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Could Motivational Interviewing Unlock the Potential of Cellular Texting? An Evidence Review of Text Messages Influencing Behavior Change

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Abstract

Cellular text messaging is an emerging technology that influences patients' decisions on health behaviors. It offers a cost-effective method to reduce healthcare costs by improving management for diseases or conditions associated with high morbidity/mortality. The objectives for this review are: 1) review current evidence on using text messages to influence patients' health behaviors; 2) evaluate which conditions or diseases are most influenced by text messaging; 3) determine if basing the text messaging in a theoretical framework improves outcomes. Common literature databases were searched for any published review articles since 2005 on this subject. Thirty-six reviews met inclusion criteria. Overall, there is high quality evidence of improvement in tobacco cessation rates with text message interventions with low quality evidence of positive results with text messaging improving weight loss, diabetic self-control, and asthma control. The heterogeneity of studies (small sample size, mixed media interventions combined with texting, varying frequency of intervention and study length) creates difficulty in interpreting overall effectiveness of text messaging. There was also a lack of evidence to support using a behavior change theory to frame the interventions. However, motivational interviewing (MI) has been shown to motivate patients in changing health-related behaviors, but has not been explored within text messaging trials. MI could offer a new technique to improve the effectiveness of text messaging interventions. High-quality research should continue to examine the use of text messaging with MI messaging.

Keywords: text message, SMS, short message service, behavioral change, motivational interviewing

Could Motivational Interviewing Unlock the Potential of Cellular Texting? An Evidence Review of Text Messages Influencing Behavior Change

The Center for Medicare and Medicaid Services (CMS) estimated the total cost of health care in the United States (US) for 2013 at $2.9 trillion. In 2012, the United States spent 17.9% of its Gross National Product on health care (World Health Organization [WHO], 2015). Overall, the cost per capita for health care in the US has steadily climbed from approximately $4,000 per person in 1995 to $8,895 in 2012 (WHO, 2015). CMS estimated that cost per capita rose to $9,255 per person in 2013 (Center for Medicare and Medicaid Services [CMS], 2014). As of 2012, the US was second in the world in health care spending per capita, behind Switzerland at $9,247 per capital on health care annually (WHO, 2015). Despite spending significant money and energy on the vast US health care system, the United States does not rank highest in any of the primary health indicators, such as life expectancy at birth, infant mortality, under five year old mortality, or maternal mortality (WHO, 2014). These international indicators do not account for other components of quality of health care such as quality of life outcomes, disability indexes or patient satisfaction scores. Other wealthy countries spend much less and have higher quality health care (rated by health indicators) but the rationale for why this occurs remains unclear. It begs the question: how can the Unites States adjust or improve its system of health care to improve quality in a cost-efficient manner?

To improve quality and cost of health care, it is useful to examine the most common diseases in the US that are responsible for the majority of health care costs (Centers for Disease Control and Prevention [CDC], 2014). According to the Centers for Disease Control (CDC), chronic diseases are the leading cause of death and disability in the US (CDC, 2014). Chronic diseases in the US include heart disease, stroke, cancer, obesity, diabetes and arthritis.

According to World Health Organization (WHO), six of the top ten causes of death in the US in 2012 were chronic diseases that all have some behavior risk factors (WHO, 2015). Those six diseases (heart disease, lung and upper respiratory tract cancers, chronic obstructive pulmonary disease, stroke, diabetes and hypertension) are at least partially related to unhealthy lifestyle choices of patients such as tobacco use, unhealthy diet, insufficient physical activities, and alcohol overuse (CDC, 2014; WHO, 2011). However, getting people to make changes to their behaviors is challenging at best. Despite national campaigns focused on exercise, healthy eating and smoking cessation, people continue to struggle with making healthy lifestyle choices and the subsequent diseases that result from making less healthy choices. Health care providers, given limitations in both time and availability, can only interact with their patients a limit amount of time to educate and manage diseases. Given limited face-to-face time, patient and physicians are now utilizing other avenues to improve their health using mobile health (mHealth) technology.

MHealth technology includes a wide-range of ever-expanding platforms including cellular text messaging, smart phone applications, web-based education and interaction sites, and data-collection applications to list only a few. This emerging technology over the last 10 to 15 years is intriguing in terms of managing people's overall health given mHealth's accessibility, asynchronous nature of communication, and relative ease of use. Current applications of mHealth extend across a wide range of diseases and conditions including weight management, diabetes control, asthma management, and tobacco cessation programs. Examining only the cellular phone components of mHealth, the number of people who could utilize this technology is staggering. According to the United Nations' International Telecommunication Union (ITU), there was an estimated 6.915 billion mobile phone subscriptions active in 2014 (United Nations' International Telecommunication Union [ITU], 2014). Of those, 1.515 billion subscriptions

were within lower-income countries, giving an average of 120.8 subscriptions per 100 inhabitants (ITU, 2014). Text messaging or Short Messaging Service (SMS) on cell phones is almost universal, extremely easy to use and gaining popularity in many sectors of the population (ITU, 2014). Globally, text messaging is exponentially growing in popularity. As reported by ITU, the total number of global text messages increased from 1.8 trillion to 6.1 trillion annually from 2007 to 2010 and has continued its exponential growth (ITU, 2010). With the expansion of text messaging's popularity, providers and researchers have begun utilizing it to influence patients' diseases and their behaviors. Text messages are relatively cheap compared to other clinical interventions (several pennies per text versus potentially hundreds or thousands of dollars). Examining texting from a cost perspective, text messaging could potentially reduce the overall health care cost, but are they effective at motivating behavioral changes in people?

Statement of Purpose

This review evaluated the current scientific evidence to determine the effectiveness of cellular text messaging in achieving behavioral changes in patients. The behavior changes targeted in this review demonstrated a health improvement, such as an improvement in diabetes, smoking cessation, or improved physical activity. Those studies focused on medical appointment reminders, vaccinations and medication adherence were excluded as they were beyond the scope of this review. Secondarily, the literature was examined to determine if there was a specific disease or behavior that was more conducive to change through text message interventions. Finally, this review examined the foundation of the text messages themselves to determine if there was a difference in effectiveness if the text messages were created within a specific behavioral change framework.

Methods

A comprehensive electronic literature search was conducted with date ranges from March 2005 through March 2015 for relevant review articles of trials examining cellular text messaging and behavior modification. The search was limited to published reviews of trials and not specific trials themselves. The literature search used MEDLINE (US National Library of Medicine, National Institutes of Health, Bethesda, Maryland), Cochrane Library (Wiley InterScience, Malden, Massachusetts), Google Scholar (Google, Mountain View, California), PsychINFO (American Psychological Association, Washington, DC), and PubMed (US National Library of Medicine, National Institutes of Health, Bethesda, Maryland). The following search terms were used in various combinations: texting, text messaging, SMS, short messaging service, mHealth, mobile health technology, cell phone messaging. References in articles meeting search criteria were reviewed for additional articles in addition to papers citing articles meeting review criteria (backward searching). The search was limited to publications in English. Trials were limited to reviews of trials performed primary in the United States and other wealthy countries.

Review of Literature

The initial search yielded 177 articles. After removal of duplicates and those articles not applicable or covering excluded topics, 36 articles were selected for inclusion in this review. (See Figure 1 for screening process flow chart.)

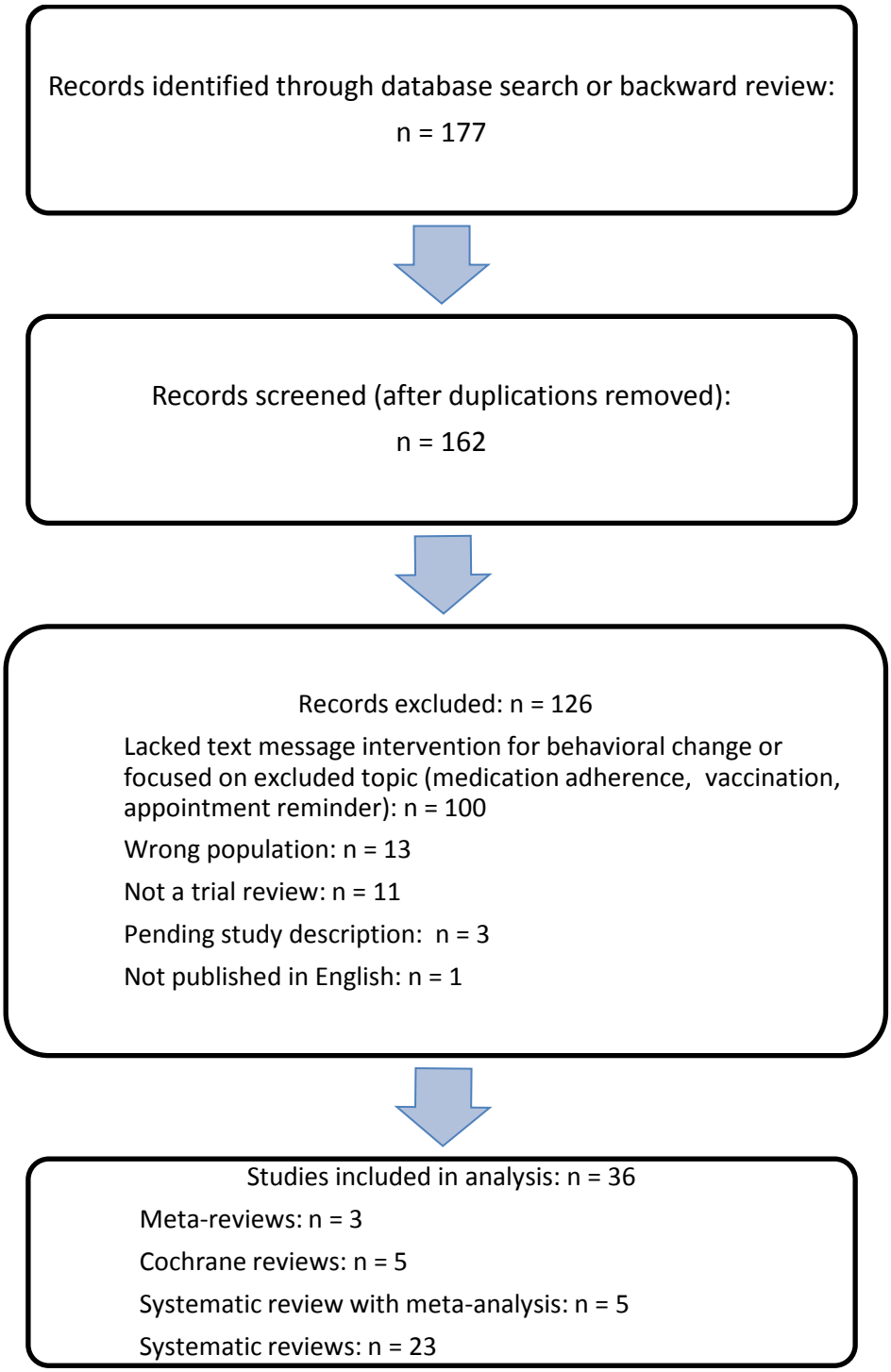

Figure 1. Screening process flow chart used for literature review.

Three meta-reviews, 1) Hall, Cole-Lewis, and Bernhardt (2015), 2) Jones, Lekhak, and Kaewluang (2014), and 3) Tang, Abraham, Greaves, and Yates (2014) examined available

review articles evaluating text messaging and behavior changes. Five reviews were Cochrane reviews about text messaging affecting various disease and prevention states. Five articles included meta-analyses of available text messaging impacts on several behaviors. The final 23 articles were systematic reviews of trials of text messaging or mHealth technologies which included at least one trial discussing the influence of text messaging on behavior change. This article reviewed the available data in the order mentioned above. Several of the individual reviews were included in overall meta-reviews, but were also discussed individually. See Table 1 for a complete list of the reviews examined in this article.

Table 1

List of Included Reviews and Results

Article Citation	**Quality Evaluation of included studies** ***Quality evaluation of review itself**	**Studies**	**Results** (If study results were broken out into TM-only interventions in a review, those TM-only study results are the only results included. Specific populations noted if applicable.)
Meta- Reviews			
Hall et al., 2015	OQAQ	15 SR	*Positive for smoking cessation (6 studies), physical activity/weight loss (11 studies), chronic disease management- diabetes (16 studies) * Positive for all meta-analyses studies *No change for smoking cessation (2 studies), physical activity/weight loss (8 studies), mixed topics (3 studies)
KR Jones et al., 2014	AMSTAR	11 SR	*Positive for short term smoking cessation, and selected clinical behaviors/outcomes (asthma peak flow and symptom scores, diabetic self-management capacity, A1C) in several reviews *No change in glycemic control in diabetics, BMI in diabetics, body weight in hypertensive patients, cholesterol in diabetics, in several reviews
Tang et al., 2014	OQAQ	20 SR (2 TM)	*Positive for weight loss (2 reviews)
Cochrane Reviews			
deJongh et al., 2012	GRADE *Hall OQAQ 18 Jones AMSTAR 11	4 RCT	*Positive for asthma- pooled symptom score and peak flow (1 study) *No change for diabetic A1C reduction, BMI, weight loss, blood pressure control (4 studies)
Vodopivec-Jamsek et al., 2012	Cochrane Handbook *Hall OQAQ 18 Jones AMSTAR 11	4 RCT (4 TM)	*Positive for tobacco cessation (1 study) *No change for physical activity, sugar sweetened beverage intake or screen time in children (1 study)
McLean et al., 2010	Cochrane Handbook	21 RCT (1 TM)	*Positive for improved peak flows in asthmatics (study) *No improvement in number of hospitalizations, symptom scores for asthmatics (1 study)

Note. A1C- hemoglobin A1C (measure of diabetic control); AMSTAR- A MeaSurement Tool to Assess systematic Reviews criteria; BMI- Body Mass Index; CBA- controlled before and after; Cochrane Handbook- Cochrane Handbook for Systematic Reviews of Interventions; DARE- Database of Abstracts of Reviews of Effects; GRADE-Grading of Recommendation Assessment, Development and Evaluation criteria; OQAQ-Overview Quality Assessment Questionnaire; qE- quasi-experimental; qRCT- quasi; RCO- random cross over; RCT-randomized control trial; SR- systematic review; STI- Sexually transmitted disease; TM- # of studies with text message-only intervention; TM +- # of studies with text message plus another intervention

Table 1 (cont'd)

Article Citation	Quality Evaluation of included studies *Quality evaluation of review itself	Studies	Results (If study results were broken out into TM-only interventions in a review, those TM-only study results are the only results included. Specific populations noted if applicable.)
Whittaker et al., 2012	Quality assessed, not using validated tool * Hall OQAQ 18	5 RCT or qRCT (3 TM)	*Positive for tobacco cessation quit rates in meta-analysis
Lavender et al., 2013	Cochrane Handbook	27 RCT (1 TM)	*No change in smoking cessation (1 study) of pregnant or post-partum women
Systematic Reviews with Meta-Analysis			
Free et al., 2013	Cochrane handbook *Hall OQAQ 17	75 studies (40 TM)	*Positive for smoking cessation in meta-analysis *No change for weight loss (2 studies)
Head et al., 2013	None reported * Hall OQAQ 17	19 RCT (9 TM)	*Positive for smoking cessation, physical activity and weight loss in meta-analysis
Liang et al., 2011	Modified Jadad scale *Jones AMSTAR 10 *DARE- publication bias	22 trials 11 RCT, 2 qRCT, 7 CBA, 2 RCO (8 TM or TM+)	*Positive for diabetic A1C in meta-analysis and in 6 of 8 TM/TM+ studies *No change in diabetic control (2 studies)
Saffari et al., 2014	Jadad criteria and Cochrane handbook criteria	10 RCT (6 TM)	*Positive for A1C reduction in meta-analysis of 6 TM only studies and 3 TM+ studies (latter 3 studies had confidence intervals that crossed 0 but trended toward positive)
Siopis et al., 2014	Quality Criteria Checklist (topic specific) *Hall OQAQ 16	13 studies	*Positive for weight loss in meta-analysis (6 studies)
Systematic Reviews			
Brown, 2013	Cochrane handbook & Melynk and Fineout-Overholt guidelines	4 cohort, 4 RCT (3 TM+)	*Positive for tobacco cessation in 2 studies of college age students *No change in tobacco cessation (1 study)
Buchholz et al., 2013	None reported	10 studies (5 RCT)	*Positive for increased physical activity (10 studies)
Chen et al., 2012	Quality assessment checklist, not validated	60 RCT/qRCT	*Positive for tobacco cessation in meta-analysis

Note. A1C- hemoglobin A1C (measure of diabetic control); AMSTAR- A MeaSurement Tool to Assess systematic Reviews criteria; BMI- Body Mass Index; CBA- controlled before and after; Cochrane Handbook- Cochrane Handbook for Systematic Reviews of Interventions; DARE- Database of Abstracts of Reviews of Effects; GRADE-Grading of Recommendation Assessment, Development and Evaluation criteria; OQAQ-Overview Quality Assessment Questionnaire; qE- quasi-experimental; qRCT- quasi; RCO- random cross over; RCT-randomized control trial; SR- systematic review; STI- Sexually transmitted disease; TM- # of studies with text message-only intervention; TM +- # of studies with text message plus another intervention

Table 1 (cont'd)

Article Citation	Quality Evaluation of included studies *Quality evaluation of review itself	Studies	Results (If study results were broken out into TM-only interventions in a review, those TM-only study results are the only results included. Specific populations noted if applicable.)
Cole-Lewis & Kershaw, 2010	Quality assessment checklist, no mention if validated *Hall OQAQ 15	12 RCT/qRCT (5 TM)	*Positive for smoking cessation and blood glucose monitoring/A1C reduction/weight loss in diabetes (8 of 9 sufficiently powered studies) * No change for physical activity, asthma
Connelly et al., 2013	Cochrane handbook & subject specific criteria score	15 studies (3 TM)	*Positive trend for physical activity in Type II diabetics (3 TM studies) and A1C in Type II diabetics (2 TM studies)
Derbyshire & Dancey, 2013	None reported	10 RCT (3 TM)	*Positive for weight loss in 3 studies of women
Fjeldsoe et al., 2009	None reported *Hall OQAQ 14 Jones AMSTAR 6 *DARE-language/publication bias	14 studies (mix)	*Positive in physical activity, weight loss, diabetic self-management, blood pressure control (13 studies) *No change in asthma (1 study) or bulimia
Herbert et al., 2013	None reported	7 studies (3 RCT) (2 TM, 5 TM+)	*Positive for diabetic control in Type I child/adolescent diabetics (5 studies) *No change in diabetic control (2 studies)
Holtz & Lauckner, 2012	None reported *Jones AMSTAR 5	21 articles (mix)	*Positive trends for A1C control and decreased BMI
Jones K et al., 2014	None reported	11 studies (3 TM)	*Positive for decreased sexually risky behavior in adolescents in 2 studies and improved screening rates for STIs in 1 study *No change in adolescents in screening rates for STIs (1 study) or risky sexual behavior (1 study)
Keating & McCurry, 2014	None reported	7 studies (3 RCT)	*No change in BMI (3 RCT studies)

Note. A1C- hemoglobin A1C (measure of diabetic control); AMSTAR- A MeaSurement Tool to Assess systematic Reviews criteria; BMI- Body Mass Index; CBA- controlled before and after; Cochrane Handbook- Cochrane Handbook for Systematic Reviews of Interventions; DARE- Database of Abstracts of Reviews of Effects; GRADE-Grading of Recommendation Assessment, Development and Evaluation criteria; OQAQ-Overview Quality Assessment Questionnaire; qE- quasi-experimental; qRCT- quasi; RCO- random cross over; RCT-randomized control trial; SR- systematic review; STI- Sexually transmitted disease; TM- # of studies with text message-only intervention; TM +- # of studies with text message plus another intervention

Table 1 (cont'd)

Article Citation	**Quality Evaluation of included studies** ***Quality evaluation of review itself**	**Studies**	**Results** (If study results were broken out into TM-only interventions in a review, those TM-only study results are the only results included. Specific populations noted if applicable.)
Kong et al., 2013	None reported	15 studies (10 RCT) (4 TM)	*Positive for smoking cessation (3 studies) *No change for smoking cessation (1 study)
Krishna et al., 2009	None reported *Jones AMSTER 3 *DARE- language/publication bias	25 studies (20 RCT)	*Positive for A1C improvement in diabetics *Mixed results for tobacco cessation *No improvement in physical activity, BMI, blood pressure or cholesterol values
Lau et al., 2011	13 item quality checklist	9 RCT (3 TM)	*No change in physical activity for children/adolescents (3 studies)
Militello et al., 2012	Downs and Black checklist *Jones AMSTAR 8 *DARE- possible language, publication bias	5 RCT, 1 qE, 1RCO (3 TM and 1 TM+)	*Positive trends in A1C in child diabetics (1 study) and decreased screen time for children (1 study) *No change with A1C in diabetics and physical activities (2 studies) for children/adolescents
Poorman et al., 2014	None reported	48 studies (30 RCT)	*Positive for smoking cessation in pregnancy (4 studies), substance abuse (1 study), gestational diabetes (2 studies), weight loss in women (3 studies) and depression (1 study) *No change for smoking cessation in pregnancy (2 studies), gestational diabetes (1 study) and mixed results on high risk sexual behavior
Russell-Minda et al., 2009	Downs and Black checklist *Jones AMSTAR 8 *DARE- possible language, publication bias	18 studies (mixed) (9 TM+)	*Positive for A1C improvement (4 studies) for diabetics *No change in A1C (2 studies) of diabetics

Note. A1C- hemoglobin A1C (measure of diabetic control); AMSTAR- A MeaSurement Tool to Assess systematic Reviews criteria; BMI- Body Mass Index; CBA- controlled before and after; Cochrane Handbook- Cochrane Handbook for Systematic Reviews of Interventions; DARE- Database of Abstracts of Reviews of Effects; GRADE-Grading of Recommendation Assessment, Development and Evaluation criteria; OQAQ-Overview Quality Assessment Questionnaire; qE- quasi-experimental; qRCT- quasi; RCO- random cross over; RCT-randomized control trial; SR- systematic review; STI- Sexually transmitted disease; TM- # of studies with text message-only intervention; TM +- # of studies with text message plus another intervention

Table 1 (cont'd)

Article Citation	**Quality Evaluation of included studies** ***Quality evaluation of review itself**	**Studies**	**Results** (If study results were broken out into TM-only interventions in a review, those TM-only study results are the only results included. Specific populations noted if applicable.)
Schnall et al., 2014	Subject specific assessment tool from CDC	12 RCT/qE (2 TM)	*Positive for HIV retesting rates and decreased methamphetamine use in men who have sex with men (1 study) *No change in high risk behavior in men who have sex with men (1 study)
Shaw & Bosworth, 2012	Quality scoring system adapted from review of eHealth intervention, not mentioned if validated * Hall OQAQ 15	14- RT or QE	*Positive for self-efficacy of weight loss (1 study), frequency and duration of physical activity (3 studies), diet (2 studies), blood pressure (2 study), weight loss (11 studies) *No change in self-efficacy of weight loss (2 study), frequency and duration of physical activity (3 studies), diet (2 studies), blood pressure (1 study), weight loss (3 studies)
Stephens & Allen, 2013	None reported	7 studies (mix) (7 TM)	*Positive for weight loss in 3 studies, dietary improvement in 1 study and decreased screen time in 1 study *No change in exercise amount in 1 study
Wei et al., 2011	None reported	24 articles (16 RCT) (24 TM)	*Positive for bulimia control in study, schizophrenia control in 2 study, diabetic control in 3 studies, asthma peak expiratory flow in 1 study, tobacco cessation in 2 studies, sunscreen use in 1 study, weight loss in 2 studies and self-breast exam in 1 study *No change for diabetic control in 1 study or tobacco cessation in 1 study
Williams, 2012	None reported	4 RCT (2 TM)	*Positive for weight loss in 2 studies and decreased abdominal circumference in 1 study
Yeager & Menachemi, 2011	None reported	61 papers (mix)	*Positive effects in primary outcomes of studies in 50 of the studies (mixed behavioral topics, results not sub-divided by topic)

Note. A1C- hemoglobin A1C (measure of diabetic control); AMSTAR- A MeaSurement Tool to Assess systematic Reviews criteria; BMI- Body Mass Index; CBA- controlled before and after; Cochrane Handbook- Cochrane Handbook for Systematic Reviews of Interventions; DARE- Database of Abstracts of Reviews of Effects; GRADE-Grading of Recommendation Assessment, Development and Evaluation criteria; OQAQ-Overview Quality Assessment Questionnaire; qE-quasi-experimental; qRCT- quasi; RCO- random cross over; RCT-randomized control trial; SR- systematic review; STI- Sexually transmitted disease; TM- # of studies with text message-only intervention; TM +- # of studies with text message plus another intervention

Meta-Reviews

Hall and colleagues (2015) performed a meta-review of 15 systematic reviews examining behavior change and clinical outcomes of text-messaging interventions, either alone or in combination with other interventions. They reviewed the literature using an Overview Quality Assessment Questionnaire (OQAQ) and excluded 10 studies in their final analysis because of low quality scores (less than 14.) The authors analyzed the studies based on the subjects of the intervention (mixed topics within systematic reviews or meta-reviews, physical activity/weight loss, smoking cessation and self-management of chronic conditions.) Positive results for text message interventions were identified for smoking cessation, physical activity, weight loss, and chronic disease managed (mainly diabetes.) Hall and colleagues removed the duplicate individual studies within each review by topic and reported aggregate data (see Table 1 for details.) This author aggregated all the data and found that 47 reviews and all the meta-analyses had positive findings (either statistically significant or trending in favor of text messaging) for text messaging intervention compared to 13 studies demonstrating no change or insufficient evidence for text messaging to affect clinical outcomes through behavior change.

K. R. Jones and colleagues (2014) performed a meta-review of 11 systematic reviews published from 2009 to 2012 focusing on self-management of chronic conditions. The behavior topics included asthma, diabetes, tobacco cessation, and HIV antiretroviral therapy adherence and included diverse populations in most age ranges. K. R. Jones and colleagues (2014) used A MeaSurement Tool to Assess Systematic Reviews (AMSTAR) to evaluate the quality/methodology of the reviews. The four Cochrane reviews, considered the gold standard given their rigorous criteria for methodology quality, received AMSTAR ratings of 11 signifying the highest quality. Three other reviews had qualities of eight or above with the remaining

scoring an AMSTAR of six or less. The authors concluded text messaging demonstrated significant improvement in short-term tobacco cessation rates and other selected clinical/ behavioral outcomes. These other behaviors included improved peak flow volumes and symptom scores in asthmatics receiving text messages in asthmatics and increased reporting in blood glucose measurements by diabetics, but without significant hemoglobin A1C improvements. Several studies also showed insufficient evidence to determine that text messaging improves behaviors. Given the significant diversity in study designs, variable quality of studies, and diversity in interventions (text messaging was often included within a more comprehensive program) K. R. Jones and colleagues (2014) could not isolate the effects of behavioral improvement through text messaging. They also stated that a majority of the studies were conducted outside of the US, and most were conducted in lower-income countries. The primary limitations of the current evidence per K. R. Jones et al. (2014) include short term interventions and follow up, heterogeneous study design, poor quality study design, small sample size limiting power to detect differences, unclear text message frequency and attrition/retention problems. Additionally, the authors observed that very few studies discussed any cost data or patient/provider subjective thoughts about text messaging or the potential harms of this intervention.

Tang and colleagues (2014) performed their meta-review based on reviews published between 2000 and 2012 strictly focusing on the topic of weight loss. Many behavioral choices are included in this topic including physical activity and nutritional/dietary choices. Using the OQAQ to evaluate the 20 reviews, these authors found that only seven of the 20 had high or the highest quality scores. Only one systematic review evaluated text message exclusively as the intervention as the other studies used additional components such as counseling and internet.

This systematic review, Cole-Lewis and Kershaw (2010), included two individual trials where weight loss was significantly higher in the intervention group after one year. The Cole-Lewis and Kershaw (2010) review was given a high quality (OAQA score of 14) and will be reviewed later in this article. Tang and colleagues (2014) also remarked they were unable to draw any conclusions regarding the usefulness of any particular underlying theory of behavior change as a majority of the reviews did not include details about text message framing. Initial the authors had planned to do a meta-analysis of the underlying theory and the outcomes but were unable to because of paucity of evidence. Overall the authors concluded there was evidence supporting mHealth interventions in assisting patients in self-directed weight loss.

Cochrane Reviews

The five Cochrane review articles focused on a variety of behavioral components and a variety of interventions that included text messaging. Per K. R. Jones et al. (2014) as discussed above, four of these five were given AMSTAR top quality scores (the other review was not included in the K. R. Jones et al. review). All of the Cochrane reviews included only randomized control trials (RCT) or quasi-randomized trials. de Jongh, Gurol-Urganci, Vodopivec-Jamsek, Car, and Atun (2012) focused on text messaging for self-management of long term illnesses. This review included only trials with text messaging alone without additional interventions. The long-term diseases included diabetes, hypertension and asthma. Results showed an improvement in peak flow values and pooled symptoms scores in asthmatics in the intervention group; however, these were all based on two-way communication between the patient and provider allowing for treatment plan adjustments. It is hard to determine if these treatment changes were the underlying cause of the health outcome improvements or if it was behavioral changes by the patient as a result of the text messages. Similarly, all the other trials

reviewed focused on health outcomes only without determining if the patients were changing their behaviors specifically or just the management of the condition (medical adjustments.) In two other reviewed trials, neither diabetics' hemoglobin A1C, body mass index (BMI), weight nor blood pressure improved using text message interventions. deJongh and colleagues (2012) concluded there is no evidence of improvement in health outcomes for chronic illnesses with texting with the exception of asthma. The authors did state that the paucity of data overall made it impossible to give quality evidence of the effectiveness of text messaging in this topic. The lack of high quality studies overall (e.g., only one of the four RCTs reviewed used an intention to treat analysis) is a significant problem with quantifying the effects of text messaging.

The second Cochrane review, by (Vodopivec-Jamsek, de Jongh, Gurol-Urganci, Atun, and Car (2012), focused on text message in preventive care on trials published between 1993 and 2009. This review focused on four RCTs that showed improvement with texting for tobacco cessation (high quality evidence). The authors also found low quality evidence of no change in physical activity, screen time, sugar-beverage consumption or weight control for children who were monitored with text messages. The challenge with the final study was the text messages were directed at the parents/guardians and not the minor patients' behavior changes.

McLean and colleagues (2010) reviewed several RCTs in their 2010 Cochrane review on the health effects of telecommunication on asthmatic patients. Only one of the RCTs focused on text messaging as an intervention. This specific trial was also reviewed by deJongh et al. (2012), which cited the same conclusions as McLean et al. (2010). No additional insight was provided in this Cochrane review.

Whittaker and colleagues (2012) published their Cochrane review with a meta-analysis in 2012 based on five RCT or quasi-RCT trials examining the effects of text messaging on tobacco

cessation. The authors reviewed the quality of studies using a standardized checklist but no validated tool was specified. Three trials used text messaging as the only intervention and the other two trials had text messaging combined with other interventions. The pooled data showed an increased long term quit rates for smoking with the interventions with a risk ratio (RR) of 1.71 compared to control programs. However, the results of all the five studies were heterogeneous; the results of three of the studies cross the line that showed no effect of the intervention. With the mixed interventions and the unclear quality analysis, it is hard to draw definitive conclusions about the efficacy of text messaging as an isolated intervention other than there is suggestion that texts improve tobacco cessation.

The final Cochrane review was by Lavender, Richens, Milan, Smyth, and Dowswell (2013) evaluating phone interventions on pregnancy outcomes, health choices and satisfaction of pregnant or immediately post-partum women. Only one of the RCTs included text message interventions, but it also included in-person follow up. This trial was focused on tobacco cessation in pregnancy. Lavender and colleagues (2013) analyzed these results with the other smoking cessation phone interventions and found no improvement in smoking cessation in this population of women. It is unclear if the text message-only trial data had been evaluated individually if it would have trended toward improvement. The authors of this review also mentioned that women in the text message arm felt annoyed by the text messages or that they received too many text messages, indicating a possible negative consequence of text messaging.

Systematic Reviews with Meta-analysis

Free and colleagues (2013) evaluated 75 different studies and used 14 in a meta-analysis, focusing on the effects of mobile health technology on disease management or behavior change. It was not possible to extract the text messaging-only interventions in the results data. The

authors used the International Cochrane Collaboration criteria to evaluate any biases in the studies but no other quality review was performed. Overall, the majority of the studies reviewed were of low or unclear quality. The pooled effects of biochemically-confirmed smoking cessation with mHealth intervention showed a RR of 2.16. They mentioned other studies suggest improvement of other diseases and behaviors with mHealth technology, but the lack of good quality makes interpretation difficult. Seven of the studies within the behavior change subgroup cited behavioral theories as underlying the mHealth intervention, but no comparative analysis was performed to determine if those studies had different results than those not couched in theory. Free et al. (2013) did conclude that text messaging and mHealth were likely cost effective interventions when used for smoking cessation.

Head, Noar, Iannarino, and Grant Harrington (2013) analyzed 19 RCTs examining text messaging intervention on health promotion activities, including physical activity and tobacco cessation. The authors did not include a quality discussion of the trials selected. Nine of the 19 RCT were text message-only intervention, but the meta-analysis included all the trials including those with additional interventions (such as websites, counseling, printed materials.) However, the analysis showed no significant difference between those interventions that used text message-only or multiple components for intervention. There was a small to medium size effect in a positive direction for smoking cessation and an increase in physical activity with intervention. The authors states that message tailoring and personalization were significantly associated with greater intervention efficacy. Additionally, they noted there was no significant difference in the size of effects of the intervention in those trials based on a theory of behavior change, compared to those trials when the text messaging was not based on an underlying theory. However, the size effect was larger in the trials with text messages based on a theory foundation. Head et al.

(2013) identified that two-way communication was more effective than one-way communication in the texting and a lower frequency of text message was received better by the participants. This second finding supports Lavender et al.'s Cochrane review (2013) that patients felt they received too many text messages.

The next meta-analysis was by Liang and colleagues (2011), focusing on diabetic self-management. Using a Modified Jadad Scale as a quality assessment, they evaluated 22 trials (a mix of RCTs, controlled before and after trials, quasi RCT, and random cross over trials). Similar to the other meta-analyses, only eight of the trials included text messaging as an isolated intervention or as a combined intervention, but the analysis included all of the mobile phone interventions. The meta-analysis overall supported mobile phone interventions, demonstrating a significant reduction in hemoglobin A1C values (0.5% reduction) in the treatment groups. On the individual trail reviews, out of the 22 trials, two showed a worsening of diabetic control in the treatment group and one showed no change in hemoglobin A1C in the treatment arm. Subgroup analysis showed Type II diabetics had a greater reduction in hemoglobin A1C than Type I diabetics had suggesting certain populations may be more influenced by texting intervention. Also, they authors noted that the trials with a larger sample size demonstrated a larger reduction in hemoglobin A1C with the intervention. Patients were also generally satisfied with the different cell phone interventions, although this was not broken out among text messaging or other interventions. However, Liang and colleagues (2011) did discuss that there was likely a selection bias in the mobile phone intervention as it focused on patients who were motivated to make a change as it was a self-directed management. It is important to recognize that in the meta review by K. R. Jones et al. (2014), it is discussed that Liang's systematic review was also evaluated in the DARE database (Database of Abstracts of Reviews of Effects). This

additional quality review recommended the results be interpreted with caution as there was likely publication bias. (Publication bias being a bias toward publishing only studies with positive results instead of publishing all results, even the negative studies or those studies with insufficient evidence for an intervention.)

Saffari, Ghanizadeh, and Koenig (2014) evaluated hemoglobin A1C reduction as the clinical outcome of behavior modification with text message intervention for diabetics in their systematic review and meta-analysis of 10 RCTs. They found that all six studies with text messaging as the only intervention had positive results supporting the intervention. Three of those six had confidence intervals that cross zero (no change in hemoglobin A1C), but the meta-analysis for those studies was statistically significant in support of text messaging. In contrast to Head et al. (2013), Saffari and colleagues (2014) found a larger effect size with text messaging plus internet interventions compared to the text-only interventions. Additionally, the authors did cite concerns about possible publication biases in the overall literature they reviewed. Generally Saffari et al. (2014) were supportive of the text messaging intervention for diabetic self-control but recommended further research to determine the subgroups of patients and disease states this intervention could be used for maximum benefit.

Siopis, Chey, and Allman-Farinelli (2014) performed a systematic review of 13 studies with subsequent meta- analysis that used text message interventions for weight loss. They used a nutrition and diet specific quality checklist published by the American Academy of Nutrition and Dietetics to evaluate the quality of the studies. The six studies used in the meta-analysis all had text messaging as the core component of the weight management intervention, although it was not specified if this was the only component of the intervention, as many of the other studies had texting as an adjunct intervention. Siopis et al. (2014) calculated a statistically significant

positive effect for text message interventions, with those in the intervention groups losing an average of seven times more weight than the control groups. Some of the limitations noted was the diversity of the different text interventions; some used text messaging to gather information from patients, some used it to reinforce target behaviors and some used it for educational purposes. It is therefore difficult to determine which specific method was most effective at achieving a behavioral change. Like Safarri et al. (2014), Siopis et al. (2014) also had concerns about publication bias in the available literature. Siopsis et al. (2014) recommended further studies be performed in diverse socioeconomic classes and in males (as many of the participants in these studies were female) to determine if this intervention remains effective across different populations.

Systematic Reviews

Brown (2013) evaluated four cohort studies and four RCTs in a systematic review of technological interventions for tobacco cessation. Brown (2013) used two different quality evaluations (Cochrane Collaboration guideline tool and Melynk and Fineout-Overholt guidelines) giving trials scores up to a max of 12 representing the highest quality. Three of the eight studies had a text messaging component and their quality scores were six, seven and nine. Of those three, two studies found positive results with technological intervention, and one showed no change between control and intervention group. As in prior reviews, the multiple interventions make it impossible to isolate the effects of text messaging specifically on the behavior change. Brown (2013) did discuss the different theoretical frameworks within each trial but did not discuss if there was any differences in outcomes based on which framework was used.

Cole-Lewis and Kershaw (2010) published a systematic review focused on text message interventions on behavior change within disease management or disease prevention. The authors reviewed 12 RCT or quasi-RCT, with five of those being text message-only interventions. The quality assessment used included a checklist of nine criteria adapted from a review of technology intervention in health, although it was not cited as a specifically validated tool. The quality scores generally were higher than other reviews' quality scores, giving an average quality assessment of 76% in disease prevention trials and 81% in disease management trials. Eight behavior topics demonstrated positive results from text messaging interventions, specifically for weight loss, smoking cessation and diabetes (improved blood glucose monitoring and decreased hemoglobin A1C). Cole-Lewis and Kershaw (2010) showed that only nine studies were sufficiently powered to detect any difference between intervention and control groups, thereby supporting the limitations of small sample sizes in the review. However, eight of those nine studies supported text messaging as a tool for behavioral change. In regards to the specifics of the text messages, the authors acknowledged that how and when the messages were sent did make a difference in the effects. Only two of the studies discussed the theoretical framework behind the text interventions, which Cole-Lewis and Kershaw (2010) felt was a limitation given the importance of framing for behavior changes.

Lau, Lau, Wong del, and Ransdell (2011) evaluated mHealth technology in improving physical activity in children and adolescents in their systematic review of nine RCTs. Only three of those included text messaging as a component of interventions with none having text messaging alone as the intervention. The authors did use a 13-item checklist for quality evaluation (max score of 13); two of the three trials that included text messaging scored over nine rating them as good quality. All three of the studies that included text messages showed no

change in physical activity with the mHealth interventions. The authors determined that those interventions based on behavior change theory produced larger differences and large effect size in favor of the technologic intervention.

Militello, Kelly, and Melnyk (2012) did a systematic review focused on text messaging's effects on child and adolescent behaviors and clinical outcomes for a variety of topics including diabetes and physical activity. Six studies were evaluated (mix of RCT, quasi experimental and randomized cross over), although only three had text message-only interventions. They used the Downs and Black checklist to evaluate the quality of their studies. K. R. Jones et al. (2014), in their meta-review, gave this review an AMSTAR rating of eight (moderate quality), although it also cited the DARE database review of Militello's review as having possible language and publication biases so the reliability of the results are questionable. There was trending evidence in two studies for improved hemoglobin A1C and decreased screen time in children with intervention, but two studies also failed to demonstrate any difference with intervention. Of note, the two studies with the highest quality review failed to show any significant outcomes.

Another systematic review of mHealth interventions on diabetics was performed by Russell-Minda and collegues (2009). It included 18 trials (both RCT and non-randomized observational studies) of which nine had text messaging components mixed with other interventions. Similar to Militello's (2012) review, Russell-Minda et al. (2009) used the Downs and Black checklist for quality review. K. R. Jones et al. (2014) also gave this review an AMSTAR score of eight, but cited the DARE database review as having concerns about language and publication biases limiting the reliability of the results because of methodologic problems. Four mixed interventional trials showed positive trends associated with improved diabetic control with intervention where as one showed no evidence of improved hemoglobin

A1C with intervention; overall the author concluded that there was moderate to strong evidence of improved hemoglobin A1C with mHealth interventions (Russell-Minda et al., 2009).

Shaw and Bosworth (2012) did a systematic review focused on text messaging impact on weight loss. They evaluated the quality of their 14 studies (all RCT or quasi-experimental) using a scoring system adapted from a review of eHealth interventions. Hall et al. (2015) gave this systematic review an OQAQ score of 15. Overall, they identified 11 studies demonstrating support for text message intervention for weight loss, compared to three studies that showed no effect for the intervention. Shaw and Bosworth (2012) additionally evaluated self- efficacy, frequency and duration of physical activity, dietary habits and blood pressure as related to weight loss and found eight positive studies and eight studies without conclusive support for text messaging interventions. The authors thought text messaging was only at its infancy in terms of research and evidence supporting it, but they felt additional high quality research should be continued given the positive trends in the results.

The remaining systematic reviews have either low quality or no reported quality evaluation performed within the review article. Therefore, they will not be reviewed individually in the narrative portion of this article. A full listing of reviewed articles and details are available in Table 1. A majority of these studies had positive results for text messaging or mixed interventions that included text messaging on topics including tobacco cessation, HIV retest rates, methamphetamine use, reduction in high risk sexual behaviors, sexually transmitted infection screening, physical activity, weight loss, bulimia, asthma, sunscreen use, and diabetes.

Results

This review had three objectives: 1) determine if overall text messaging is effective at changing patients' behaviors; 2) identify if specific behavioral topics are more amendable to

changes with text messaging; and 3) examine the influence of framing text messaging interventions using an established behavioral change framework on outcomes. After evaluating the current scientific literature, text messaging interventions appear to be helpful in modifying patients' behaviors primarily for smoking cessation, although there are positive trends for other conditions such as asthma, diabetes and weight loss. The highest quality evidence (moderate to high quality) supports using text message interventions to aid patients with tobacco cessation. Regarding diabetes and asthma, it is challenging to determine if the patients' behavior itself changed from the text message intervention or if increased two-way communication with treatment plan modification were responsible for improvements in clinical outcomes. The positive trends (if not statistically significant) for text message interventions in chronic disease self-management by patients deserves further investigation as the evidence currently is low to moderate quality at best.

Several reviews (Brown, 2013; Free et al., 2013; Lau, Lau, Wong del, & Ransdell, 2011) discussed the importance in framing text message interventions based on an established framework, although Head et al. (2013) showed there was no significant difference between interventions couched in theory and those not based on behavioral change theories. However, Head et al. (2013) also found that the effect size for text message interventions was larger if theory was underpinning the messaging. Tang et al. (2014) attempted to evaluate the effects of framing the interventions, but the lack of data prevented the authors from drawing a definitive, evidence-based conclusion.

Discussion

Despite promising results, there are significant gaps and limitations in the scientific evidence regarding the effectiveness of text messaging on motivating behavioral changes in

patients. Some of these issues are related to study design and patient selection, but some issues are more generalizable beyond the studies themselves. (A complete list of limitations from the included reviews is included in Table 2.)

Table 2

Limitations of the Current Research on Text Messaging Influencing Behavioral Change

Article Citation	Short term (intervention and/or follow up)	Hetero-geneous study design	Poor quality (design, randomization, blinding, bias in results)	Small sample size and/or underpowered	Variable text message frequency	Attrition/ poor retention of patients	Lack control group
Meta-Reviews							
Hall et al., 2015	x	x	x	x			
Jones KR et al., 2014	x	x	x	x	x	x	
Tang et al., 2014	x		x				
Cochrane Reviews							
deJongh et al., 2012	x			x			
Vodopivec-Jamsek et al., 2012				x			
McLean et al., 2010		x	x			x	
Whittaker et al., 2012		x					
Lavender et al., 2013		x	x				
Systematic Reviews with Meta-Analysis							
Free et al., 2013			x				
Head et al., 2013			x				
Liang et al., 2011				x		x	
Saffari et al., 2014	x			x			
Siopis et al., 2014	x					x	

Table 2 (cont'd)

Article Citation	Short term (intervention and/or follow up)	Hetero-geneous study design	Poor quality (design, randomization, blinding, bias in results)	Small sample size and/or underpowered	Variable text message frequency	Attrition/ poor retention of patients	Lack control group
Systematic Reviews							
Brown, 2013			x	x			x
Buchholz et al., 2013		x		x	x		
Chen et al., 2012		x					
Cole-Lewis & Kershaw, 2010	x			x	x		
Connelly et al., 2013						x	
Derbyshire & Dancey, 2013			x				
Fjeldsoe et al., 2009	x	x	x		x	x	
Herbert et al., 2013	x			x		x	
Holtz & Lauckner, 2012	x		x	x			
Jones K et al., 2014			x	x		x	
Keating & McCurry, 2014					x		
Kong et al., 2013		x					
Krishna et al., 2009				x			
Lau et al., 2011	x	x	x				x
Militello et al., 2012	x			x			
Poorman et al., 2014						x	
Russell-Minda et al., 2009			x				
Schnall et al., 2014	x	x		x			x
Shaw & Bosworth, 2012	x	x		x			
Stephens & Allen, 2013	x	x		x	x		

Table 2 (cont'd)

Article Citation	Short term (intervention and/or follow up)	Hetero-geneous study design	Poor quality (design, randomization, blinding, bias in results)	Small sample size and/or underpowered	Variable text message frequency	Attrition/ poor retention of patients	Lack control group
Wei et al., 2011	x		x	x		x	
Williams , 2012				x			
Yeager & Menachemi, 2011				x			

One of the most cited limitations in all the reviews was a lack of high quality research on this subject. The available studies are heterogeneous in design and intervention. Ideally, the highest quality evidence would come from RCTs. While the number of RCTs studying the effects of text messaging are increasing over time, a large portion of the studies are only quasi-experimental or single-group pilot studies. Also, the sample sizes are often small and lack the power to determine any differences between the intervention and non-intervention groups. Often, there is a lack of a control group to draw an appropriate comparison (Brown, 2013; Lau et al., 2011).

Another problem related to the heterogeneity of design is the variability of duration of the intervention and the follow-up period in all the studies. Interventions with text messaging range from one text message during one week to several messages daily for a year. The text message "dose" was often not stated in the trials. Without consistent durations of intervention, frequency of text messaging, or reasonable follow up intervals, it is difficulty to evaluate the effectiveness of text messaging. Each of these factors may definitively affect the study outcomes. For instance, Lavender et al. (2013), published results from one study where the patients' complained about received too many text messages and found it annoying, which could affect their behavior.

In another study that focused on adolescent weight management, the participants felt they received too many messages (Siopis, Chey, & Allman-Farinelli, 2014).

Heterogeneity in the studies is introduced by using multiple interventions simultaneously. By using several components such as websites, in-person counseling or follow up, printed materials in addition to text messaging, isolating the effects of the text messaging alone is almost impossible (Siopis et al., 2014; Stephens & Allen, 2013). Despite not being able to isolate the effects, many clinical interventions use a wide variety of mediums and communication methods to help reach a wider variety of patients that may respond to different techniques. It would be helpful to isolate the effects of texting alone, but it may be appropriate to use multi-interventions to improve the effectiveness in different populations.

The research trials currently also have mixed data in regards to the type of text messaging being utilized. Text messaging can be one-way communications, providing a patient with information, education or motivational messages. However, it can also be two-way communication; the patient can provide input or answer questions and the research team can respond back, or the research team can initiate the conversation. These styles of communication can significant impact the effects of text messaging.

Additionally the direction of initiation could have an effect on selection bias of the patients involved in the studies. If the patient is responsible for initiating the text messages, it suggests they may be more motivated to make changes or at a later stage of change, compared to another patient who initially receives the messages without requesting them.

There is a gap in cost-efficiency data for text messaging. Free et al. (2013) suggested text interventions are cost effective although K. R. Jones et al. (2014) stated there is limited evidence for cost efficiency as a majority of the studies did not publish cost data. If the text messaging is

effective, it is reasonable to suspect if may be cheaper than other clinical interventions, but definitive data need to evaluate the direct cost (cost of text themselves) and the indirect cost of texting (cost analysis comparing cost of text with the cost of either other interventions or the cost of the behavior.)

The DARE database also suggests a publication bias in the current literature on text messaging interventions, citing this bias in the following reviews: Liang et al. (2011), Militello et al. (2012), Russell-Minda et al. (2009), Fjeldsoe, Marshall, and Miller (2009), Krishna, Boren, and Balas (2009). Both Saffari et al. (2014) and Siopis et al. (2014) had concerns about publication bias in the general literature of text messaging. Reviewing the Cochrane review articles (the gold standard for quality), the number of supportive or inconclusive trials is almost evenly split. Comparing this split to the remaining reviews in this literature search, the overwhelming majority have more supportive or positive results with text message/mHealth technology interventions than trials with no change or insufficient evidence.

Beyond the publication bias of the research, there are almost no data about the possible risks of text messaging interventions (de Jongh et al., 2012; K. R. Jones et al., 2014; Keating & McCurry, 2015). Risks could include loss of privacy, irritation or annoyance from multiple text messaging, and emotional or intense reactions to text messages, such a shame or guilt. There are currently limited data on patient satisfaction related to text messaging interventions (de Jongh et al., 2012). A few reviews remarked that most of the patients were satisfied with the intervention, but given the heterogeneity of the text message dose and frequency, it is hard to generalize patient satisfaction (Liang et al., 2011; Militello et al., 2012).

A cited concern in several studies was the homogeneity of the populations being evaluated, which could limit the generalizability of the effects to the general public. Keating and

McCurry (2015) and Siopsis et al. (2014) both reviewed weight management and stated a large majority of the participants were female. The style of communication with text messaging may vary by gender, although further research would be needed to determine if that characteristic could be used to maximize the effects of text messaging.

In addition to the research gaps, there are broader concerns that could limit the use of text messages as an interventional strategy. Mobile phones are subject to technical issues, jeopardizing the reliability of services. This factor is especially true in countries where the cellular infrastructure is not as reliable as that found in wealthy countries. Additionally, text messaging is effective only if a patient has access to a cell phone with texting services, understands how to use the text messaging services, and is literate. These facts demonstrate this intervention might be beyond the reach of certain sub-groups of the population such as those economically or educationally disadvantaged (Head, Noar, Iannarino, & Grant Harrington, 2013). Also, text messages have the potential to threaten confidentiality as the message could be misdirected to the wrong cellular number or another person could read the text messaging on the patient's phone.

In addition to the limitations of the current research, this review has several limitations. The author did not review any current, unpublished reviews that could produce more definitive evidence for the use of text messaging in health behavior changes. The limitation to English-only publications could have neglected important studies in none-English journals. This study focused on research in wealthy countries primarily, although texting may have a significant benefit also in countries where health care systems are not widely available. Additionally, the author excluded medication adherence in this review. Medication adherence is a patient

behavior that has been shown to be improved by text messaging reminders (K. R. Jones et al., 2014).

Recommendations

Overall, there are credible advantages of using text messages for improving patient behavior. The asynchronous nature of text delivery allows messaging to reach the patient at any time. The text messages can be programmed to be delivered at the specific times when the patient is making a behavioral choice. With the almost ubiquitous nature of cell phones, those patients who do not have access to health care services because of geographic distance or lack of transportation, or for those who do not like to seek assistance in-person, text messaging provides a different avenue of providing information, education and motivation that has the potential to improve patients' health. Text messaging has the ability to be personalized or tailored to patients which may motivate more change than generic messages (Head et al., 2013).

As discussed in the introduction, patients' individual choices about their health and lifestyle have a dramatic impact on their overall health. Getting patients to change those behaviors is challenging and has been the driving factors in the development of numerous theoretical models of behavioral change. Entire fields of public health policy, psychology and advertising departments are built around various frameworks of influencing people's decisions.

Given the positive trends in this emerging field of text messaging, it stands to reason that researchers would want to base those texting interventions on change methods that have been proven to be most efficient at motivating behavioral change. However, the research behind using a theoretical foundation for the text messages or mHealth intervention is significantly lacking. A majority of the studies, as highlighted in the literature review, do not base their interventions in change theories or do not state the theory being used. None of the meta-reviews comment if a

theoretical basis improved outcomes, other than Tang et al. (2014), who cited a paucity of evidence from which to draw any such conclusions. Head et al. (2013) in their systematic review, failed to show any statistically significant difference between theoretically-guided interventions and those not based on theory; however, the quality of studies is sub-optimal and may not accurately portray the true effects of using theory to develop the text messaging interventions. Lau et al. (2011) cited information and communication technology-based interventions that were grounded in behavior change theories were more likely to show a significant difference and larger effect size. Similarly, Poorman, Gazmararian, Parker, Yang, and Elon (2014) stated those text messaging interventions grounded in a behavioral change theory were more effective than those interventions not utilizing theory.

One technique, motivational interviewing (MI), has been demonstrating in the scientific literature to be effective at motivating health-related behavioral changes in patients (Lundahl et al., 2013). Motivational interviewing is a counseling style that centers on helping individual patients recognize ambivalence toward a decision and subsequently the underlying motivation behind their decisions (Miller & Rollnick, 2012). Patients, with the help of a facilitator, apply their individual perspective and knowledge in order to identify problems, barriers and personalized solutions to those problems. The patient-facilitator relationship is built around acceptance and compassion without judgement. It is primarily goal-oriented and patient-centric. Lundhal and colleagues (2013) published a systematic review and meta-analysis of 48 studies (with over 9,500 patients) that demonstrated a statistically significant, modest advantage of using MI to motivate behavioral change in patients (Odds Ratio 1.55, Confidence Interval 1.40-1.71 $p<0.001$). More specifically, MI was particularly helpful in tobacco and alcohol use, sedentary

behavior, body weight, self-monitoring and confidence in change. These are many of the same areas that text messaging has been shown to be effective or promising.

Another meta-analysis by VanBuskirk and Wetherall (2014) evaluated MI within a primary care setting specifically. This research evaluated 12 RCTs and found nine of the 12 showed positive results of using MI across a range of topics, such as diet/exercise behaviors, colorectal cancer screening, medication adherence, and blood pressure control. It is noteworthy that six of these RCT were regarding substance use, which is the subject area that MI was originally designed to target. One limitation cited was the heterogeneity of the MI studies, much like the text messaging interventions studies.

In the literature review of text messaging interventions, MI was never mentioned as a supporting theory or basis. Free et al. (2013) and Lau et al. (2011) specifically mentioned that MI was not a theory identified as unpinning any of the trials they reviewed (Free et al., 2013; Lau et al., 2011). The only mention of a motivational based theory was the Info-Motivation Behavioral Skills model cited in a systematic review focused on HIV related behaviors in men who have sex with men (Schnall, Travers, Rojas, & Carballo-Dieguez, 2014). However, this intervention was a web-based education study and not a text message trial. Another systematic review by Poorman et al. (2014) noted that motivational messages were more effective than informational messages, although this wasn't specifically motivational interviewing (Poorman, Gazmararian, Parker, Yang, & Elon, 2014). This author knows of one current, on-going, unpublished study using MI as the underlying theory in a text-messaging intervention RCT in a federally funded clinic focused on behavior change in substance abuse/overuse (L. Ilyas, personal communication, 2015). Results are not yet available, as follow up is on-going. This trial is the first to this author's knowledge of specifically targeting text messaging using MI

questions. There are limitations with the Ilyas'study with respect to small sample size and participant attrition.

It is important to recognize that several studies discussed components of MI in their interventions. MI is an individualized treatment that requires specifically tailored messages to the individual to help the patients identify their own barriers and solutions to overcome and make behavioral changes. Several authors included tables addressing the techniques of behavior change used in the various trials that they analyzed (Free et al., 2013; Lau et al., 2011). While none used motivation interviewing specifically, many studies used techniques such as tailoring, goal setting, barrier identification, goal setting, action planning, plan social support and prompt self-monitoring of behavioral outcome. These same techniques are often employed within the MI construct. With the growing positive trends within texting, MI could be a construct that fits in nicely with the current strategies within text message protocols.

With strong evidence behind MI in triggering behavioral change, this author recommends additional, high quality research using MI as the underlying theory in text messaging interventions. Texting lends itself to personalization and tailoring, which is a foundation of the MI philosophy. The effectiveness of text messaging to motivate behavior change may improve with MI specifically. As with any theory, various sub-populations of patients and different specific behaviors (chronic disease management, substance use, medication adherence) may respond differently to MI-focused text messages. Therefore, sufficiently large sample sizes of patients in RCTs in a variety of health behaviors would help identify who would benefit the most from MI intervention.

This author recognizes the challenges of adapting MI to text messaging for a larger patient population to motivate behavior change. MI requires interaction and back and forth

communication between patients and facilitators. Therefore, it may be hard to make a general algorithm for patients when the primary focus of MI is highly individualized. However, there are similarities within specific behavioral topics that may lend themselves to the MI framework. For example, smokers attempting to quit face many of the same barriers and challenges (social network includes smokers, cravings, habit breaking). Many of the tobacco cessation text messaging trials show positive results, potentially because the path to behavioral change for this topic has similarities and would allow for an MI-specific, text message intervention.

The healthcare world is changing quickly with the explosion of mHealth technology and individual patients have the opportunity to become drivers in their own health outcomes instead of relying on health care providers to manage their conditions. By harnessing motivational interviewing within the dynamic mHealth construct, this proven, evidence-based approach could assist health care providers in promoting behavior changes in their patients to improve overall health and potentially reduce health care costs.

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Appendix A: Competency Checklists

Tier 1 Core Public Health Competencies Used in CE

Domain #1: Analytic/Assessment Skills
Uses information technology in accessing, collecting, analyzing, using, maintaining, and disseminating data and information
Selects valid and reliable data
Identifies gaps in data
Collects valid and reliable quantitative and qualitative data
Describes public health applications of quantitative and qualitative data
Uses quantitative and qualitative data
Describes how evidence (e.g., data, findings reported in peer-reviewed literature) is used in decision making
Domain #2: Policy Development/Program Planning Skills
Contributes to development of program goals and objectives
Identifies current trends (e.g., health, fiscal, social, political, environmental) affecting the health of a community
Gathers information that can inform options for policies, programs, and services (e.g., secondhand smoking policies, data use policies, HR policies, immunization programs, food safety programs
Gathers information for evaluating policies, programs, and services (e.g., outputs, outcomes, processes, procedures, return on investment)
Describes how public health informatics is used in developing, implementing, evaluating, and improving policies, programs, and services (e.g., integrated data systems, electronic reporting, knowledge management systems, geographic information systems)
Domain #3: Communication Skills
Identifies the literacy of populations served (e.g., ability to obtain, interpret, and use health and other information; social media literacy)
Communicates in writing and orally with linguistic and cultural proficiency (e.g., using age-appropriate materials, incorporating images)
Conveys data and information to professionals and the public using a variety of approaches (e.g., reports, presentations, email, letters)
Communicates information to influence behavior and improve health (e.g., uses social marketing methods, considers behavioral theories such as the Health Belief Model or Stages of Change Model)
Facilitates communication among individuals, groups, and organizations
Domain #5: Community Dimensions of Practice Skills
Suggests relationships that may be needed to improve health in a community
Supports relationships that improve health in a community
Collaborates with community partners to improve health in a community (e.g., participates in committees, shares data and information, connects people to resources)
Engages community members (e.g., focus groups, talking circles, formal meetings, key informant interviews) to improve health in a community
Provides input for developing, implementing, evaluating, and improving policies, programs, and services
Informs the public about policies, programs, and resources that improve health in a community
Describes the importance of community-based participatory research
Domain #6:Public Health Sciences Skills
Describes the scientific foundation of the field of public health
Describes how public health sciences (e.g., biostatistics, epidemiology, environmental health sciences, health services administration, social and behavioral sciences, and public health informatics) are used in the delivery of the 10 Essential Public Health Services
Retrieves evidence (e.g., research findings, case reports, community surveys) from print and electronic sources (e.g., PubMed, Journal of Public Health Management and Practice, Morbidity and Mortality Weekly Report, The World Health Report) to support decision making
Recognizes limitations of evidence (e.g., validity, reliability, sample size, bias, generalizability)
Describes evidence used in developing, implementing, evaluating, and improving policies, programs, and services
Contributes to the public health evidence base (e.g., participating in Public Health Practice-Based Research Networks, community-based participatory research, and academic health departments; authoring articles; making data available to researchers)

Domain #8: Leadership and Systems Thinking Skills
Describes the ways public health, health care, and other organizations can work together or individually to impact the health of a community
Contributes to development of a vision for a healthy community (e.g., emphasis on prevention, health equity for all, excellence and innovation)
Participates in professional development opportunities
Describes ways to improve individual and program performance

Public Health Management Competencies Used in CE
Be capable of applying communication and group dynamic strategies to individual and group interaction
Know effective communication strategies used by health service organizations
Know change management principles
Have a knowledge of strategies used for monitoring, evaluating, and continuously improving program performance
Be capable of applying decision-making processes
Have a knowledge of human resource principles to enhance organizational management, motivate personnel and resolve conflict
A knowledge of ethical principles relative to data collection, usage, and reporting results