. The intervention described in this paper has subsequently been implemented in Palestine as a cluster-randomized controlled effectiveness trial (ISRCTN10520687)

## Methods

### Setting

We conducted this research to prepare a TCC intervention for a cluster-randomized trial (trial registration No: ISRCTN10520687), embedded in the national MCH eRegistry in the public primary healthcare clinics in Palestine [26, 27]. Approximately 50% of women in Palestine utilize public primary healthcare clinics for ANC and PNC services [33]. The organizational structure of the public primary healthcare clinics is reported elsewhere [27, 34]. The female literacy rate is above 94% [35], while approximately 85% of the women registered in the MCH eRegistry provided a mobile phone number.

We concentrated our efforts on addressing priority issues identified by a national expert panel: anemia, hypertensive disorders of pregnancy (HDP), gestational diabetes mellitus (GDM), fetal growth restriction (FGR), and untimely ANC attendance.

### Theoretical framework and data collection instrument

We used the HBM [24] to guide our interviews and assessments of the beliefs and perceptions of women around the prioritized high-risk conditions described above. We developed two in-depth interview guides, one for pregnant women and one for healthcare providers, to explore all six constructs (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cue to action, self-efficacy) of the HBM [24]. The HBM constructs were consolidated into three domains: 1) women's perceptions of personal risks for the high-risk conditions (susceptibility and severity), 2) benefits of attending ANC for those high-risk conditions, and 3) factors influencing the decision to attend timely ANC (perceived barriers, cues-to-action, and self-efficacy). The interview guides also included additional questions regarding health information sources, counseling, and views on the use of SMS to address knowledge gaps. The English interview guides were translated to Arabic and back-translated to English by an external person.

### Sampling and data collection process

We purposively selected seven public primary healthcare clinics where both pregnant women and healthcare providers were invited to participate in the study. Women who attended ANC at data collection day were asked to take part in the study by means of convenience sampling. We obtained oral informed consent from all informants. In total, four trained female nurses conducted 15 in-depth interviews in a private room, and three phone-interviews with pregnant women who stopped coming back to the clinics where they started ANC. The interviewers also conducted in-depth interviews with eight healthcare providers: four MCH doctors and four nurses/midwives. We stopped further interviews after reaching theoretical saturation. All interviews were audio-recorded.

### Data analysis

We transcribed the interviews, translated them to English, and used NVivo 12 software (QSR International Pty Ltd. Version 12, 2018) for data management and all subsequent analyses. We performed thematic analyses according to HBM constructs. First, we categorized the texts into nodes, referring to the HBM constructs, and then performed line-by-line coding. Then the main themes were developed and named from codes under each nodes. We also thematically analyzed information unrelated to the HBM. Three researchers participated in defining the themes based on the data.

### Composing and evaluating the text messages

We used the results of the in-depth interviews to compose the TCC content to be sent via SMS. The TCC content was developed to fill the major awareness and knowledge gaps related to three HBM constructs (Table 2). The prioritized conditions were linked with screening plans at each of the five sentinel ANC visits, according to the national guidelines (Additional file 1). We used the Model of Actionable Feedback (MAF) [36] and concepts of social nudging and Enhanced Active Choice (EAC) [11] to compose the TCC content (Additional file 2). We did not state the recipient's risk factors to ensure confidentiality. The TCC content was composed in English, translated to Arabic, and independently back-translated to English. We gathered feedback on the TCC content in a stepwise

manner, and incorporated comments prior to the next rounds of feedback. The first consultation with national health education experts on the TCC content suggested further contextualization such as using local expressions. Next, we interviewed healthcare providers and pregnant women to assess the TCC content's understandability and acceptance. Information regarding the preferred time of the day to receive the text messages was also gathered. The final text message library was created after considering all comments.

## Technology platform

We wrote algorithms based on individual health data, scheduled visits and gestational age, all data points available in the MCH eRegistry, to trigger each message type in the text message library at a particular time and to a particular recipient. The algorithms are scheduled to run daily to identify recipients of specific messages in the text message library. We use the DHIS2 Tracker App [25] to send messages from the MCH eRegistry through a local telecom service provider's SMS gateway, as per agreement with the Ministry of Health.

# Results

We present 1) findings from the in-depth interviews with pregnant women and healthcare providers from the same facilities, and 2) how we utilized these findings in iterative rounds of development and evaluation with users in the co-design of the TCC text messages.

### Part I: Findings from in-depth interviews

Among 18 interviewed pregnant women, seven had high-risk conditions in the current pregnancy, and seven were primigravida. The participants mean age was 26 years, ranging from 20 to 33 years. All interviewed women had formal education and seven of them held college degree or above.

We present pregnant women's perceptions of the prioritized high-risk conditions (anemia, HDP, GDM, FGR, ANC and PNC attendance) and the benefits of attending ANC, using the HBM (Table 1). We also present results from healthcare providers' perspectives and experiences, where relevant.

### Perceptions of high-risk conditions and timely attendance

**Perception of susceptibility and severity:** Pregnant women, in general, perceived that they had low susceptibility to the high-risk conditions, and that these had low severity. Women with knowledge of the high risk conditions, a history of pregnancy complications, or knew someone with a history of pregnancy complications, perceived greater susceptibility to the high-risk conditions compared with their peers. Women engaged in self-care activities, such as healthy diet, exercise, and regular checkups, perceived themselves as less susceptible to pregnancy complications compared with women not engaged in self-care activities. Most pregnant women knew the general consequences and complications of anemia, diabetes, and hypertension as chronic diseases, but not their effects in pregnancy on maternal and fetal outcomes (Table 1).

**Perceived benefits of timely ANC attendance:** Pregnant women recognized the benefits of attending ANC on wellbeing, both for their baby and themselves. However, they had little awareness of the need for timely ANC attendance for appropriate screening and management for specific conditions. Individual background characteristics determined the pregnant women's perceived benefits of attending ANC for the sake of each high-risk condition. Women identified with a high-risk condition or with a history of a pregnancy complication,

attended ANC more often than women without any current or previous complications. These women were also more aware of what to expect during ANC visits and the importance of timely attendance. Primigravida women were eager to attend ANC, but reported low awareness regarding expected screening and management activities, and the importance of timely attendance. Healthcare providers reported that they provided attractive ANC services to women, contributing to the women's regular ANC attendance (Table 1).

Table 1: Health Belief Model constructs including the main themes with quotes from the participants, Palestine, 2017

Model constructs	Description of the themes	Example excerpts
Perceived susceptibility	<b>Knowledge:</b> Susceptibility is perceived as higher among women who know the complications that can develop in pregnancy	<p>"I don't know about the disease, so how can I know if I am susceptible to it or not."</p> <p>- <i>a primigravida</i></p>
	<b>Self-care:</b> Women perceive lower susceptibility as they engage in preventive self-care (e.g. healthy diets) and follow recommendations of care providers (e.g. ANC and screening)	<p>"No, because I came to the clinic every time, and they [healthcare providers] reassured me that I didn't have anything worrying. Also, in fact, I do not like sweets and sugar." - <i>a primigravida</i></p> <p>"I do not think so, because I am eating a good diet. As long as you have a good diet and milk and your hemoglobin is 12 and you are at the end of your pregnancy..."</p> <p>- <i>a low risk woman</i></p>
	<b>Pregnancy history:</b> Women with complications in previous pregnancies perceive themselves as more susceptible	<p>"Yes, I had it [hypertension] in my first pregnancy and I recovered after delivery. Yes, I am susceptible because..."</p> <p>- <i>an 8 months pregnant woman</i></p>
	<b>Family history:</b> Women with a family history of pregnancy complications or chronic conditions perceive themselves as more susceptible	<p>"No I don't worry, and there is nobody in my family who has diabetes"</p> <p>- <i>a 29 year old hypertensive woman</i></p> <p>"I don't know exactly, my parents don't have hypertension and my husband's parents have hypertension, so maybe my children will have hypertension in the future."</p> <p>- <i>a pregnant woman who had miscarried five times</i></p>
Perceived severity	<b>Chronic conditions, not pregnancy complications.</b> Women relate their perception of severity to the conditions as chronic conditions, but not their potential for complicating pregnancy	<p>"I know that diabetes delays healing of the wound and this may cause amputation of limbs..." - <i>a woman attending a high-risk clinic</i></p> <p>"Heart problems and increase heart rate, dizziness and loss of consciousness"</p> <p>- <i>a low-risk woman</i></p> <p>"I do not know if it affects [the baby]"</p> <p>- <i>a 20 year old primigravida with moderate anemia</i></p>
	<b>History of friends/relatives:</b> Women who know friends/family with a history of pregnancy	<p>"...hypertension is dangerous for pregnant women and leads to</p>

	<p>complications perceive complications as more severe</p>	<p>preeclampsia, I know a friend who had eclampsia at the end of the eighth month”</p> <p>- <i>a multigravida</i></p> <p>“My sister had anemia and her hemoglobin became 5, and she needed two units of blood...”</p> <p>- <i>a grand multipara</i></p>
	<p><b>Being affected by a complication:</b> Women diagnosed with a high risk condition, often articulate clearly the potentially severe consequences of the condition</p>	<p>“Premature baby, low birth weight or IUGR”</p> <p>- <i>a pregnant woman in a high-risk clinic</i></p> <p>“It can cause early labor, bleeding and thrombosis”</p> <p>- <i>a woman with coagulation disorder</i></p>
Perceived benefit	<p><b>Expectations to care content:</b> Advance knowledge of purpose and what tests each scheduled visit would include, affects the women's perception of benefit</p>	<p>“I found that [private] doctor and [public] clinic providing the same services, such as weight, height, blood pressure measurements, so I decided to follow up in the [public] clinic”</p> <p>- <i>a pregnant woman at low-risk clinic trying out services in Gaza</i></p> <p>“I have to come. It is my duty to come for ANC visit”</p> <p>- <i>a primigravida</i></p>
	<p><b>Being affected by a complication:</b> Women diagnosed with a high risk condition perceive the importance of visiting the clinics according to the schedule, but only for the specific condition they are diagnosed with</p>	<p>“...examine the level of sugar and control...”</p> <p>- <i>a woman attending a high-risk clinic</i></p> <p>“I follow my periodic check-ups every month ...I receive the anticoagulant injections...”</p> <p>- <i>a woman with coagulation disorder</i></p> <p>“Of course it is beneficial, since I get the anti-hypertensive drugs, iron and vitamins”</p> <p>- <i>a woman diagnosed with HDP</i></p>
Perceived barrier	<p><b>Perception of benefits:</b> The better the perceived benefit the woman have, the less perceived barrier to attend the scheduled visits</p>	<p>“I think that there are no obstacles, and I should follow the right things for my benefit.”</p> <p>- <i>a primigravida</i></p> <p>“I think, there are no difficulties, and the most important thing is having personal</p>

		will"  - <i>a grand multipara</i>  <b>Family logistics:</b> Women with small children and little family support, report this as a barrier to attend ANC  "In the first and second pregnancies, I attended regularly, but when the number of my children increased, it became less often than before."  - <i>a mother of three</i>  "...my children are small and my husband works in military and he comes back at night..."  - <i>a multipara</i>
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**Perceptions about barriers, cues-to-action, and self-efficacy:** In general, women's perceptions of barriers, lack of cues-to-action, or lack of self-efficacy were not main factors preventing women from attending ANC services. Among women interviewed, the majority reported that accessibility and lack of support from the husband and/or other family members were not a problem. However, a few women with young children stated that childcare was a barrier for them to attend ANC. Low perceived benefits from ANC attendance, along with low perceptions of susceptibility to, and severity of, the high-risk conditions, were the main barriers to timely ANC attendance.

Most women attended ANC despite the lack of cues-to-action, such as a formal appointment reminder system. However, both healthcare providers and women indicated that healthcare providers sometime contact women with a missed appointment via phone or through social networks including family members. Healthcare providers pointed out that these approaches are time consuming and done irregularly. Women diagnosed with a high-risk condition and perceived this as severe, attended ANC due to their concerns. As one midwife pointed out, "...*they feel it is important for them, they write the date on their mobile so that they cannot forget it*"

Regarding self-efficacy, almost all women said that they independently decided to attend ANC, and that they are confident about their choice. They also reported that they have adequate social capital to do so. One interviewee said, "*Inshalah, since I am educated, I can do the right thing.*"

### Pregnant women's awareness, health information sources and counseling

All pregnant women had heard of anemia, HDP, GDM and FGR. However, the awareness level and descriptions of causes and consequences varied based on the level of education, parity, personal history and knowing someone with at least one of the conditions. Women diagnosed with a condition were more aware of that condition and followed its progress more closely, compared to women not diagnosed with any of the high-risk conditions. Most of the diagnosed women remembered lab results, such as hemoglobin levels over time (Additional file 3 <sup>a</sup>).

Healthcare providers, especially MCH doctors, were the main trusted sources of pregnancy related information. Several women also mentioned that they use the internet or ask their mothers if they need information immediately, and if they do not understand or find contradictory information, they prefer to confirm it with a doctor (Additional file 3 <sup>b</sup>).

Most women felt that they received adequate health information during ANC visits (Additional file 3<sup>c</sup>). Women diagnosed with one of the high-risk conditions received information regarding that specific condition. Healthcare providers stated that they spent less time on counseling and health education than desired, due to the high patient load (Additional file 3<sup>d</sup>), and this was confirmed by some pregnant women diagnosed with a high-risk condition (Additional file 3<sup>e</sup>).

## **Attendance at ANC**

Almost all women stated that they visited the health facility when they missed a period, and most healthcare providers had observed an increasing trend in early initiation of ANC. Most women were committed to scheduled ANC visits, but the degree of adherence differed based on their background characteristics, such as education, parity, and previous adverse pregnancy outcome (Additional file 3<sup>f</sup>). Healthcare providers also said that most women are committed to scheduled ANC visits, including those with low-risk pregnancies. Women showed an interest in more frequent visits than currently recommended (Additional file 3<sup>g,h</sup>).

In sum, the in-depth interviews indicated that many women had limited knowledge about pregnancy related anemia, HDP, GDM, and FGR, and perceived the susceptibility to, and severity of, such conditions as low. While the general motivation to attend ANC was high, awareness of the importance of timely attendance to be appropriately screened and managed for such conditions was low. Women with high exposure to information about such pregnancy-related complications and the role of ANC (i.e. complications in current or prior pregnancy, knowing someone who experienced it, etc.) had high awareness of both susceptibility and severity, as well as of the benefits of timely ANC.

## **Part II: Composing the text messages**

We used the findings from the in-depth interviews above to identify gaps in information and awareness, across the HBM constructs, to be addressed in TCC. The national ANC guidelines recommend specific interventions towards the prioritized pregnancy related conditions in ANC visits at specific gestational ages (Additional file 1). Based on the Model of Actionable Feedback, we identified these visits as windows of opportunity for timely and actionable TCC, by combining actionable reminders of scheduled ANC visits with timely information on the susceptibility and severity of the focus condition, and the specific benefits of care, in this upcoming ANC visit. After cross linking the HBM constructs to address for each visit, our iterative process of co-design with users was guided by the Enhanced Active Choice and nudging theories and the Model of Actionable Feedback for the detailed framing, composition and timing of each text message.

### **Intervention structure: target condition, frequency, timing and intensity**

We developed text messages to be delivered in concert with the five sentinel recommended visits (gestational week <16, 18-22, 24-28, 32 and 36) [34] in addition to a welcome message sent at the time of enrollment. The content of the text message at each gestational week window was, among other factors, determined by the timing of the screening tests for the prioritized conditions (Additional file 1). We applied the following message types and frequencies per visit:

1. One week before a scheduled sentinel visit: Women with a scheduled visit within an appropriate gestational age window, described above, receive this message. The message content addresses the benefit of attending

ANC and the susceptibility to and, severity of the specific high-risk condition to be screened for, at that visit, according to national guidelines.

2. Three days before scheduled sentinel visit: Only women with risk factors for the high-risk condition to be screened for at that appropriately timed sentinel visit, receive this message as a “scaled intensity” to intensify the intervention for those with the highest need.
3. 24-hours before any scheduled visit: All women with a scheduled visit irrespective of the gestational age receive this simple reminder.
4. 24-hours after missed appointments for a sentinel visit: Only women with a missed appointment for an appropriately timed sentinel visit receive this reminder to re-schedule the appointment.

The package of text messages included continuity of care and postpartum care messages (Figure 1). To illustrate, a woman above 34 years of age without a diagnosed high-risk condition, will receive 19 text messages if she starts ANC before gestational week 15, and is scheduled for and attends all five sentinel visits. Missed appointment reminders would be additional.

24-hours before appointment is sent for all scheduled appointments, including PNC appointments

A week before and risk-factor SMS differ for each of the five sentinel visits, as indicated in Additional file 1

### **Content and framing of the text messages**

The SMS content addressed key themes within the HBM constructs identified in Part I. To address gaps in perceived susceptibility, the text message included information about a woman’s relative chance of getting each high-risk condition (Table 2). We followed message-framing concepts and expressed proportions in an “x in y” format. For women with risk factors, we stated the risk factor and the increased susceptibility to the corresponding high-risk condition.

We stated the consequences of each high-risk condition to both the woman and her baby to address the perceived severity, given that most women knew the general population consequences of the chronic disease, but not the specific adverse effects during gestation. We avoided serious and grave consequences, such as death or malformation, to prevent unwarranted worries in pregnancy. We presented the potential screening tests that could detect each high-risk condition to address the perceived benefits (Additional file 1).

With this information, we composed the contents addressing the identified constructs; see an example in Table 2.

Table 2: Content creation for the identified constructs of the Health Belief Model, an example

Targeted HBM constructs	Gaps and considerations	Source of information	Example phrases
<b>Perceived Susceptibility</b>	· Specifying risks to pregnancy	· <i>Finding from part I</i>	<i>1 in 20 develop high blood pressure in pregnancy.</i>
	· Statistics	· <i>Theory: nudging</i>	
	· Scaled intensity: more messages to those with risk-factors	· <i>Theory: MAF</i>	
<b>Perceived Severity</b>	· Consequences to the baby and the women herself	· <i>Findings from part I</i>	<i>This can affect the baby's nutrition and growth. If not measured and managed, it can affect your health too.</i>
	· No mentioning of severe/grave consequences	· <i>Theory: EAC and MAF</i>	
<b>Perceived Benefits</b>	· Guideline based available screening services at the PHCs	· <i>Mapping: ANC guideline</i>	<i>We will measure your blood pressure and proteins in your urine that can be a sign of high blood pressure.</i>
	· Specifying beneficial test beforehand	· <i>Findings from part I and EAC</i>	
	Personalization		
	· Timed to the benefit	· <i>Theory: MAF</i>	
		· <i>Theory: MAF and EAC</i>	

HBM = Health Belief Model, MAF = Model of Actionable Feedback, EAC = Enhanced Active Choice

The Model of Actionable Feedback [36] and concepts of social nudging and Enhanced Active Choice [11] were used to structure the text messages, and make them action oriented while addressing knowledge gaps, beliefs and perceptions (Figure 2, Additional file 2). Concepts from the Model of Actionable Feedback, including timeliness, non-punitiveness, customizability, and individualization, were among the guiding principles at each stage of the TCC content development, evaluation, and implementation. See [Additional file 2](#) for details on the application of the Model of Actionable Feedback and Enhanced Active Choice in composing the text messages.

[Woman's name] the algorithm pulls the first name of the recipient and inserts here

[Visit Date] the date of scheduled visit appears in YYYY.MM.DD format automatically

[Clinic's name] the name of public primary health care where the woman attends her visits automatically inserted

## Evaluation of the draft text messages

Generally, the content of the text messages was understandable and acceptable after evaluation by health educators, healthcare providers and pregnant women consecutively. Minor changes to select messages were made based on comments from interviewed stakeholders. Contextualized translation into Arabic was preferred over literal translation. Regarding the timing, women preferred to receive the text messages after working hours when they are free to read the text messages.

## Discussion

In co-design with users, we developed an SMS based TCC intervention tailored to individuals. We underpinned our intervention with behavior change theories and recommendations from systematic reviews [13, 14, 17, 18], and composed messages following recommended framing models[11, 37]. The message development process was iterative, and we involved end-users from the beginning. The MCH eRegistry [26, 27] presents a unique opportunity to develop an individually tailored and automated TCC intervention.

Our qualitative findings revealed that perceived susceptibility, severity, and benefits are the main HBM constructs affecting whether or not pregnant women attend ANC for screening and management of high-risk conditions (anemia, HDP, GDM, and FGR) in a timely fashion. This is in line with the systematic reviews of ANC service utilization, reported that the women's perception of risks (perceived susceptibility and severity) and the benefits of ANC in identifying and managing risks affect timely attendance to the services [38, 39]. Access to health care facilities was not reported as an important barrier to attendance in our sample, while it has been reported that the presence of checkpoints made access difficult in this context [40], and one of the major factors in other settings [38, 39].

Analyses guided by the HBM assisted us in identifying information targets for this TCC intervention. Our TCC intervention directly targets perceived susceptibility, severity, and benefits, and indirectly targets perceived barriers, cues-to-action and self-efficacy. Through SMS, we aim to improve the awareness of personal susceptibility to, and severity of high-risk conditions, and the benefit of timely ANC attendance for screening and management. We believe that these text messages from the eRegistry can serve as cues-to-action and affect self-efficacy by empowering women.

Among behavior change theories used for similar interventions [22], we selected the HBM as theoretical framework based on its common use in similar resource-limited settings [24]; the nature of our behavior change goal; the scope of our intervention; and our target audience [22]. HBM served as a lens to understand the context and identify the major gaps to be addressed. We also used social nudging, a concept derived from behavioral science, and the Enhanced Active Choice model for framing the text messages [11, 37]. We wanted women to make a conscious decision regarding ANC and PNC attendance. Information about the gains and losses of timely attendance was used to nudge women to attend timely scheduled visits [11]. The Model of Actionable Feedback was used to help transition women's intention of performing the behavior to actually practicing it [36]. It guided, for example, the insertion of the scheduled date right after the personalized greetings, since the action or targeted behavior change goal, is to attend the facility in a timely manner. All the different components in a text message were created based on the concepts and applications of theories we used (Fig 2).

Limited information exists regarding the best processes for designing the content of a TCC intervention. It is recommended to publish the development process, as well as the effectiveness of mHealth interventions [41], to increase scientific discussions and improve the quality of mHealth interventions including TCC. We have considered learning points from previous development processes despite the differences in technologies used [23, 41, 42]. Communicating back to the client from the registries is one of the functions which can be utilized better [26]. We demonstrate how longitudinally collected data can be harvested to deliver more personalized health education and promotion messages in the growing field of mobile technology for health.

### **Strengths and limitations**

Our text messages are based on modifiable factors among the recipients, such as gaps in knowledge and perceptions. We have refrained from sending condition-specific messages to woman diagnosed with that same high-risk condition, i.e. a woman with hypertensive disease in pregnancy will not receive messages about her susceptibility to develop hypertension in pregnancy. We also avoid sending recommendations for action to women with high risk conditions managed in high risk clinics where management may be highly individualized and not determined solely by guideline-driven algorithms.

We addressed confidentiality issues concerning the TCC content throughout the design process. Women might share their phones with other family members, and someone other than herself might therefore see the text messages. We have therefore de-sensitized the TCC content by not indicating that the receiver has a specific risk factor. For example, for a woman with high BMI, we phrased the message as "*...High weight increases the risk of diabetes. We will measure your...*" without directly stating that she is obese.

Our project pioneers the use of the DHIS2 Tracker software to send tailored text messages on specific dates and times at national scale. This involves scheduling of messages based on data, a functionality that did not exist in the software at the outset of the project, and therefore required longer development and enhancement time than first anticipated. Future projects, should take the readiness of the technology and the time needed for software development into account when planning the overall timeline. It is a challenge to express necessary and personalized information in a clear and understandable way within the limitations of SMS messages (size of screen, acceptability, and cost increasing by "one SMS" for each 160 characters in Latin letters [43] and 70 characters in Arabic). The fact that several of our messages had over 140 Arabic characters (i.e. cost as for three messages), has consequences for sustainability. We have not utilized the full potential of the technology due to development needs, but further tailoring to various static and dynamic personal characteristics should be possible with the MCH eRegistry. Additionally, two-way communication has been shown to be more effective than one-way messaging [44]; this feature is not yet routinely available in the software.

There is no one-size-fits-all approach for deciding the ideal 'dosage' of text messages to be delivered to an individual to change behavior. The threshold is likely to vary according to the richness of the content, intervention type, and target group [45, 46]. We have chosen our dosage after discussing with the local experts, but have not put the final quantity under formal evaluation. We selected the timing by considering the balance between the time needed to prepare for a visit (one week ahead as a cue to action and enable reflection and planning of practicalities) and not forgetting the date of that visit (24 hours before as a simple reminder) (24 hours before as a simple reminder). However, most untailored TCC interventions in the field of maternal and child health, has reported sending more text messages per week than we propose [13, 15, 47].

## **Conclusions**

The stepwise iterative process revealed elements critical to an effective TCC intervention, which otherwise could have been easily missed. The theories served as a lens through which we assessed gaps in anticipated behavior, a focus for composing the TCC content, and a guide for evaluating content understandability and acceptability. Co-designing with users enhanced contextualization and refinement of the TCC content. Behavioral science concepts made us value each word and its relative position in the text. The MCH eRegistry can serve as a unique platform through which to target communication. Reporting on the development process of our TCC intervention will improve transparency and contribute to scientific dialogue to improve its effectiveness.

## **Abbreviations**

ANC Antenatal Care

FGR Fetal Growth Restriction

GDM Gestational Diabetes Mellitus

HBM Health Belief Model

HPD Hypertensive Disorders of Pregnancy

MCH Maternal and Child Health

mHealth Mobile Health

PNC Postnatal Care

SMS Short Message Service

TCC Targeted Client Communication

WHO World Health Organization

## **Declarations**

### **Ethics approval and consent to participate**

We obtained ethical approval from the Palestinian Health Research Council (04/06/2018, ref: PHRC/HC/401/18), and exemption from ethical review from the Regional Committee for Health Research Ethics (REK) - Section South East B, from Norway (05/06/2018, ref: REK sør-øst 2018/1148) as health systems research falls outside of the mandate for ethical review in Norway. We secured oral informed consent from the participants prior to conducting the in-depth interviews.

### **Consent for publication**

Informed oral consent was obtained from all participants.

## **Availability of data and material**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## **Competing interests**

The authors declare that they have no competing interests

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## **Authors' contributions**

Conceptualization, J.F.F.; Methodology, J.F.F., K.M., and B.B.; Investigation, B.B., B.G., I.A.W., K.A.K., M.B., T.H. T.A.; Software, B.O., B.B., M.F., M.B., Y.R.; Writing- original draft, B.B., K.M., J.F.F.; Writing- Review and Editing, all ; Funding Acquisition, J.F.F.

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## Figures

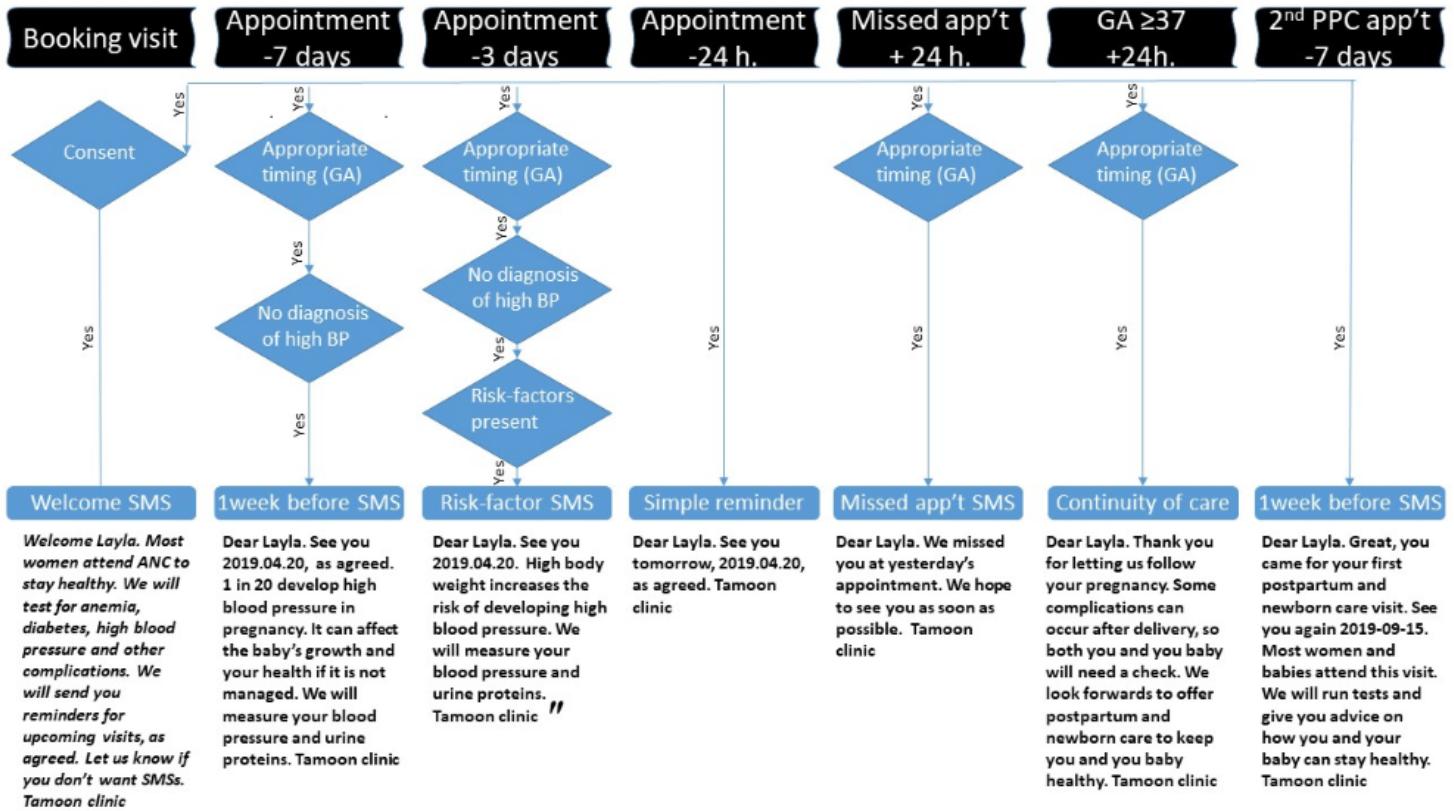


Figure 1

SMS library example for a low risk overweight woman targeting hypertensive disorders in pregnancy

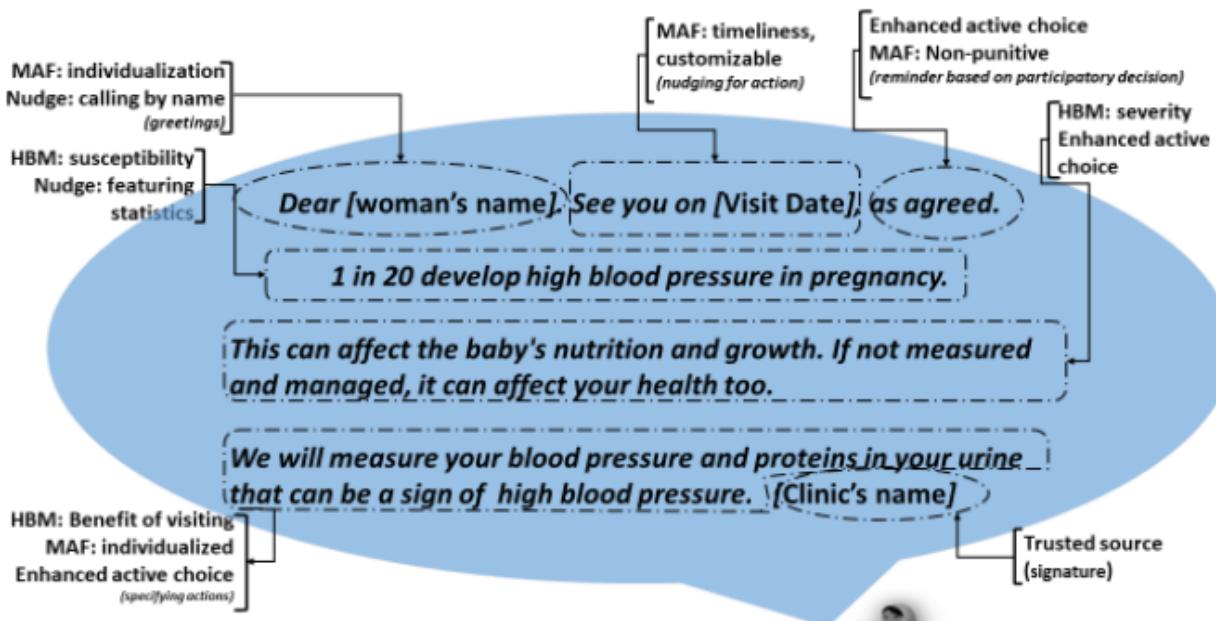


Figure 2

An example of how the Health Belief Model (HBM), Model of Actionable Feedback (MAF), Enhanced Active Choice (EAC) and social nudging theories were used to compose the text messages

## Supplementary Files

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