Reducing provider workload while preserving patient safety via a 2-way texting intervention in Zimbabwe's voluntary medical male circumcision program: study protocol for an un-blinded, prospective, non-inferiority, randomized controlled trial

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Method Article

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Abstract

Background: Surgical male circumcision (MC) safely reduces risk of female-to-male HIV-1 transmission by up to 60%. The average rate of global moderate and severe adverse events is 0.8%: 99% of men heal from MC without incident. To reach the 2016 global MC target of 20 million, productivity must double in countries plagued by severe healthcare worker shortages like Zimbabwe. The ZAZIC consortium partners with the Zimbabwe Ministry of Health and Child Care and performed over 120,000 MCs. MC care in Zimbabwe requires in-person, follow-up visits at post-operative days 2,7, and 42. ZAZIC program adverse event rate is 0.4%; therefore, overstretched clinic staff conducted more than 200,000 unnecessary reviews for MC clients without complications.

Methods: Through an un-blinded, prospective, randomized, control trial in two high-volume MC facilities, we will compare two groups of adult MC clients with cell phones randomized 1:1 into two groups: 1) routine care (control group N=361) and 2) clients who receive and respond to a daily text with in-person follow-up only if desired or if a complication is suspected (intervention N=361). If an intervention client responds affirmatively to any automated daily text with a suspected AE, an MC nurse will exchange manual, modifiable, scripted texts with the client to determine symptoms and severity, requesting an in-person visit if desired or warranted. Both arms will complete a study-specific, Day 14, in-person, follow-up review for verification of self-reports (intervention) and comparison (control). Data collection includes extraction of routine client MC records, 2WT study-specific database reports, and participant usability surveys. Intent-to-treat (ITT) analysis will explore differences between groups to determine if two-way texting (2wT) can safely reduce MC follow-up visits; estimate the cost savings associated with 2wT over routine MC follow-up; and assess the acceptability and feasibility of 2wT for scale-up.

Discussion: It is expected that this mobile health intervention will be as safe as routine care while providing distinct advantages in efficiency, costs, and reduced healthcare worker burden. The success of this intervention could lead to adaptation and adoption of this intervention at the national level, increasing efficiency of MC scale up, reducing burdens on providers and patients.

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Keywords: Voluntary medical male circumcision, Zimbabwe, mobile health, healthcare delivery innovations

Background

Male circumcision (MC) reduces the risk of female-to-male HIV-1 transmission by up to 60% (1-3). From 2008-2015, 10.4 million voluntary medical male circumcision (VMMC) procedures were performed (4), falling far short of the 20 million needed to reach the UNAIDS/ World Health Organization (WHO) target of 80% coverage in 14 priority countries by 2016 (5). Reaching the target could avert 3.4 million HIV infections and save $16.5 billion in HIV-related care through 2025 (6). Although surgical VMMC has been streamlined and made efficient through operational optimization (7), current VMMC follow-up requires at least one in-person visit within 14 days of MC (8-10). VMMC program guidelines often require multiple, additional visits over the 42-day healing period. Severe healthcare worker shortages (11) combined with rapidly expanding VMMC programs threaten already overburdened healthcare systems by recruiting workers away from facilities or diverting their efforts from other competing patient care needs.

In pilot studies and controlled trials in sub-Saharan Africa, surgical adverse event (AE) rates from combined moderate and severe AEs range from 0.5% to 8% with few severe AEs resulting in permanent impairment (1-3, 12-19). Although AE reporting in field settings is challenging (20-22), AE rates averaged 0.8% (range: 0.4%-4.2%) in all southern African countries from 2010-2012 (23). These low AE rates correspond to 99% of men healing without incident, leading to millions of healthcare visits conducted without cause and needlessly increasing the workload. For men, these unnecessary visits likely create barriers to care such as transportation costs, wait times, and inconvenience (24-29), potentially reducing VMMC uptake. Empowering men to seek in-person follow-up care only when needed or desired would decrease the burden for both healthcare workers and

patients, thereby improving efficiency and reducing both direct and indirect costs for this critical component of combination HIV prevention.

The spread of mobile telephones throughout sub-Saharan Africa affords an important opportunity to address these inefficiencies and retain quality care. Text messages show immense promise to positively influence health behavior and improve clinical care (30-32). Most short message service (SMS)-based health promotion efforts use one-way 'push' messages, blasting pre-defined messages to many people simultaneously (33-35). Among VMMC programs, a randomized control trial determined that automated SMS modestly increased adherence to 7-day follow-up visits from 59.7% to 65.4% (RR 1.09, 95% CI 1.00–1.20; p = 0.04) but did not influence resumption of sex during the 42-day healing period (relative risk=1.13, 95% CI 0.91-1.38, p=0.3) (29, 36). An important weakness of these one-way, blast approaches is the one-size-fits-all approach, removing patients' ability to communicate back with healthcare workers (37), potentially reducing patient engagement in care.

Two-way texting (2wT) between providers and patients shows promise to provide quality interactive care. In Kenya, patients enrolled in a SMS study significantly increased adherence and viral load suppression, but high-volume, manual texting was time-consuming and not sustainable for healthcare workers (38). Another Kenyan study engaged patients in important health-related conversations and provided critical health information (39); however, this intervention tasked the health workers to respond to complicated, open-ended questions, investing considerable time. In 2008 members of this study team pioneered an alternative approach to provide high-quality, efficient, coordinated service by enabling patients or community health workers to exchange ad hoc messages with facility-based nurses in Malawi (40, 41). Use of interactive, mobile technology that improves both care quality and care efficiency for providers and patients is warranted.

Zimbabwe is primed for this type of mobile intervention. In 2014, Zimbabwe reached about 25% of its 1.3 million VMMC target for 2018 (42). Although some AE underreporting is possible (42), Zimbabwe's VMMC program is safe with the national VMMC program's AE rate of 0.35% (42). Under the current VMMC Zimbabwe Ministry of Health and Child Care (MoHCC) standards, 1 million additional VMMCs in Zimbabwe will translate into more than 2 million unnecessary follow-up visits. As each VMMC client likely passes through reception, observation, and examination, the healthcare workload and time lost for VMMC clients healing without complication is likely several times higher. Moreover, VMMC staff are MoHCC employees who perform most VMMCs in outreach sites (tertiary clinics, schools, communities). Unnecessary follow-up in outreach sites results in additional days away from routine clinic duties, stretching human resources required for myriad other health needs. While healthcare is strained, mobile technology is advancing rapidly: in 2014 approximately 81% of Zimbabweans had a cell phone (43). This setting with high, unnecessary in-person VMMC follow-up; healthcare worker shortages; and high cell coverage is ideal to test and evaluate a better, low-cost approach to minimizing the burden on both the healthcare system and VMMC clients.

Building upon these previous mHealth initiatives, we seek to implement a two-way texting (2wT) intervention that combines automated and interactive text messaging to maintain safety while dramatically reducing the burden that in-person VMMC follow-up places on weak health systems. Automated messaging during Days 1-14 after circumcision could track men who are healing without complication, enabling a conservative estimate of more than 80% of clients to avoid unnecessary in-person follow-up at post-operative Days 2, 7 and 42. When a patient responds to an automated prompt message in a way that flags a potential AE, interactive messaging with a nurse would encourage them to promptly seek in-person, follow-up care. 2wT would act as active but efficient surveillance, improving care. By combining automated messaging to screen out cases with no complications and interactive texting to identify potential AEs, this intervention could make the care pathway far more efficient, reducing the costs of VMMC care over time for both providers and patients. Reduced in-person follow-up could also free these same healthcare workers to perform additional VMMC surgeries.

As a national VMMC implementing partner, the ZAZIC consortium, led by the University of Washington's International Training and Education Center for Health (I-TECH) and local implementing partners, The University of Zimbabwe(UZ)-University of California San Francisco Collaborative Research Program, Zimbabwe Association of Church-related Hospitals (ZACH), and Zimbabwe Community Health Intervention Research Project (ZiCHIRe), works in partnership with the Zimbabwe MoHCC to implement VMMC services in 10 districts (44). ZAZIC's program is highly productive and safe: between July 2015-June, 2016, ZAZIC conducted 47,905 MCs and 45,989 follow-up visits to find 151 AEs, an AE rate of 0.3% (45). Adherence to follow-up visits,

another indicator of program quality (46), was good. Over 88% of men reportedly attended both Day 2 and Day 7 follow-up; more than 30% also had a Day 42 visit to verify complete healing (47). With high follow-up visits, even if 20% of men were reviewed on Days 2 and 7 for high sensitivity of AE detection, almost 74,000 in-person visits were unnecessary and could potentially be replaced with 2wT interactions between patients and providers. ZAZIC continues to rapidly scale up. In ZAZIC's largest urban district, Chitungwiza, we have reached only 14% of the intended 80% target for 2018, indicating ZAZIC projected exponential increase over the coming 2 years. Greater efficiency would enable more VMMCs.

We propose to maintain patient safety while reducing the substantial VMMC follow-up workload burden by using two-way mobile phone texts to provide in-person review only for men who indicate a desire or need for follow-up. This tailored approach to post-procedure VMMC care could reduce unnecessary visits and remove barriers for VMMC clients without deterioration of quality care. ZAZIC's diverse, expert team of researchers from the University of Washington, Seattle, USA; the University of Zimbabwe; Medic Mobile, Nairobi, Kenya; and Zimbabwean partner organizations will test this mHealth intervention. We believe that bi-directional, interactive, text-based short message service (SMS) during the most critical 14 days after circumcision will help men identify and act on any sign of an adverse event, thereby seeking in-person follow-up only when an AE is suspected and reducing unnecessary visits. Reduced in-person follow-up could also free healthcare workers to perform additional VMMC surgeries. The proposed mHealth study could establish new, low-cost, technology-supported VMMC follow-up that will streamline in-person care, therefore reducing provider workload and patient burden while maintaining the quality of care.

Methods

Ethics:

This study was approved by the Medical Research Council of Zimbabwe (MRCZ) and the University of Washington IRB. No deviations from the protocol after approval will be implemented without prior approved amendment by these IRBs except where it may be necessary to eliminate any immediate hazard to study participants. In such case, the deviation will be reported to the IRBs as soon as possible. Written informed consent will be obtained from all participants prior to enrollment in the study.

Data Safety and Monitoring Board:

We will form an independent Data Safety and Monitoring Board (DSMB). The DSMB will be available to review and advise on any concerning findings, such as social harms or other adverse events linked to the study, distress evoked among participants that might outweigh the potential benefits of the study, difficulties in recruitment, difficulties in study site participation, or any other issues that threaten the scientific or ethical foundation of the study. The DSMB will have the power to stop the study at any time. The investigators will also reach out to the UW IRB and members of the Medical Research Council of Zimbabwe in the event of concerns related to participant well-being or study validity, to consult on whether study procedures need to be modified or halted.

Study objectives:

Using a prospective, randomized control trial (RCT), our intervention compares two groups of clients with cell phones: 1) routine care (control group) and 2) clients who receive and respond to a daily text with in-person follow-up only if desired or if an AE is suspected (intervention). Both arms complete a study-specific, Day 14, in-person, follow-up review for verification of self-reports (intervention) and comparison (control). The intended timeline is presented in Figure 1. The specific objectives are to:

Objective 1: Determine if 2-way texting can safely reduce VMMC follow-up visits through an un-blinded, prospective, non-inferiority, RCT in high-volume facilities providing VMMC. Two-way texting (2wT) will provide interactive, text-based follow-up. 2wT men healing without complication could decline in-person follow-up; those with suspected AEs will be referred to in-person care. We will compare the safety outcome of combined moderate or severe AE rate ≤ Day 14 post-VMMC and the workload outcome of average number of in-person follow-up visits between control and intervention arms.

Objective 2: Estimate the cost savings associated with 2wT over routine VMMC follow-up by determining the programmatic costs of 2wT from a systems perspective, including the technology (48), healthcare worker costs, and client perspective (travel, text costs, missed work). We will estimate the incremental intervention costs relative to routine practice to quantify gains in healthcare efficiency for scale-up and adoption.

Objective 3: Assess the acceptability and feasibility of 2wT for further scale-up via qualitative interviews with VMMC healthcare workers and brief quantitative interviews with 2wT clients inform intervention acceptance. Meetings with local researchers and collaborators will further assess feasibility, adaptation, open-source collaborative development, and system integration for replication and sustainability in Zimbabwe and the region.

Technology overview:

Studies that demonstrate the impacts of mHealth interventions too often have evaluated technologies that are made 'from scratch' and as a result are not robust enough to merit widespread replication (40, 49). By partnering with a well-established non-profit mHealth organization, Medic Mobile (http://medicmobile.org/), and integrating with their existing software platform, open-source community and current efforts to integrate with existing health information systems (HIS) throughout sub-Saharan Africa, our team and proposed intervention are well positioned to scale up and sustain any promising results. Since 2008, Medic Mobile has been a leader in the global mHealth community (50-52), equipping more than 13,500 health workers serving over 8 million people across 23 countries. The Mobile Medic Toolkit is an Android-based application that supports texting in any language and works with or without internet connectivity on basic phones, smartphones, tablets, and computers (53). The existing, well-proven, app-based Toolkit that will be the basis for 2wT provides an automated and prioritized list of upcoming tasks, guiding health worker through actions (e.g., response waiting, referral)The Toolkit provides real-time progress indicators such as texting delivery rates and response rates. Data from mobile users are replicated to Medic Mobile web app and analytics tools for real-time response. The platform is highly configurable, currently supporting evidence-backed workflows and program implementation related to ensuring safe deliveries (54), tracking tuberculosis patients (55), boosting immunization rates (56) and monitoring stocks of essential medicines (57). These adaptable tools are free, open-source, and developed using human-centered design with input from people delivering care in the hardest-to-reach communities. While this technology has never been used in a VMMC program and requires adaptation of the clinical content, the existing 2wT software toolkit already contains the robust messaging features discussed in this proposal. The software adaptation process to alter and test alternative clinical content and the local specifications requires little additional software development. The adaptation process will be completed by collaborator, Holeman, with additional technical and training support provided by Nairobi-based technical experts. The automated versus manual texts are presented in Figure 2.

Study design:

Study sites:

In Zimbabwe, 81% of people already had mobile phone subscriptions in 2014 (43), indicating that the technology infrastructure exists and uptake is high. 2wT will be implemented in existing VMMC sites in the Chitungwiza District, a district purposefully selected for its high VMMC volume clinic locations and Norton Hospital which is in Chegutu District. Chitungwiza District, a suburb of Harare, has an estimated 300,000 eligible, HIV-negative men ages 15-29; only 14% of eligible men have been circumcised to date. We will implement 2wT in up to 5 ZAZIC VMMC sites in Chitungwiza- Seke North clinic, Seke South clinic, Zengeza clinic, Chitungwiza central hospital and CitiMed hospital, sites averaging 50-200 VMMC/month. Norton Hospital performs on average 200-300 VMMC/month. As of March, 2017, all VMMC clients are surgical, rather than PrePex device-based, clients.

Recruitment:

The City Health Director who manage the national VMMC program at the Provincial level in conjunction with our implementing partners will facilitate access to the clinics/hospitals where ZAZIC provides ongoing support for VMMC. We will also seek

permission from the facility manager to conduct the study at that particular clinic. It would be expected that demand creation would happen in anticipation of the study implementation.

Each site will establish local recruitment and screening methods that operationalize protocol-specified requirements for eligibility determination in a manner that is tailored to and most efficient for the local study setting and target study population. In brief, information about the study will be disseminated through the Zimbabwe Ministry of Health and Child Care (MoHCC), ZAZIC, and HCW at the selected sites. VMMC demand creation as part of routine ZAZIC program practice will support study recruitment. HCW recruited for participation in the study will be reached at their workplaces (the health care facilities) following communication between the study team and the site leadership. VMMC clients will be recruited in the VMMC clinic area. Recruitment will be managed by a specifically-trained research coordinator who receive payment for their roles as part of routine or study work. This research coordinator will meet with VMMC patients to sensitize them about the opportunity to participate in a study of text-based follow-up; those meeting eligibility criteria will be individually informed by 2wT staff about the opportunity to participate in the study. Interested patients will be referred to the site study coordinator for study enrollment and informed consent. This person will meet with patients in a private setting, further explain the study, confirm study eligibility, and seek informed consent.

Participant eligibility:

VMMC client recruitment, voluntary consent, and enrollment will be managed by the on-site 2wT study coordinator before VMMC surgery. Eligibility criteria for VMMC clients are: 1) 18 years or older; 2) possession of own phone at enrollment; 3) provides contact details (phone, address, next of kin); 4) requests surgical VMMC; 5) willing to follow MoHCC VMMC protocols; 6) willing to come in Day 14; 7) willing to respond to a questionnaire administered by phone 42 days after circumcision; and 8) no intraoperative adverse event during routine VMMC. Men without cell phones and those who chose PrePex will be excluded as PrePex requires a device-removal visit 7 days after placement and has distinctly different follow-up protocols. As phone sharing practices are common, informed consent will ascertain whether eligible men have consistent access to a phone to receive messages about AEs. Participants who refuse enrollment will be asked to provide informed consent for data collection about reasons for non-participation. We expect to enroll and randomize 722 men into a 1:1 ratio of intervention and control within 6 months, allowing observation of the primary outcome by end of year 1. On Day 14, all men in both arms who return for follow-up will receive a $5 airtime credit. Men who have an inter-operative AE during routine VMMC will be withdrawn from the study as these men will have known, additional follow-up risks and mandatory in-person visits.

For health care workers (Objective 3) within the 6 study sites, inclusion criteria are: employees posted at the site; are at least 18 years of age or over; provide health care services to patients as part of the VMMC programs; and are able to provide written informed consent. Healthcare workers will be excluded if they are not willing to participate or not willing to be recorded

Study Participants:

Study participants are described in Table 1. There will be 50 men enrolled in the pilot who will be enrolled in texting and not be randomized. These men will not be included in outcome analysis. There will be 722 men in the full study randomized in a 1:1 ratio of texting and control for 361 men in texting and 361 in control (routine care).

Study Procedures:

Study pilot:

We will conduct a rapid situation analysis with healthcare workers, VMMC clients, and stakeholders to assess suitable responses to VMMC client texts, setting standards for text responses and in-person follow-up. We will modify existing usability surveys for this public health context. A small pilot with 50 VMMC clients who will be enrolled in the texting intervention will include usability testing with both 2wT clients and nurses implementing the 2wT system, illuminating system experiences from both perspectives. Usability results will inform in-box modification, message format preferences (SMS or WhatsApp) and optimal message delivery (timing, frequency, language preferences). Experience from study coordinator and other team

members will add detail to inform 2wT adaptation and modification of Standard Operating Procedures before implementation. We will examine local infrastructure (e.g. electricity and cell network), and explore 2wT cost reduction options (e.g., text bundling, free-call back numbers) and adapt accordingly

Routine VMMC care (control arm):

For the 361 men randomized into the control arm, ZAZIC follows all MoHCC protocols based on WHO guidelines (8) including routine surgical VMMC follow-up on post-surgery days 2, 7 and 42 (Table 2). Patients may seek care outside scheduled visits for suspicion of AEs at any healthcare facility at any time but most often return to their VMMC site. Referral cards for VMMC clients provide local numbers for patients to text, call, or request a call back for emergencies. A standardized approach is used to assess, identify, and record the severity of AEs (46). All VMMC care, from assessment of all AEs through complete healing, is provided free to clients from MoHCC. Clients who do not return to the clinic for follow-up on Day 2 or Day 7 are traced: 3 attempts by phone and then up to 3 attempts at in-person tracking after which they are considered lost to follow-up (LTFU) (47). There is no tracing for Day 42 visits. For the purposes of this study, control arm VMMC clients will be asked to come in on Day 14 for an additional follow-up visit. No active follow-up is provided at Day 14.

VMMC care procedures (2wT arm):

We will conduct a prospective, un-blinded, randomized control trial (RCT) among VMMC clients in a 1:1 ratio of control to intervention. Study participants and clinic staff are not masked to treatment. For the 361 men randomized into the intervention arm, men in the 2wT will receive routine VMMC surgical care and counseling, including referral cards for emergencies. 2wT clients will receive automated daily texts from days 1-14 (Table 2). Texting language may be in English, Shona, or Ndebele at the choice of the participant. It is free to receive call and texts; it costs $0.05 to send a SMS in Zimbabwe (58). If they respond that they suspect no adverse event, no immediate follow-up action will be taken. If a 2wT VMMC client responds affirmatively to any daily text that he suspects an AE, a VMMC nurse will exchange modifiable, scripted texts with the client to determine the symptoms, frequency, and severity. Then, if deemed necessary, the client will be asked to return to clinic the following day or earlier if an emergency is suspected. AE management will adhere to MoHCC routine care. If 2wT patients do not respond to texts on Day 2 or Day 7, the same MoHCC tracing process will be activated, after which they will be considered LTFU. All study participants will be asked to come to the clinic for study-specific, Day 14 follow-up to review healing and verify adverse event reporting. Day 14 was chosen for verification because 95% of all AEs within the ZAZIC VMMC program are reported Day 14 or earlier (47), suggesting that most AEs have occurred by this time point. In a previous field study of AEs, the most common AEs of bleeding and infection were found a mean of 6.7 and 9.0 days, respectively, after VMMC (20), further supporting the 14 day period used in this and a previous study(13). The Day 14 review will be conducted by routine VMMC providers according to MoHCC review guidelines. At Day 42, we will implement a brief text-based survey with 2wT clients to ascertain complete healing, providing stronger inferences at study completion.

No compensation will be provided for healthcare workers. A $5 cell phone credit will be given for both control and intervention arm participants on Day 14 visit in appreciation of their time.

Training of Study Personnel:

VMMC staff at study sites will be informed of the study and briefed on study protocols. A 2wT study coordinator will be trained in confidentiality, protection of human subjects, enrollment, and data collection methods, working to not interfere with routine VMMC flow. For technology training, an experienced Medic Mobile trainer from Nairobi will work with the local study coordinator and team members in-person to implement and learn to maintain the Medic Mobile toolkit independently. We believe that achieving local maintenance and ownership of the system is feasible because of Medic Mobile's considerable investments in open source collaboration and in designing software that is user friendly and intuitive enough to be adapted and maintained by local staff. As part of 2wT, one experienced VMMC nurse will serve as Study Coordinator in Harare and will manage the texting database, including text and voice follow-up communication with intervention clients. Zimbabwe-based co-investigators and interested partner organization researchers will also be invited for Medic Mobile training.

Randomization Process:

We will create and allocate 361 “texting” and 361 “routine” (ensuring 10 extra per group for withdraws) envelopes. Envelopes were block randomized in groups of 20 using a manual shuffling to ensure a near random order. The full set of 722 will be numbered before distribution to sites. A set of 20 extra envelopes will be created – 10 per arm – to allow for withdraws with replacement.. Each group assignment envelope will be drawn by the site coordinator and then opened with the participant. Security envelopes will be used to help prevent selection of assigned group. Subjects within each block are randomly assigned to treatment conditions.

Data collection:

Sample Size:

For Objective 1, the RCT will apply hypothesis testing for non-inferiority to examine the outcome of interest: AE rate (moderate or severe) occurring ≤ Day 14. A non-inferiority trial is appropriate as we wish to test our assumption that 2wT with reduced in-person follow-up is as safe (not clinically nor statistically inferior) as routine VMMC (59, 60), but with additional advantages including efficiency and lower direct and indirect costs to providers and patients. The non-inferiority margin, based on statistical and clinical considerations, is the maximum difference between the rate of AEs ≤14 Days in control and 2wT arms where we would conclude that 2wT is not inferior to routine care. We set that margin to 1.6% which would create a non-inferiority cutoff of 2% AEs or less in 2wT. The AE proportion cutoff for 2wT non-inferiority was set at a conservative 2% AEs to match the lower bound of AE rates reported by previous rigorous studies (1-3) and because an AE rate of 2% is regarded as a commonly-used standard of VMMC safety (61, 62), including in Zimbabwe (42). Including a possible 10% LTFU, 361 participants per arm provides 90% power at an alpha of 2.5% to detect AEs greater than the non-inferiority margin of 1.6% (Table 3). We would conclude that 2wT is not inferior if we can rule out an AE rate of greater than 2%.

Measures and Analysis:

During informed consent, participants will be asked to give permission to use data from their routine VMMC medical records, including the VMMC register and client intake form (CIF). Data from paper CIFs includes VMMC number, age, circumcision type, eligibility criteria, pre-procedure assessment, and adverse events during the procedure. Variables of interest from CIFs and register will also be entered using Medic Mobile software and verified through data checks, easing merging with the SMS database data management. De-identified, coded data will be shared between researchers via secure networks.

For Objective 1, the 2wT safety outcome of interest is cumulative AE rate (moderate or severe) ≤ Day 14. Incidence of AEs before Day 14 will be extracted from routine VMMC data for both 2wT and control. Incident AEs on Day 14 will be identified, classified, and graded for severity using routine MoHCC protocols (9) and recorded on routine VMMC AE forms. We will compare cumulative rates of any moderate or severe AE ≤ Day 14 between groups using Fisher’s exact test as the expected number of AEs is low. The rates will be calculated per arm as: (# moderate + severe AEs)/ (total # VMMC clients who attend/responded to 2, 7 or 14 Day follow-up visits or texts). Multivariate logistic regression models (any AE v none) will quantify the magnitude of difference, adjusting for any potential confounders. To determine follow-up visit reduction, we will compare the mean number of in-person visits for intervention and control using a t-test. A multivariate linear regression model will further quantify the effect of intervention on visit reduction, adjusting for potential confounders. Secondary outcomes include: AE rates on Day 14, texting response rate, time between 2wT AE text reporting and follow-up, severity of AEs. We will perform appropriate summaries of missing data and LTFU, testing for systematic differences in response by study arm. Data will be exported from the study database into STATA 12.0 for analysis. *We hypothesize that 1) 2wT is non-inferior to routine follow-up for patient safety and that 2) 2wT will reduce unnecessary follow-up over routine care.*

For Objective 2, 2wT costs, we will calculate the relative costs and outcomes (effects) of intervention versus control, including costs for technology, healthcare worker time, and client considerations (travel, text costs, missed work). We will conduct both activity-based costing from the implementation perspective and from the technology perspective to extrapolate our results as

costs that would be incurred by the MoHCC should they elect widespread scale up of 2wT. Approach for costing. First we quantify the total direct and indirect costs of 2wT deployment, a method previously used for technology cost assessment in Malawi (48), which includes comprehensive costs from installation and training, routine maintenance, healthcare worker time associated with 2wT, and staff efficiency gains/losses in addition to the direct cost of technology. Second, we will estimate incremental costs (incremental relative to routine practice) for the intervention. This component entails a micro-costing study using activity-based approaches for costs incurred (trainings, VMMC service provision, follow-up) and costs averted (health costs for providers and patients saved by reducing visits), adapting previous VMMC costing estimates (63) for 2017 dollars when appropriate. Cost data will also be collected from the study budget, public health clinic budgets, published government reports, and the health economics literature. Lastly, to estimate the cost savings associated with 2wT over routine VMMC follow-up, we will conduct a time-motion study (64, 65) to quantify time spent for VMMC follow-up, indicating potential time savings for providers and VMMC clients. One trained observer will record VMMC client/provider follow-up interactions for 5 days, recording times and activities using a pre-established checklist and a personal digital assistant (PDA) that assigns start and end times. During these same 5 days, client time from registration through visit completion will be recorded by a second observer. Data will be exported into STATA 12.0 for analysis. The combined, overall costs for the delivery of 2wT in public health clinics will be estimated and compared to routine follow-up. *We hypothesize that 2wT will reduce the costs associated with VMMC patient follow-up over routine care.*

For Objective 3, 2wT acceptability, using study recruitment and enrollment logs in addition to the texting database, we will describe levels of acceptance, participation, refusal and drop-out. We will carry out key informant interviews (KIIs) with up to 8 health care workers to gauge acceptability, satisfaction, identify facilitators and barriers to program success, and ascertain suggestions for intervention improvement. KIIs will be audio recorded and transcribed. Atlas.Ti software will be used to create a spreadsheet of key themes, perceived barriers, and suggested facilitators to the program from KIIs. We will also implement questionnaires at the Day 14 visit with a subset of 100 2wT VMMC clients in the main study who were randomized to texting to gauge satisfaction, estimate direct and indirect costs (time away from work, transportation costs), and ascertain suggestions for intervention improvement. Responses from these brief, self-administered, quantitative surveys with VMMC clients will be entered in Excel and frequencies explored in STATA 12.0. For feasibility, costing data will be combined with usability and acceptability information. Qualitative data will be entered, coded and analyzed as text documents in Atlas.ti 6. The first-line data quality assurance will be the responsibility of the I-TECH investigators. These files will also be sent to the team in Seattle, USA for secondary data quality assurance and analysis. The recordings of the interviews will be destroyed one year after the activity ends. However, the transcriptions will be kept for five years in compliance with University of Washington policy. These comprehensive data will be discussed at a final stakeholder meeting to disseminate study results, validate interpretations and refine recommendations for future scale up and modification of 2wT in Zimbabwe and beyond. Additional meetings between local researchers and the MoHCC will further determine feasibility for replication and scale-up. *We hypothesize that acceptability, usability, and feasibility will be high, aiding program scalability.*

Discussion

This study is innovative in several ways. First, we aim to replace in-person follow-up visits with 2wT interaction between patients and providers holds potential to dramatically reduce the burden on the health system at low cost while maintaining patient safety. This rigorous research involving local researchers is needed to test and optimize the approach. Moreover, we aim to implement 2wT within an existing MoHCC VMMC program structure that will greatly improve the likelihood of program scalability and sustainability. We will also quantify expected MoHCC cost savings provided by 2wT scale-up. This study sets a precedent by employing digital technology to identify cases of uncomplicated healing and thereby to reduce the burden of unnecessary VMMC clinic visits for both providers and patients - thus opening use of mHealth in post-operative care or other contexts with low rates of complications, potentially even long-term antiretroviral therapy use. Lastly, as the rate of unnecessary, in-person care in VMMC programs is likely high, potential gains in efficiency identified through this low-cost digital innovation are large, increasing the likelihood of scale-up and replication in the region.

Although it is expected that this trial will yield important data to inform VMMC program expansion in Zimbabwe, some limitations exist to potential conclusions and findings generalizability. Men undergoing PrePex VMMC are excluded, limiting generalizability to surgical VMMC. Phone ownership in Zimbabwe's urban areas is high, but there is a possibility that the population who undergoes VMMC has lower than estimated phone access, reducing the potential efficiency of a texting approach to follow-up. While evidence from Kenya and elsewhere suggests that patients are likely to interact with health professionals via SMS, it is possible that a higher than estimated percentage of clients will not respond to SMS, increasing the need for follow- up by voice calls, thus reducing the efficiency and cost gains afforded by the intervention. Lastly, we anticipate some challenges in program implementation such as network outages (though these are increasingly fewer and shorter) and user error, but previous Medic Mobile experience and the expert local team will enable swift identification of bottlenecks and appropriate, real-time, solutions.

If texting with VMMC clients is found to be non-inferior to routine, in-person follow-up for detection of AEs, scale up could dramatically reduce time spent on unnecessary VMMC follow-up visits by healthcare personnel and decrease the burden on VMMC clients. Future funding could enable scale-up of the intervention in other high volume VMMC sites with high mobile phone coverage, conducting additional rigorous evaluation in diverse field and clinical contexts. We would seek funding to test 2wT among rural populations or smaller urban areas. Lastly, we will explore how 2wT could be integrated into DHIS2, the national health information system, to improve and ease reporting.

Abbreviations

2wT: Two-way texting

AE: Adverse event

HIV: human immunodeficiency virus

MC: Medical Circumcision

MoHCC: Zimbabwe Ministry of Health and Child Care

VMMC: Voluntary Medical Male Circumcision

Declarations

Trial Status: The trial recruitment for participants in the pilot phase ran from 16 April 2018 to 4 May 2018. For the full study, recruitment in one of two study sites (Seke South) began on June 20th, 2018 and in the other site (Norton) on December 11, 2018. We aim to complete recruitment by 28 February, 2019.

Ethics approval and consent to participate: This study was approved by the Medical Research Council of Zimbabwe (MRCZ) and the University of Washington Internal Review Board. Written informed consent will be obtained from all participants prior to enrollment in the study.

Consent for publication: Not applicable

Availability of data and material: Not applicable

Competing interests: The authors declare no competing interests

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Authors' contributions: CF is the principal investigator and conceived the study with VM, SB, and MT. CF, VM, and MT led the development of the study protocols. BM led ZAZIC consortium participation. SX provided MoHCC input. IH led the technology development, testing, and implementation. CF and VM finalized the data collection instruments and field work SOPs. CF led development of the manuscript. All other authors contributed to manuscript editing and review. VM supervised the pilot and full study implementation. IH led system data collection procedures and data quality. CF, VM, SX, BM, SB, and MT are supervising the implementation of the cluster randomized trial. All authors contributed to the intellectual content of the manuscript, to the development of the trial protocol, and have read and approved the final manuscript.

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References

1. Gray RH, Kigozi G, Serwadda D, et al. Male circumcision for HIV prevention in men in Rakai, Uganda: a randomised trial. The Lancet. 2007;369(9562):657-66.
2. Bailey RC, Moses S, Parker CB, et al. Male circumcision for HIV prevention in young men in Kisumu, Kenya: a randomised controlled trial. Lancet. 2007;369(9562):643-56.
3. Auvert B, Taljaard D, Lagarde E, et al. Randomized, controlled intervention trial of male circumcision for reduction of HIV infection risk: the ANRS 1265 Trial. PLos med. 2005;2(11):e298.
4. World Health Organization. WHO Progress Brief: Voluntary Medical Male Circumcision for HIV Prevention In 14 Priority Countries in East And Southern Africa2015 March 1, 2016. Available from: http://apps.who.int/iris/bitstream/10665/179933/1/WHO_HIV_2015.21_eng.pdf?ua=1&ua=1.
5. WHO U. Joint Strategic Action Framework to Accelerate the Scale-Up of Voluntary Medical Male Circumcision for HIV Prevention in Eastern and Southern Africa (2012–2016). Geneva: UNAIDS. 2011.
6. Njeuhmeli E, Forsythe S, Reed J, et al. Voluntary medical male circumcision: modeling the impact and cost of expanding male circumcision for HIV prevention in eastern and southern Africa. PLoS medicine. 2011;8(11):e1001132.
7. World Health Organization. Considerations for implementing models for optimizing the volume and efficiency of male circumcision services2010 [cited 2014 June 1]; Field testing edition: February 2010 Available from: http://www.malecircumcision.org/programs/documents/mc_MOVE_2010_web.pdf.
8. World Health Organization. Manual for male circumcision under local anaesthesia. Geneva: WHO. 2009.
9. President's Emergency Plan for AIDS Relief. PEPFAR's Best Practices for Voluntary Medical Male Circumcision Site Operations: A service guide for site operations. 2013 May 2014. Available from: http://www.malecircumcision.org/resources/documents/VMMC%20Best%20Practices03.04.2013_web.pdf. .
10. President's Emergency Plan for AIDS Relief. PEPFAR Monitoring, Evaluation, and Reporting Indicator Reference Guide. Washington DC: PEPFAR; 2015.
11. Campbell J, Dussault G, Buchan J, et al. A universal truth: no health without a workforce. Geneva: World Health Organization. 2013.
12. Phili R, Abdool-Karim Q, Ngesa O. Low adverse event rates following voluntary medical male circumcision in a high HIV disease burden public sector prevention programme in South Africa. Journal of the International AIDS Society. 2014;17(1).
13. Reed J, Grund J, Liu Y, et al. Evaluation of loss-to-follow-up and post-operative adverse events in a voluntary medical male circumcision program in Nyanza Province, Kenya. Journal of acquired immune deficiency syndromes (1999). 2015.
14. Lebina L, Taruberekera N, Milovanovic M, et al. Piloting PrePex for Adult and Adolescent Male Circumcision in South Africa - Pain Is an Issue. PLoS One. 2015;10(9):e0138755.
15. Brito MO, Lerebours L, Volquez C, et al. A Clinical Trial to Introduce Voluntary Medical Male Circumcision for HIV Prevention in Areas of High Prevalence in the Dominican Republic. PLoS One. 2015;10(9):e0137376.

16. Kigozi G, Musoke R, Watya S, et al. The safety and acceptance of the PrePex device for non-surgical adult male circumcision in Rakai, Uganda. A non-randomized observational study. PLoS One. 2014;9(8):e100008.
17. Feldblum PJ, Odoyo-June E, Obiero W, et al. Safety, effectiveness and acceptability of the PrePex device for adult male circumcision in Kenya. PLoS One. 2014;9(5):e95357.
18. Ashengo TA, Grund J, Mhlanga M, et al. Feasibility and validity of telephone triage for adverse events during a voluntary medical male circumcision campaign in Swaziland. BMC Public Health. 2014;14:858.
19. Duffy K, Galukande M, Wooding N, et al. Reach and cost-effectiveness of the PrePex device for safe male circumcision in Uganda. PLoS One. 2013;8(5):e63134.
20. Herman-Roloff A, Bailey RC, Agot K. Factors associated with the safety of voluntary medical male circumcision in Nyanza province, Kenya. Bull World Health Organ. 2012;90(10):773-81.
21. Kohler PK, Namate D, Barnhart S, et al. Classification and rates of adverse events in a Malawi male circumcision program: impact of quality improvement training. BMC Health Serv Res. 2016;16(1):61.
22. World Health Organization Regional Office for Africa. Progress in scaling up voluntary medical male circumcision or HIV prevention in Est and Southern Africa January-December 20122013 October 27, 2014. Available from: http://www.malecircumcision.org/country_updates/documents/Progress%20in%20scaling%20up%20VMMC_Dec2013.pdf.
23. Centers for Disease Control and Prevention. Voluntary medical male circumcision-southern and eastern Africa, 2010-2012. MMWR Morbidity and mortality weekly report [Internet]. 2013 August 19, 2016; 62(47):[953 p.]. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6247a3.htm.
24. Lankowski AJ, Siedner MJ, Bangsberg DR, et al. Impact of geographic and transportation-related barriers on HIV outcomes in sub-Saharan Africa: a systematic review. AIDS Behav. 2014;18(7):1199-223.
25. Govindasamy D, Meghij J, Negussi EK, et al. Interventions to improve or facilitate linkage to or retention in pre-ART (HIV) care and initiation of ART in low-and middle-income settings-a systematic review. Journal of the International AIDS Society. 2014;17(1).
26. Mukherjee JS, Ivers L, Leandre F, et al. Antiretroviral therapy in resource-poor settings: decreasing barriers to access and promoting adherence. JAIDS Journal of Acquired Immune Deficiency Syndromes. 2006;43:S123-S6.
27. Tuller DM, Bangsberg DR, Senkungu J, et al. Transportation costs impede sustained adherence and access to HAART in a clinic population in southwestern Uganda: a qualitative study. AIDS and Behavior. 2010;14(4):778-84.
28. Hardon AP, Akurut D, Comoro C, et al. Hunger, waiting time and transport costs: time to confront challenges to ART adherence in Africa. AIDS care. 2007;19(5):658-65.
29. Odeny TA, Bailey RC, Bukusi EA, et al. Text Messaging to Improve Attendance at Post-Operative Clinic Visits after Adult Male Circumcision for HIV Prevention: A Randomized Controlled Trial. PLoS ONE. 2012;7(9):e43832.
30. Cole-Lewis H, Kershaw T. Text Messaging as a Tool for Behavior Change in Disease Prevention and Management. Epidemiologic reviews. 2010;32(1):56-69.
31. Health UDo, Services H. Using health text messages to improve consumer health knowledge, behaviors, and outcomes: an environmental scan. 2014. URL: http://www hrsa gov/healthit/txt4tots/environmentalscan pdf [accessed 2015-03-24] [WebCite Cache]. 2015.
32. Déglise C, Suggs LS, Odermatt P. SMS for disease control in developing countries: a systematic review of mobile health applications. Journal of Telemedicine and Telecare. 2012;18(5):273-81.
33. Mbuagbaw L, Thabane L, Ongolo-Zogo P, et al. The Cameroon Mobile Phone SMS (CAMPS) trial: a randomized trial of text messaging versus usual care for adherence to antiretroviral therapy. PloS one. 2012;7(12):e46909.
34. Pop-Eleches C, Thirumurthy H, Habyarimana JP, et al. Mobile phone technologies improve adherence to antiretroviral treatment in a resource-limited setting: a randomized controlled trial of text message reminders. AIDS (London, England). 2011;25(6):825.
35. Kunutsor S, Walley J, Katabira E, et al. Using mobile phones to improve clinic attendance amongst an antiretroviral treatment cohort in rural Uganda: a cross-sectional and prospective study. AIDS and behavior. 2010;14(6):1347-52.

36. Odeny TA, Bailey RC, Bukusi EA, et al. Effect of text messaging to deter early resumption of sexual activity after male circumcision for HIV prevention: a randomized controlled trial. Journal of acquired immune deficiency syndromes (1999). 2014;65(2):e50.
37. DeRenzi B, Findlater L, Payne J, et al., editors. Improving community health worker performance through automated SMS. Proceedings of the fifth international conference on information and communication technologies and development; 2012: ACM.
38. Lester RT, Ritvo P, Mills EJ, et al. Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomised trial. The Lancet. 2010;376(9755):1838-45.
39. Perrier T, Dell N, DeRenzi B, et al., editors. Engaging pregnant women in Kenya with a hybrid computer-human SMS communication system. Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems; 2015: ACM.
40. Holeman I, Evans J, Kane D, et al. Mobile health for cancer in low to middle income countries: priorities for research and development. European journal of cancer care. 2014;23(6):750-6.
41. Mahmud N, Rodriguez J, Nesbit J. A text message-based intervention to bridge the healthcare communication gap in the rural developing world. Technology and Health Care. 2010;18(2):137-44.
42. Zimbabwe Ministry of Health and Child Care. Accelerated Strategic and Operational Plan 2014 – 2018. Harare- Zimbabwe; 2014.
43. World Bank. Mobile cellular subscriptions (per 100 people), 1960-2014: The World Bank; 2016 [cited 2016 August 21]. Available from: http://data.worldbank.org/indicator/IT.CEL.SETS.P2.
44. Feldacker C, Makunike-Chikwinya B, Holec M, et al. Implementing voluntary medical male circumcision using an innovative, integrated, health systems approach: experiences from 21 districts in Zimbabwe. Global health action. 2018;11(1):1414997.
45. Bochner A, C F, B M, et al. Adverse event profile of a mature voluntary medical male circumcision progra mme performing PrePex and surgical procedures in Zimbabwe. Journal of the International AIDS Society. 2017(20:21394).
46. President's Emergency Plan for AIDS Relief. PEPFAR Monitoring, Evaluation, and Reporting Indicator Reference Guide. March 2015 ed. Washington DC: PEPFAR; 2015.
47. Marongwe P. Routine implementation of ZAZIC VMMC program. In: Feldacker C, editor. Key VMMC follow-up visit details from ZAZIC VMMC Program Officer ed. Harare2016.
48. Driessen J, Cioffi M, Alide N, et al. Modeling return on investment for an electronic medical record system in Lilongwe, Malawi. Journal of the American Medical Informatics Association. 2013;20(4):743-8.
49. Tomlinson M, Rotheram-Borus MJ, Swartz L, et al. Scaling up mHealth: where is the evidence? PLoS Med. 2013;10(2):e1001382.
50. DeRenzi B, Borriello G, Jackson J, et al. Mobile Phone Tools for Field-Based Health care Workers in Low-Income Countries. Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine. 2011;78(3):406-18.
51. Thirumurthy H, Lester RT. M-health for health behaviour change in resource-limited settings: applications to HIV care and beyond. Bulletin of the World Health Organization. 2012;90(5):390-2.
52. Banks K, McDonald SM, Scialom F. Mobile technology and the last mile:"Reluctant innovation" and FrontlineSMS. innovations. 2011;6(1):7-12.
53. Jumreornvong O. New Weapon In The War Against AIDS: Your Mobile Phone. Intersect: The Stanford Journal of Science, Technology and Society. 2014;7(1).
54. Medic Mobile. Medic Mobile For Antenatal Care: Do-It-Yourself Toolkit: Medic Mobile; 2016 [Available from: http://medicmobile.org/diy.
55. West D. How mobile devices are transforming healthcare. Issues in technology innovation. 2012;18(1):1-11.
56. Pathak P. India Vaccination Pilot Progress Report. Medic Mobile and Clif Bar. 2012.

57. Medic Mobile. Drug Stock Monitoring: Medic Mobile; 2016 [cited 2016 August 22, 2016]. Available from: http://medicmobile.org/usecases/drug-stock-monitoring.
58. Econet. Econet Wireless Tariffs (Incl VAT) Harare, Zimbabwe2016 [Available from: https://www.econet.co.zw/services/tariffs.
59. D'Agostino RB, Massaro JM, Sullivan LM. Non-inferiority trials: design concepts and issues–the encounters of academic consultants in statistics. Statistics in medicine. 2003;22(2):169-86.
60. Schumi J, Wittes JT. Through the looking glass: understanding non-inferiority. Trials. 2011;12(1):1.
61. World Health Organization. WHO Technical Advisory Group on Innovations in Male Circumcision: Evaluation of two adult devices: Meeting report. Geneva, Switzerland: WHO; January, 2013 8/10/2015.
62. Byabagambi J, Kigonya A, Lawino A, et al. A Guide to Improving the Quality of Safe Male Circumcision in Uganda2015 [cited 2016 August 12]. Available from: https://www.usaidassist.org/sites/assist/files/uganda_guide_to_improving_the_quality_of_smc_a4_feb2015_ada.pdf.
63. Schutte C, Tshimanga M, Mugurungi O, et al. Comparative cost analysis of surgical and PrePex device male circumcision in Zimbabwe and Mozambique. Journal of Acquired Immune Deficiency Syndromes (1999). 2016;72(Suppl 1):S96.
64. Finkler SA, Knickman JR, Hendrickson G, et al. A comparison of work-sampling and time-and-motion techniques for studies in health services research. Health services research. 1993;28(5):577.
65. Were MC, Sutherland J, Bwana M, et al. Patterns of care in two HIV continuity clinics in Uganda, Africa: a time-motion study. AIDS care. 2008;20(6):677-82.

Tables

Table 1: Study participants

Group name/description	Data collection method	Age range of subjects	Target number of individuals
Pilot: Assigned texting	Usability survey, routine VMMC clinical review; 2WT texting database	18-65	50
Main study: randomized texting	Usability survey, routine VMMC clinical review; 2WT texting database; Day 14 review Subset of first 100 willing to complete the satisfaction and acceptability questionnaires Time-motion subset	18-65	361
Main study: randomized control group	Routine VMMC clinical review; Day 14 review	18-65	361
Healthcare workers	Key informant interview	18-65	~8

Table 2: Procedures for Intervention and Control

	Control	2wT
Day 0 Routine VMMC registration and client intake forms	X	X
Day 0 VMMC surgery and counseling	X	X
Day 0 Study consent	X	X
In-person follow-up		
Routine Day-2	X	
Routine Day-7	X	
Study-specific Day-14	X	X
Routine Day-42	X	
Routine lost to follow-up tracing		
Day 2	X	X
Day 7	X	X
Daily texts days 1-14		X
MoHCC routine AE procedures		
In-person, any day, follow-up for suspicion of AE	X	X
Emergency VMMC after-hours care	X	X
AE identification	X	X
AE severity grading	X	X
AE management and treatment	X	X
AE reporting on routine MoHCC forms	X	X

Table 3: Sample sizes at different non-inferiority margins*

Non-inferiority margin	AE proportion cutoff for 2WT non-inferiority	Sample size (per arm)
0.6%	1% AEs or less	2326
1.6%	2% AEs or less	328
2.6%	3% AEs or less	124

*Using ssi command from STATA 12.0 for one-sided, non-inferiority

Figures

	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pilot, technology adaptation	X							
2wT implementation		X	X					
Aim1 Statistical analysis				X	X			
Aim 2 Cost effectiveness analysis				X	X			
Tech assessment/adaptation		X	X					
Aim 3 KIIs/brief client survey			X	X				
Local stakeholder meeting						X		
Publication and dissemination							X	X

Figure 1

Study implementation timeline.

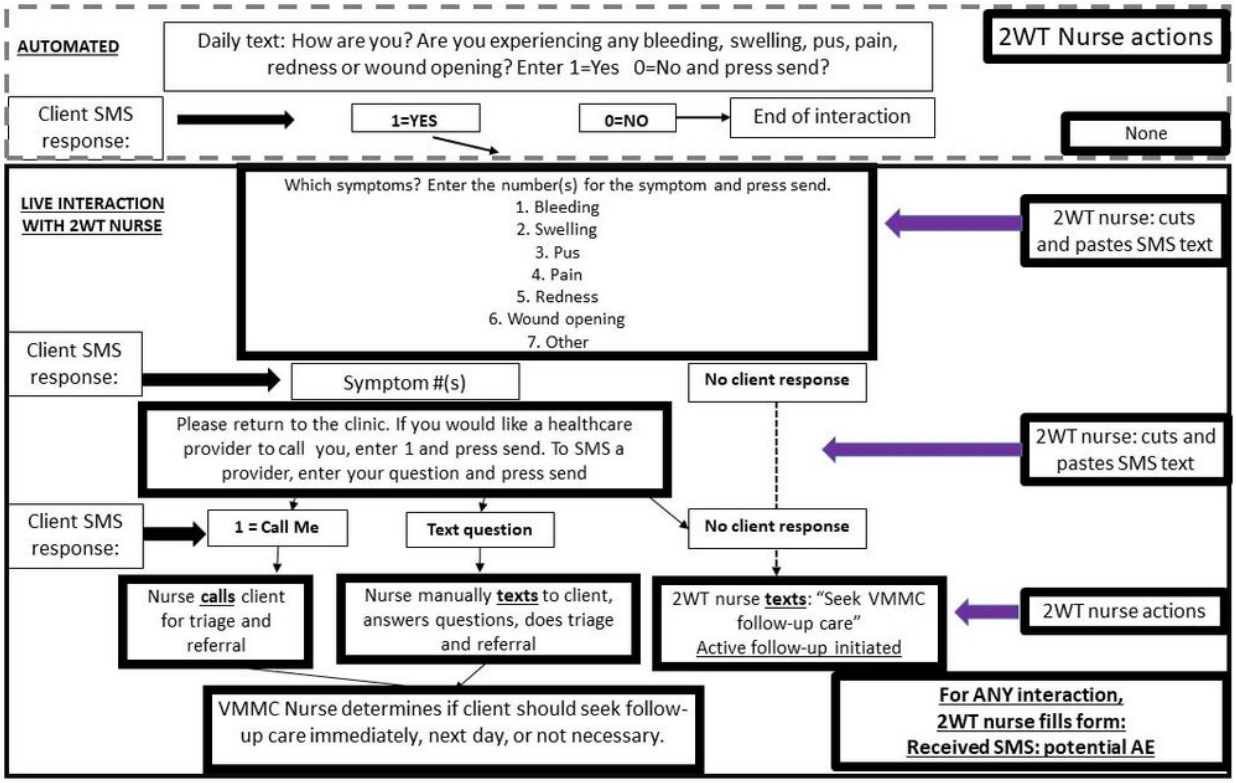

Figure 2

2wT nurse/patient interaction flow diagram.

Supplementary Files

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