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ORIGINAL PAPER

A Randomized Controlled Trial of a Texting Intervention to Maintain Sexual Risk Reduction with Clients Among Female Sex Workers in Tijuana and Ciudad Juarez, Mexico

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Abstract
Mobile phone technology may help sustain reductions in HIV/STI transmission risk behaviors among female sex workers (FSWs). We examined the efficacy of a text messaging intervention designed to maintain behavioral improvements in safer sex practices among 602 FSWs in Tijuana and Ciudad Juarez, Mexico. We hypothesized that FSWs who received brief risk reduction counseling and theory-based safer sex maintenance text messages over a 24-month period would have fewer incident HIV/STIs and report greater maintenance of safer sex practices compared to FSWs who received counseling and texts on maintaining general health. Theory-based texts did not change the odds of becoming infected with HIV/STIs in either study site. However, they did lead to significant, sustained protected sex in Tijuana. Theory-based text messaging interventions may help sustain reductions in sexual risk behavior among FSWs.
Trial Registration Clinical Trials.gov. Identifier: NCT02447484

Keywords Female sex workers · Mexico · HIV prevention · Behavior maintenance · Texting intervention

Resúmen
La tecnología de teléfonos móviles se puede usar para mantener disminuciones en los comportamientos de riesgo de transmisión de VIH/ITS en mujeres trabajadoras sexuales (MTS). Examinamos la eficacia de una intervención con mensajes de texto diseñada para mantener mejoras en comportamiento de prácticas sexuales más seguras en 602 MTS en Tijuana y Ciudad Juárez, México. Propusimos que las MTS que recibieron la consejería breve de reducción del riesgo y los mensajes de texto para mantenimiento de sexo más seguro basado en teoría por un periodo superior a 24 meses tendrían menos incidentes de VIH/ITS e informarían mayor mantenimiento de prácticas de sexo más seguro comparadas con las MTS que recibieron consejería y mensajes de texto sobre mantener una salud general. Los textos basados en teoría no cambiaron la probabilidad de infectarse con VIH/ITS en ninguno de las dos ciudades. Sin embargo, estas dieron lugar a sexo protegido

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sostenido, significativo en Tijuana. Las intervenciones de mensajes de texto basados en teoría pueden ayudar a mantener disminuciones en comportamientos sexuales de riesgo en MTS.

Palabras Claves Trabajadora sexual Mujer · México · prevención de VIH · mantenimiento de comportamiento · intervención de mensajes de texto

Introduction

Globally, female sex workers (FSWs) are at increased risk for HIV and other sexually transmitted infections (STIs) [1]. In Mexico, a low- to middle-income country (LMIC), HIV prevalence among FSWs in the northern border region (2004–2006) was estimated at 6.0% while prevalence of gonorrhea, Chlamydia, and syphilis were 6.4%, 13.0%, and 14.2%, respectively [2]. To date, two different HIV prevention interventions have been shown efficacious in increasing condom use with male clients over a 6-month period (Mujer Segura [MS] intervention) [3] and reducing HIV/STI incidence over 12-month follow-up among FSWs who inject drugs (FSW-IDU; Mujer Más Segura [MMS] intervention) [4] in the Mexico-U.S. border cities of Tijuana and Ciudad (Cd.) Juarez. Despite the proven efficacy of these behavior change interventions, studies that examine the *long-term* maintenance of sexual risk reduction behaviors (e.g., condom use) among FSWs are lacking.

In other health domains (e.g., diet and exercise) and risk populations, it has been reported that positive changes in behavior begin to erode within 6 to 12 months in the absence of ongoing intervention and support [5, 6]. This observation underscores the critical need for innovative strategies to sustain behavioral intervention effects over longer periods of time (> 12 months) among FSWs in LMIC.

In the past decade, the ability to contact and intervene with hard-to-reach populations, such as FSWs, has been improved by the increased availability and use of mobile phones by sex workers for the purpose of client solicitation [7, 8]. Behavior change interventions that incorporate text messages delivered to mobile phones with in-person HIV prevention have shown promise in reducing HIV transmission risk behaviors (e.g., increased condom use with clients) among sex workers in India and Mexico [9, 10]. However, studies of mobile phone-based interventions that promote strategies to maintain sexual risk reduction among FSWs and other high-risk populations are lacking [10].

As detailed in a previously published article using data from a subsample of 302 FSWs enrolled in the MSS intervention in Tijuana and Cd. Juarez (~150 per site), we examined the role of time perspectives (i.e., short-term versus future-oriented) on FSWs' safer sex maintenance behaviors over a 6-month period. We found a combined lower HIV/STI incidence among FSWs who received future-oriented safer sex maintenance text messages that promoted planning for goals and deferring immediate needs and desires [10]. These findings suggested that text messages focused on time perspectives as a messaging target may reduce HIV/STI incidence among a subset of FSWs. The current study focuses on different messaging targets and also reports intervention effects for the entire sample of FSWs over a longer time period.

The present study, called Mujer Saludable Siempre (MSS; Healthy Women Forever), examined the efficacy of a mobile phone-based, text messaging intervention to maintain behavioral improvements in safer sex practices with clients among 602 FSWs in Tijuana and Cd. Juarez, Mexico where HIV prevalence is elevated [11, 12]. We hypothesized that FSWs who received MS counseling and theory-based, safer sex maintenance text messages over a 24-month period (MSS) would have fewer incident cases of HIV/STIs and report greater maintenance of safer sex practices (i.e., condom use) with clients compared to FSWs who received MS counseling and general health promotion maintenance text messages over the same time period. This study contributes to our knowledge of behavior change maintenance in HIV/STI prevention research by evaluating the efficacy of a theory-based, technology-enabled, maintenance-focused intervention to sustain positive behavior change among high-risk FSWs in a LMIC.

Methods

Participants and Setting

Our sample consisted of 602 FSWs who were recruited in Tijuana and Cd. Juarez between January 2016 and December 2017 into a randomized controlled trial of a text messaging intervention (MSS) designed to sustain long-term improvements in sexual risk behavior with male clients achieved following the completion of a brief (30–45 min), single-session sexual risk reduction intervention (MS) at baseline. Eligibility requirements were: cisgender female, at least 18 years of age, self-identify as a FSW, report having traded sex for drugs, money, shelter or other material benefit in the previous 4 weeks, had condom unprotected vaginal or anal sex with a client at least once during the previous 4 weeks, have no previous HIV-positive test result (either tested negative

or never tested), own a mobile phone, and agree to be tested for HIV and STIs at baseline and 6-, 12-, 18- and 24-month follow-up assessments.

Recruitment Procedures

FSWs (~300 per site) were recruited through time-location sampling [3, 4]. Outreach workers compiled a map of sex work venues (e.g., bars, hotels, alleys, street corners), and then canvassed those venues to locate potentially eligible participants in both Tijuana and Cd. Juarez. Women who appeared eligible were approached and, if willing, were asked a few basic screening questions (e.g., age, sex worker status). Those who were interested in the project were referred for a screening interview at our office in Tijuana's Zona Roja (red-light district) or to our office at Salud y Desarollo Comunitario de Ciudad Juarez, A.C. and Federación Méxicana de Asociaciones Privadas, A.C. (SADEC-FEMAP) located in downtown Cd. Juarez.

Baseline Assessment and Mujer Segura Counseling

All eligible women were scheduled for a baseline visit, which involved the provision of biological samples, a 60-min face-to-face interview administered by CAPI (Nova Software, MD, USA), and the 30-min MS sexual risk reduction counseling session, which has been described previously [3]. The theory-based MS intervention combines principles of Motivational Interviewing (MI), Social Cognitive Theory (SCT), and Theory of Reasoned Action (TRA) [13–18]. Participants who reported injection of drugs in the past month also received the 15-min safer injection component of MMS, which provided information on the dangers of needle sharing practices, methods for cleaning needles, and the availability of local syringe exchange programs [19]. As is widely known, FSWs who inject drugs face heightened risk of HIV/STI infection associated with this additional route of transmission [3, 4]. Participants were reimbursed the equivalent of $30 USD for their two-hour baseline session. All study procedures were approved by ethics committees at the University of California, San Diego, Xochicalco University in Tijuana, and SADEC-FEMAP in Cd. Juarez. All participants provided written, informed consent prior to undergoing study procedures.

Randomization Procedures

Eight hundred seventy-eight women were screened for eligibility. Approximately 69% (n = 602) met criteria for eligibility and were enrolled in the study (302 in Tijuana, 300 in Cd. Juarez). For each site, FSWs were randomized to one of two groups [Intervention Group (n = 302) (i.e., safer sex maintenance texts) and Control group (n = 300) (i.e., general health promotion maintenance texts)] using a computerized randomization scheme. Figure 1 summarizes participant flow through the study.

Intervention Condition: Safer Sex Maintenance Text Messages

In the intervention condition, all messages were theory-based and developed by our bi-national team of investigators. Voils' et al. [5] theoretical framework for behavioral maintenance was adopted for this study. The framework delineates cognitive and behavioral processes (e.g., recovery self-efficacy, self-monitoring) that can be used to maintain safer sex practices with clients and reinforce safer sex skills learned in the brief sexual risk reduction counseling session. Commonly used cognitive, behavioral, and motivational strategies [17, 20] were applied to the maintenance of safer sex and injection practices. In addition to the strong theoretical foundation, other aspects of our text messaging maintenance intervention included the tailoring and personalization of messages, which involves linking a stressor identified by the participant to a potential lapse in safer sex (e.g., Friend, divorce is stressful, but if you stick with your goal of always using condoms with clients, you will feel good about yourself), as well as flexibility in delivery, two-way communications, and loss- and gain-framed messages [21–24].

Risk domains covered in the pool of 660 intervention text messages included sexual risk, drug use, alcohol use, as well as structural and personal barriers to condom use with clients. Examples of text messages include: "Friend, every day remind yourself how hard you have worked to stay safe and healthy by using condoms" and "Friend, using drugs during sex can lead to unsafe sex. Resisting temptation will make you feel strong." As previously described [10], our research team conducted formative research with 25 FSWs in Tijuana (i.e., focus groups with feedback on content and relevance of the text messages) to ensure confidential, relevant, appealing, and culturally-sensitive text messages that were consistent with the MS counseling materials.

Control Condition: General Health Maintenance Text Messages

FSWs in the control condition received general health text messages for 24 months following completion of the MS intervention, making the two conditions time equivalent. Control condition texts were also developed by our bi-national research team and adapted from materials used in the control condition from our study of FSWs in 13 cities throughout Mexico [25].The general health maintenance text messages were tested in focus groups as described above. The risk domains represented in the control condition paralleled several of those used in the intervention condition (i.e.,

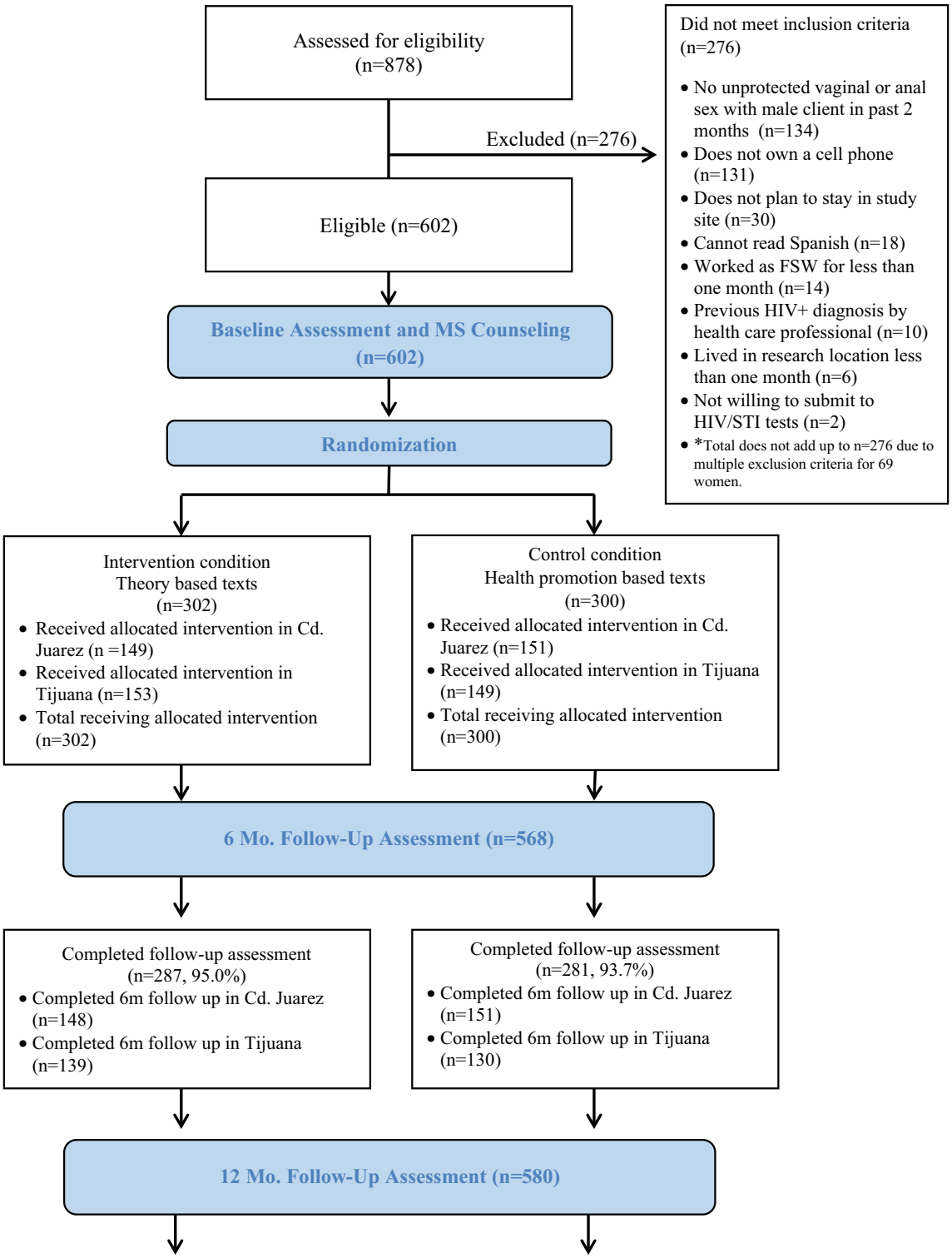

Fig. 1 CONSORT diagram summarizing participant flow through the study

sexual risk, drug use, alcohol use); however, the text messages were distinctly different because of their non-theoretical and general information content. The control condition also included text messages in two unique domains that were not addressed in the intervention. They included communication with medical professionals and general health

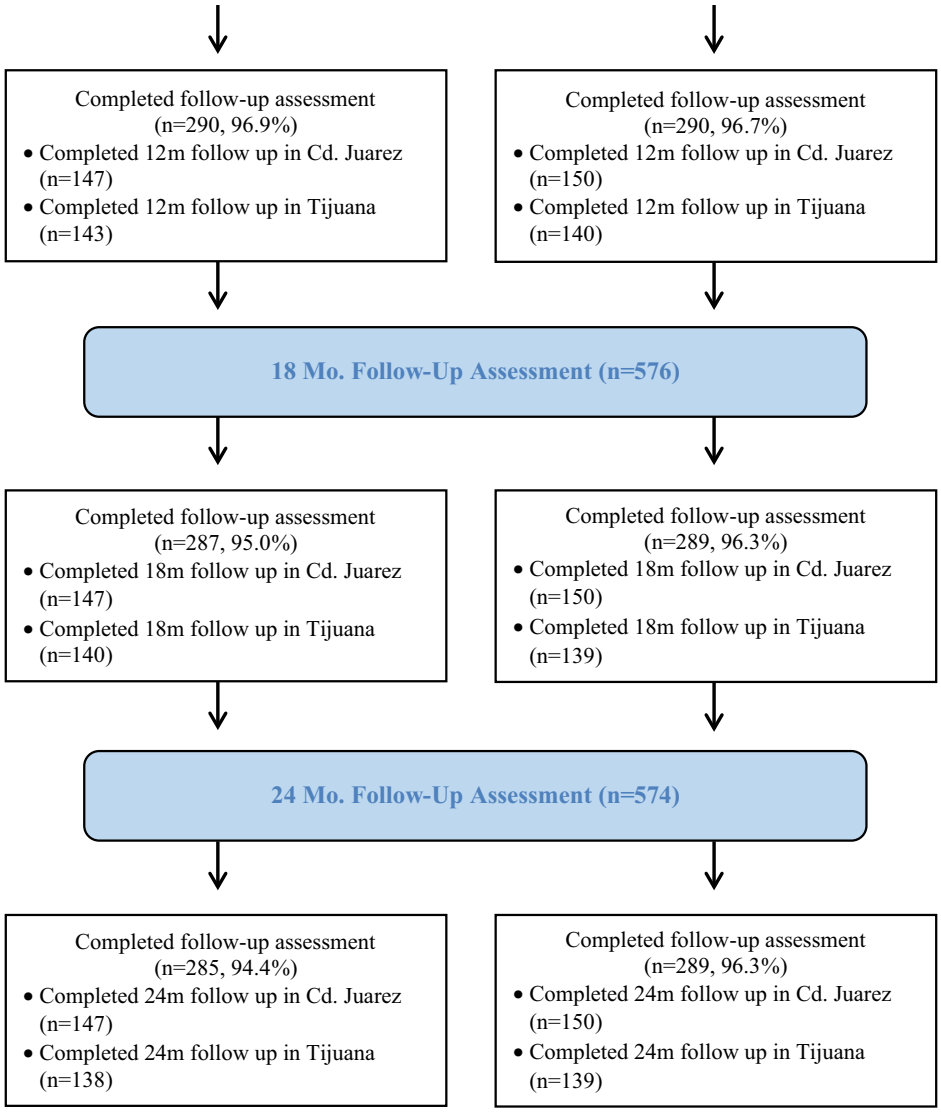

Fig. 1 (continued)

information. Examples of text messages in the control condition include: "Friend, if you limit your alcohol to one drink per day, you will reduce your risk for many diseases," and "Friend, when you meet with your doctor, ask your main questions first."

Text Message Delivery System

The text messaging system was programmed by a group at UCSD that automated the sending and receiving of text messages. Participants selected the days and times that they preferred to receive their text messages. Two text messages were sent per day for 5 days each week for 24 months.

Measures

HIV and STI Diagnoses (Primary Outcome)

All participants underwent HIV/STI testing at their baseline visit as well as 6-, 12-, 18-, and 24-month follow-up visits. The blood draw and rapid HIV and syphilis testing were conducted at our project offices. Test results were provided to participants by nurses within one week of testing. The Advanced Quality™ Rapid Anti-HIV (1&2) Test by InTec Products, Inc., which has high sensitivity and specificity [26] was used for rapid HIV testing. The One Step Syphilis rapid test by InTec Products, Inc. was used for rapid syphilis

testing. The Aptima® Combo 2 Assay (Hologic) was used to detect *Neisseria gonorrhoeae* and *Chlamydia trachomatis* in urine samples via nucleic acid amplification testing. Blood samples that yielded a positive result on the rapid HIV or syphilis tests (or both) were shipped to the San Diego County Public Health Laboratory (SDCPHL) along with urine samples. SDCPHL performed enzyme immunoassay (EIA) and indirect fluorescent antibody (IFA) or Multispot to confirm HIV. Confirmatory syphilis testing involved a rapid plasma reagin (RPR) Panel that included qualitative, quantitative, and T pallidum particle agglutination (TP-PA). Participants who tested positive for HIV were referred to the municipal clinic in their city for free medical care. Those who tested positive for another STI were treated presumptively in our project offices.

Sexual Risk Behavior (Secondary Outcome)

The number of unprotected vaginal and anal sex acts with clients (past month) was computed at each assessment by subtracting the total number of times a condom was used during vaginal and anal sex from the total number of vaginal and anal sex acts.

Covariates: Type of Sex Worker and Injection Drug Use

Type of sex worker and recent injection drug use (past month) were different by intervention group at baseline assessment and were thus included as covariates in the analyses. To measure type of sex worker, participants viewed a list of nine types (barmaid, dance hostess, taxi girl, brothel worker, street worker [i.e., street, alley], lover, call girl or escort, companion for parties and vacations, other) and asked to select the one that best described their situation. Sex worker type was dichotomized as street worker = 1, all other types = 0. Injection drug use in the past month was measured by a single question (In the past 4 weeks, did you inject any drugs?).

Baseline Descriptive Measures

Socio-demographic variables included age in years, resides with spouse or steady partner (1 = yes, 0 = no), has children under 18 years of age (1 = yes, 0 = no), average monthly income over the past 6 months (1 = ≥ 3500 MX pesos, 0 = ≤ 3499 MX pesos). *Substance use factors* included the following: used any drug in past month (1 = yes, 0 = no), used heroin, methamphetamine, cocaine or combination in the past month (1 = yes, 0 = no), used drugs with clients before or during sex with clients in the past 6 months (1 = yes, 0 = no), and used alcohol with clients before or during sex with clients in the past 6 months (1 = yes, 0 = no). Severity of alcohol use during the last year was measured by the 10-item Alcohol Use Disorders Identification Test (AUDIT-10) [27]. Summary scores were recoded into a binary variable (hazardous drinking = 1, non-hazardous drinking = 0), where a score of 8 or more for women indicated hazardous drinking [27, 28]. *Behavioral determinants* included measures of HIV knowledge [29], self-efficacy for condom use [30], outcome expectancies for condom use [30], attitudes towards condom use [30], intentions to use condoms [30], and perceived norms for condom use [30]. Seven theory-based scales [5] were used to measure *safer sex behavioral maintenance strategies*, including self-regulatory focus, maintenance self-efficacy, recovery self-efficacy, planning for high-risk situations, self-monitoring, satisfaction with outcomes, and enlisting social support [31].

Statistical Analysis

We analyzed the data in stages. First, we examined descriptive statistics by group (intervention vs. control) and city (Tijuana vs. Cd. Juarez) on socio-demographic variables, substance use, condom use, and theory-based behavioral determinants (e.g., self-efficacy for condom use) and behavior change maintenance (e.g., recovery self-efficacy). After ensuring statistical assumptions were met, we examined baseline differences by group and city using chi-square tests for categorical variables and t-tests for continuous variables. Then, we conducted outcome analysis using a mixed-model repeated-measures analysis to test for a "difference-in-differences" between groups over time. To do so, we used generalized estimating equations (GEE; with time as repeated) testing the intervention effect on the primary outcome, HIV/STIs (i.e., testing positive for HIV/STI at follow-up; yes/no) throughout the 24-month follow-up period, using a binomial distribution and logit function. Third, we conducted outcome analysis using GEE tests of the intervention effect on the secondary behavioral outcome, total unprotected vaginal or anal sex with regular and non-regular clients in the past month. For this analysis, the outcome was modeled as a count outcome using a negative binomial distribution.

Primary and secondary outcome analyses used intention-to-treat analysis that included all participants who were randomized. Analyses were stratified by city and adjusted for covariates associated with group assignment at baseline (i.e., type of sex worker: street or establishment/indoor, and injection drug use in the past month: yes or no).We tested a linear effect of time, as well as a quadrative or curvilinear effect using time-squared (i.e., to examine whether the behavioral trajectory was stable, or had a straight slope versus some curvature, indicating a linear reduction in behavior change, or participants reverting back to initial behavior, respectively).

Since the primary objective of this study was to evaluate the *sustainment* of behavior change (i.e., *Mujer Segura* was already shown to be efficacious), we focused on outcomes only during the follow-up period (i.e., baseline assessment was excluded from the models). Difference-in-differences were evaluated by testing the interaction between group and time for each outcome (i.e., whether the groups significantly differed in changes in outcomes over the follow-up period). Participants in the intervention and control conditions did not significantly differ in the outcome variables (HIV/STIs or condom use with clients) at baseline.

Results

Among the 602 participants, the average age was 37.6 (SD = 10.3, range 18–70), 14.8% reported at least some high school, 26.9% were married, and 24% resided with a spouse or steady partner. The majority of FSWs (96.0%) had at least one child, 70.8% of whom were under 18 years of age. Approximately 65% of FSWs described themselves as a street-based sex worker. The percentage of FSWs who tested positive for any STI (including HIV) at 6-, 12-, 18- and 24-month follow-up were 28.8% (n = 163), 30.6% (n = 175), 32.3% (n = 182), and 34.6% (n = 193), respectively (Table 1).

Rates of participant follow-up over the course of the study were high, averaging 94.4% at 6 months, 96.8% at 12 months, 95.7% at 18 months, and 95.4% at 24 months. A comparison of participants who were lost to follow-up (n = 28) and those who were not lost to follow-up (n = 574) indicated that the former were significantly more likely to live in Tijuana (8.3% vs. 1.0%, $\chi^2 = 18.0$, $p < 0.001$) and to describe themselves as street-based FSWs (6.7% vs. 0.9%, $\chi^2 = 10.1$, $p < 0.001$). Among those who were lost to follow-up, six were deceased and 22 could not be located.

Baseline Descriptives By Group and City

Table 1 describes the entire sample, and provides descriptives (frequency distributions for categorical variables, or means and standard deviations for continuous variables) by group and by city.

Compared to women in the control group, women in the intervention group were more likely to work as street-based sex workers (vs. establishment-based) and report injection drug use in the past month.

Compared to FSWs in Cd. Juarez, women in Tijuana were significantly more likely to have at least some high school education, less likely to have an average income of at least 3500 Mexican pesos in the past 6 months, more likely to identify as a street-based FSW, less likely to report injection use of drugs in the past month, and less likely to report having used alcohol with clients before or during sex in the past 6 months. FSWs in Tijuana also reported fewer unprotected vaginal and anal sex acts with regular and non-regular clients in the past month, had lower HIV knowledge scores, had higher scores on self-efficacy for condom use and intentions to use condoms, and reported greater use of five types of safer sex behavioral maintenance strategies (i.e., recovery self-efficacy, planning for high-risk situations, maintenance self-efficacy, self-monitoring, and satisfaction with outcomes), including a higher score on total use of maintenance strategies compared to FSWs in Cd. Juarez.

Primary Outcome Analysis: HIV/STIs at Followup

Table 2 summarizes GEE modeling results on the primary outcome, HIV/STIs at follow-up visits. Results showed that the intervention was not efficacious at predicting the odds of becoming infected with any STI including HIV among women in both Tijuana and Cd. Juarez (non-significant group × time interaction).

Secondary Outcome Analysis: Condom Unprotected Sex with Clients

Secondary outcome analyses testing the effects of the intervention in Tijuana and Cd. Juarez on condom use showed that the intervention was not efficacious at changing condom use among women in Cd. Juarez. That is, there was not a significant difference in changes over time in condom use between the two groups (group × time interaction) among women in this city. However, the intervention did produce significant and sustained behavior change among women in Tijuana. These results are summarized in Table 3.

Among participants in Tijuana, the results demonstrated that after adjusting for type of sex worker (street vs. establishment) and injection drug use, there was a significant group × time interaction, demonstrating a "difference-in-differences" in behavior change between women in the intervention group and women in the control group.

Figure 2 shows that among women in Tijuana in the intervention group, total condom unprotected vaginal and anal sex with regular and non-regular clients was low at 6-months post-counseling (first follow-up assessment), and stayed low through the end of the study (24 months post-counseling). Comparatively, women in the control group also showed a reduction in risk behavior, but not until 12 months post-counseling, but behavior showed a significant upturn at 18 months. The significant interaction between group and time-squared (i.e., the curvilinear effect of time) indicates that the groups differed in the stability of their behavior change. To confirm these findings about the differences in the stability of behavior between the intervention and control group among women in Tijuana, we conducted stratified analyses by group and tested the effect of time (linear and

Table 1 Baseline descriptive statistics

	Total (n = 602)		Intervention (n = 302)		Control (n = 300)		Test statistic[a]	p-value
	n	%	n	%	n	%		
Sociodemographics								
Age (years) (Mean, SD)	37.6	10.3	37.5	10.2	37.7	10.5	0.26	0.79
Married	162	26.9	77	25.5	85	28.3	0.62	0.46
Resides with spouse or steady partner	146	24.3	69	22.8	77	25.7	0.65	0.45
Has children under 18	426	70.8	214	70.9	212	70.7	.003	1
Education (at least some high school)	89	14.8	45	14.9	44	14.7	.007	1
Average income (at least 3500 pesos) past 6 months	463	76.9	227	75.2	236	78.7	1.04	0.33
Type of FSW							4.44	.041*
Street-based	390	64.8	208	68.9	182	60.7		
Establishment/Indoor-based	212	35.2	94	31.1	118	39.3		
Drug use								
Used any drugs in the past month	379	63.0	195	64.6	184	61.3	0.67	0.45
Injected drugs in the past month	180	29.9	102	33.8	78	26.0	4.34	.041*
Used heroin, meth, cocaine, or combination in past month	344	57.1	177	58.6	167	55.7	0.53	0.51
Hazardous alcohol use	258	42.9	127	42.1	131	43.7	0.16	0.74
Used drugs with clients before or during sex in past 6 months	269	44.7	140	46.4	129	43.0	0.69	0.41
Used alcohol with clients before or during sex in past 6 months	330	54.8	167	55.3	163	54.3	.057	0.87

	Tijuana (n = 302)		Cd. Juarez (n = 300)		Test statistic[a]	p-value
	n	%	n	%		
Sociodemographics						
Age (years) (Mean, SD)	38	10.00	37.2	10.70	0.92	0.36
Married	82	27.2	80	26.7	.018	0.93
Resides with spouse or steady partner	74	24.5	72	24.0	.056	0.85
Has children under 18	221	73.2	205	68.3	2.44	0.13
Education (at least some high school)	62	20.5	27	9.0	15.88	< .001***
Average income (at least 3500 pesos) past 6 months	182	60.3	281	93.7	94.55	< .001***
Type of FSW					12.06	< .001***
Street-based	216	71.5	174	58.0		
Establishment/Indoor-based	86	28.5	126	42.0		
Drug use						
Used any drugs in the past month	181	59.9	198	66.0	2.38	0.13
Injected drugs in the past month	79	26.2	101	33.7	4.05	.05*
Used heroin, meth, cocaine, or combination in past month	170	56.3	174	58.0	0.18	0.68
Hazardous alcohol use	122	40.4	136	45.3	1.50	0.25
Used drugs with clients before or during sex in past 6 months	133	44.0	136	45.3	0.10	0.81
Used alcohol with clients before or during sex in past 6 months	138	45.7	192	64.0	20.36	< .001***

	Total		Intervention		Control		Test statistic[a]	p-value
	n	%	n	%	n	%		
Condom use with clients								
Total condom unprotected vaginal and anal sex with regular clients in past month (M, SD)	18.11	25.18	18.47	24.86	17.76	25.53	− 0.33	0.74
Total condom unprotected vaginal and anal sex with non-regular clients in past month (M, SD)	19.94	30.54	18.93	29.47	20.99	31.63	0.81	0.42
Any STI	201	33.3	106	35.1	95	31.7	0.80	0.39
Behavioral determinants								
HIV knowledge (M, SD)[b]	13.44	2.57	13.55	2.53	13.33	2.60	− 1.05	0.30
Self-efficacy for condom use (M, SD)[c]	2.98	0.51	2.96	0.51	3.00	0.50	0.90	0.37

Table 1 (continued)

	Total		Intervention		Control		Test statistic[a]	p-value
	n	%	n	%	n	%		
Outcome expectancies for condom use (M, SD)[c]	2.61	0.27	2.62	0.27	2.61	0.27	− 0.70	0.49
Attitudes towards condom use (M, SD)[d]	4.36	0.69	4.35	0.68	4.38	0.69	0.65	0.52
Intentions to use condoms (M, SD)[d]	4.13	0.84	4.14	0.82	4.11	0.85	− 0.51	0.61
Perceived norms for condom use (M, SD)[d]	4.23	0.91	4.26	0.86	4.2	0.95	− 0.75	0.45

	Tijuana		Cd. Juarez		Test statistic[a]	p-value
	n	%	n	%		
Condom use with clients						
Total condom unprotected vaginal and anal sex with regular clients in past month (M, SD)	13.77	0.26	22.66	23.47	− 4.24	< .001***
Total condom unprotected vaginal and anal sex with non-regular clients in past month (M, SD)	11.43	22.48	28.18	34.80	− 6.84	< .001***
Any STI	112	37.1	89	29.7	3.73	0.06
Behavioral determinants						
HIV knowledge (M, SD)[b]	13.20	2.71	13.69	2.40	− 2.35	0.02*
Self-efficacy for condom use (M, SD)[c]	3.14	0.56	2.82	0.39	8.04	< .001***
Outcome expectancies for condom use (M, SD)[c]	2.61	0.29	2.62	0.35	− 0.36	0.72
Attitudes towards condom use (M, SD)[d]	4.38	0.70	4.35	0.67	− 0.50	0.62
Intentions to use condoms (M, SD)[d]	4.28	0.84	3.97	0.81	4.61	< 0.002**
Perceived norms for condom use (M, SD)[d]	4.28	0.79	4.18	1.00	1.44	0.15

	Total		Intervention		Control		Test Statistic[a]	p-value
	n	%	n	%	n	%		
Safer sex behavioral maintenance strategies								
Recovery self-efficacy (M, SD)[c]	2.98	0.56	3.01	0.54	2.95	0.58	− 1.28	0.20
Planning for high risk situations (M, SD)[c]	2.79	0.58	2.80	0.58	2.78	0.59	− 0.44	0.66
Maintenance self-efficacy (M, SD)[c]	2.90	0.57	2.90	0.56	2.89	0.58	− 0.34	0.73
Self-monitoring (M, SD)[c]	2.80	0.57	2.82	0.55	2.78	0.58	− 0.96	0.34
Satisfaction with outcomes (M, SD)[c]	2.99	0.40	3.00	0.38	2.97	0.42	− 0.93	0.35
Enlist social support (M, SD)[c]	2.41	0.60	2.42	0.55	2.40	0.64	− 0.41	0.69
Self-regulatory focus (M, SD)[c]	2.93	0.55	2.96	0.52	2.89	0.57	− 1.51	0.13
Total score for maintenance strategies (M, SD)[e]	19.78	3.19	19.91	3.01	19.65	3.37	− 0.99	0.33

	Tijuana		Cd. Juarez		Test statistic[a]	p-value
	n	%	n	%		
Safer sex behavioral maintenance strategies						
Recovery self-efficacy (M, SD)[c]	3.07	0.67	2.89	0.40	3.95	< .001***
Planning for high risk situations (M, SD)[c]	2.88	0.70	2.69	0.41	3.99	< .001***
Maintenance self-efficacy (M, SD)[c]	3.04	0.66	2.75	0.42	6.49	< .001***
Self-monitoring (M, SD)[c]	2.90	0.68	2.69	0.40	4.65	< .001***
Satisfaction with outcomes (M, SD)[c]	3.02	0.49	2.95	0.27	2.49	0.01**
Enlist social support (M, SD)[c]	2.41	0.72	2.41	0.43	− 0.02	0.98
Self-regulatory focus (M, SD)[c]	2.96	0.68	2.89	0.37	1.62	0.11
Total score for maintenance strategies (M, SD)[e]	20.29	3.85	19.27	2.24	3.97	< .001***

*p < .05, **p < .01, ***p < .001

[a]Test statistic is Student's *t* for continuous variables and Chi-square for categorical variables

[b]Range is 1 to 18

[c]Range is 1 to 4

[d]Range is 1 to 5

[e]Range is 7 to 28

Table 2 Intervention effect on incident HIV/STI diagnoses among female sex workers in Tijuana and Ciudad Juarez

	Tijuana				Ciudad Juarez			
	OR	95% CI		p	OR	95% CI		p
		Lower	Upper			Lower	Upper	
Group (Intervention vs. control)	1.46	0.61	3.52	0.39	2.05	0.94	4.48	0.07
Time	1.10	0.96	1.26	0.19	1.04	0.93	1.16	0.51
Type of sex worker (street vs. establishment)	1.97	1.21	3.20	0.01**	3.21	1.96	5.24	< .001***
Injection drug use	1.75	1.13	2.72	0.01**	1.47	0.92	2.34	0.11
Group × Time	0.92	0.47	1.77	0.79	0.58	0.33	1.03	0.06
Group × Time-squared	1.02	0.90	1.15	0.76	1.13	1.01	1.26	0.03*

Table 3 Intervention effect on condom unprotected sex with clients among female sex workers in Tijuana and Ciudad Juarez

	Tijuana				Ciudad Juarez			
	B	95% CI		p	B	95% CI		p
		Lower	Upper			Lower	Upper	
Group (Intervention vs. control)	− 2.09	− 3.41	− 0.77	0.002**	0.09	− 0.43	0.60	0.74
Time	− 1.96	− 2.51	− 0.80	< .001***	− 0.15	− 0.49	0.18	0.38
Type of sex worker (street vs. establishment)	0.26	− 0.12	0.65	0.18	− .27	0.08	0.46	0.019*
Injection drug use	0.58	0.26	0.90	0.001***	0.27	0.08	0.46	0.004**
Group × Time	1.61	0.39	2.83	0.01**	− 0.18	− 0.62	0.26	0.43
Group × Time-squared	− 0.28	− 0.51	− 0.04	0.02*	0.04	− 0.05	0.13	0.35

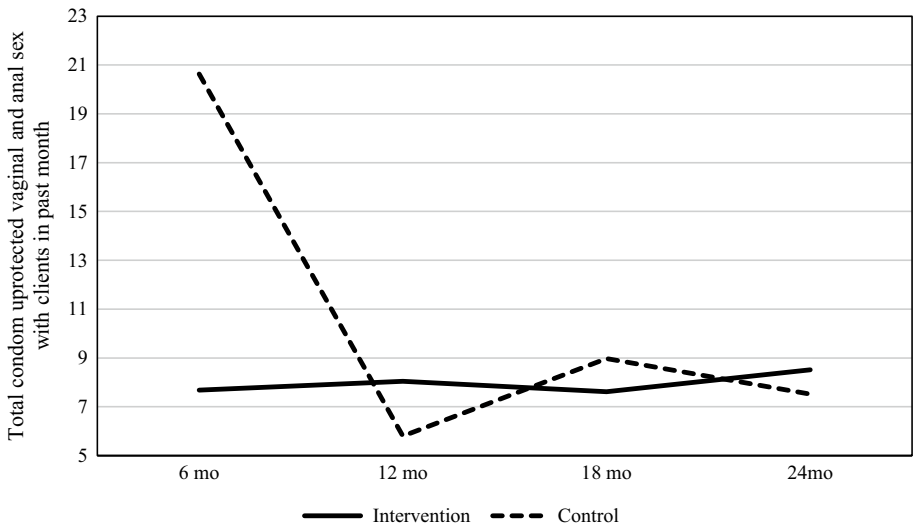

Fig. 2 Condom unprotected sex with clients by intervention group

quadratic), adjusting for type of sex worker and injection drug use. Results are displayed in Table 4, and show that among women in the control group, unprotected sex with clients increased in a linear fashion during the course of follow-up (through 24 months). This linear effect of time was not found among women in the intervention group, indicating that behavior change was sustained through 24 months.

Discussion

Our primary hypothesis that participants in the MSS intervention condition would have fewer incident cases of HIV/STIs over time compared to the control group was not borne out by the data. The evaluation of this safer sex maintenance intervention was conducted under conservative conditions.

Table 4 Stratified analysis testing the effect of time on condom unprotected sex among women in the intervention and control group in Tijuana

	Intervention				Control			
	B	95% CI		p	B	95% CI		p
		Lower	Upper			Lower	Upper	
Type of sex worker (street vs. establishment)	0.93	0.23	1.64	0.01**	0.51	− 0.15	1.17	0.13
Injection drug use	0.99	0.36	1.63	0.002**	− 0.02	− 0.65	0.61	0.94
Time (linear effect)	− 0.02	− 0.72	0.68	0.96	0.69	0.02	1.35	0.04*
Time− squared (quadratic effect)	0.02	− 0.11	0.16	0.72	− 0.11	− 0.23	0.01	0.07

In the previously published evaluation of the MS intervention, which compared the MS counseling session to a control condition, FSWs who received the experimental intervention had a lower incidence of HIV/STIs compared to women in the control condition [3]. In this study, *all* of the FSWs received the MS intervention. The lack of intervention effect in relation to HIV/STIs over time suggests that beyond receiving the MS intervention, receipt of MSS safer sex maintenance text messages or equivalent numbers of general health promotion messages may be sufficient to sustain behavioral changes achieved through exposure to MS.

Perhaps more in line with what would be expected, this study found support for our secondary hypothesis that FSWs who received MS counseling and theory-based safer sex maintenance text messages over a 24-month period had greater maintenance of safer sex practices (i.e., condom use) with clients compared to FSWs who received MS counseling and general health promotion maintenance texts over the same time period. The significant group × time interaction effect was found among FSWs in Tijuana, but not Cd. Juarez. The latter may be explained by two important baseline differences between FSWs in the study sites. Specifically, FSWs in Cd. Juarez were significantly more likely to report injection use of drugs and a greater likelihood of using alcohol with clients before or during sex in the past six months compared to their counterparts in Tijuana. Although FSWs in both Tijuana and Cd. Juarez reduced their sexual risk behavior six months post-counseling, it is likely that behavior maintenance was more challenging for FSWs in Cd. Juarez because of these two behavioral factors. Indeed, it has previously been reported that use of drugs and alcohol results in lower ability to acquire and retain HIV prevention knowledge and skills [32]. Moreover, future studies should examine the role of alcohol and injection drug use in other adherence-dependent interventions to reduce HIV/STI risk in this population. For example, it would be informative to determine if other forms of HIV/STI risk reduction (e.g., PrEP) are similarly affected by these two behavioral factors. It is possible that they do not interfere with usage in the same way as they do for condoms. Further research is warranted.

The lack of intervention effects among FSWs in Cd. Juarez might also be explained by the observation that FSWs in Cd. Juarez had greater access to free condoms compared to women in Tijuana during the study period. HIV prevention project programs operating in Cd. Juarez distributed an average of 760,000 free condoms to FSWs per year in the city between 2016 and 2018. There was significantly lower distribution of free condoms in Tijuana (~ 500,000 per year) during this time period.

Overall, the efficacy of MSS in Tijuana demonstrates the feasibility of using mobile phone technology to achieve long-term maintenance of positive behavior change (i.e., sexual risk reduction with clients) in a high-risk population of FSWs in a LMIC. It also points to the value of using theory-based text messages in the design and development of efficacious behavioral maintenance interventions. However, the present analyses did not determine which elements or domains (e.g., social support, recovery self-efficacy) of our theory-based text messaging intervention had the strongest association with sustained behavior change among FSWs. It is possible that all seven theoretical domains worked together synergistically. It is also possible or even more likely that a specific domain(s) acted as the dominant mechanism(s) of behavioral maintenance. Future studies should seek to maximize the efficacy of behavioral maintenance interventions for FSWs by specifying the precise theoretical mechanisms of behavioral maintenance that determine sexual risk reduction maintenance behaviors among FSWs.

The likely role of substance use (particularly injection drug use) in the absence of an intervention effect among FSWs in Cd. Juarez has potential implications for the use of technology in the design of behavioral maintenance interventions for this high-risk population. It has been reported that between 30 and 40% of people who use drugs experience cognitive deficits (e.g., difficulties with memory, attention, learning new information) that might affect their ability and motivation to benefit fully from technology-based interventions [32–34]. Indeed, neurocognitive impairment (NCI) associated with drug use has been associated with decreased engagement in HIV treatment [35], lower retention in care,

and poor adherence to medication treatment [32, 36, 37]. Our finding that injection drug use was associated with more unprotected vaginal and anal sex acts with clients suggests that mobile phone-based safer sex maintenance messages need to be tailored to the personal characteristics and circumstances of FSWs who inject drugs. Indeed, mobile phone intervention studies to promote ART adherence have shown good retention of people who are substance users, especially when the content of the messages align with the identified needs of the population [38, 39]. Moreover, the extent of NCI in subgroups of drug-using FSWs should be explored in future studies of the efficacy of text message-based safer sex maintenance interventions.

Future studies should also explore the changing and evolving role of technology in behavioral maintenance interventions targeting FSWs in LMIC. As the number of FSWs with access to mobile phones increases around the globe, both positive and negative consequences associated with their role in soliciting clients should be considered. Mobile phone solicitations provide the opportunity for longer-term relationships with clients that can foster feelings of trust and caring, which are associated with higher rates of condom unprotected sex [8]. Also, direct solicitations via mobile phones can lead to a greater number of clients and more "hidden" (i.e., private) encounters that may result in less protection from abusive, manipulative, and violent clients, culminating in potentially more condom unprotected sex [8, 9].

Previous studies have described changes in FSWs' sex work environments associated with the use of mobile phones for client solicitation in LMIC [8, 9]. It is possible that differential rates of change in the use of mobile phones in the study sites played a role in the lack of intervention effects in Cd. Juarez. Future studies need to monitor changes in the visibility of sex work associated with mobile phone solicitation of clients and furthermore assess the role of mobile phone technology in relation to its effects on sexual risk behaviors (both risks and protections) and ultimately the effectiveness of longer-term behavioral maintenance interventions such as MSS [40].

It has also been suggested that interventions that use mobile technology can help to reduce stigma and discrimination that have been reported by FSWs who attend face-to-face counseling sessions in clinics or offices that are known to house HIV prevention programs [41]. However, it is important to note that FSWs in both of our study sites expressed gratitude for our project's open door policy where they were welcomed, provided snacks and beverages, and had the opportunity to develop trust and rapport with project staff. Overall, our findings support the integration of mobile phone-based HIV prevention interventions and traditional face-to-face counseling sessions as a vehicle for behavior change and long-term maintenance of safer sex practices among FWS in a LMIC.

Study Limitations

Our ability to generalize the study findings to other populations of FSWs was limited by the recruitment of convenience samples in both study sites. A number of site differences were identified at baseline, including higher levels of unprotected sex with clients in Cd. Juarez compared to Tijuana. FSWs in Cd. Juarez also had higher monthly income, which may indicate that they are engaging in unprotected sex for higher pay. Also, our measure of sexual risk behavior was determined through self-report, which might have lacked the sensitivity needed to detect changes in behavior. Despite this study's interest in HIV seroconversion as a key outcome, only 2% (n = 12) FSWs seroconverted over the 24-month study period, which resulted analytically in the merging of data on HIV and STI incidence as the primary outcome of interest. Although our study was powered to detect differences between groups separately for the primary outcome (HIV/STIs), it is likely that power was limited by fewer incident STIs than expected, and our control condition may have been more active than was anticipated. Finally, the study design did not include a no text message condition, which might have been associated with stronger intervention effects.

Conclusions

This study demonstrates the efficacy of a technology-enabled text messaging behavioral maintenance intervention designed to sustain reductions in sexual risk behavior following brief counseling among FSWs in a LMIC. The design of the study, which involved formative research, identified the need for tailoring and personalization of safer sex text messages that were also viewed as relevant to the context of sex work. This approach, which is likely to have contributed to the efficacy of our intervention, could be adapted to the experiences and needs of FSWs in other LMIC as well as other high-risk populations around the globe [7].

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All study procedures were approved by ethics committees at the University of California, San Diego, Xochicalco University in Tijuana, and SADEC-FEMAP in Cd. Juarez. All procedures were conducted in accordance with the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all participants prior to undergoing any study procedures.

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