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A systematic review of nudge theories and strategies used to influence adult health behaviour and outcome in diabetes management

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Declaration of Interest

None

Abstract

Background. - Diabetes is a chronic disease associated with a variety of complications, and nudgingmay be a potential solution to improve diabetes control. Since nudging is a new concept, no review of literature on nudging diabetic patients into improving their health behaviour has been done. Therefore, we aim to collate a list of nudge intervention and determine the context in which nudging is successful.

Methods. **-** We adopted a two-arm search strategy comprising the search of literature databases and snowballing using relevant search terms. We summarized patient characteristics, the nudge intervention, according to nudging strategies, delivery modeand their outcomes. The conditions present in effective nudge interventions were assessed and reported.

Results. - We retrieved 11,494 studies from our searches and included 33. An additional five studies were added through snowballing. Studies included utilized *framing* (n=5), *reminders* (n=10), *gamification* (n=2), *social modelling* (n=5) and *social influence* (n=16). Studies on reminders and gamification were more likely to have a statistically significant outcome. The targeted health behaviours identified were *medication adherence, physical activity, diet, blood glucose monitoring, foot care, self-efficacy, HbA1C and quality of life*. Of these, studies with adherence to medication, foot care practice and quality of life as targeted health behaviours were more likely to show a statistically significant outcome.

Conclusion. - Nudging has shown potential in changing health behaviour of patients with diabetes in specific context. We identified two possible factors (delivery mode and patient characteristics) that may affect the effectiveness of nudge intervention.

Keywords: Choice architecture; Diabetes; Framing; Gamification; Nudge; Reminders; Social influence; Social modelling

Introduction

Diabetes is a chronic disease that can cause severe macrovascular and microvascular complications [1]. These complications have shown to increase the risk of all-cause mortality and decrease the quality of life [2]. Globally, the number of people with diabetes has quadrupled in the past three decades, with Asia being the epicenter of this global epidemic [3]. Unhealthy diet and a sedentary lifestyle have been recognized to be the most important contributors to the current diabetes epidemic [4]. Therefore, there is an urgent need to target diabetes through both pharmacological and non-pharmacological interventions [5]. The latter include eating healthily [6], increasing level of physical activity [7], and improving sleep hygiene [8], all of which depends on patients' self-management. Nudging patients by prompting them to make healthier choices, can potentially alleviate the burden on the healthcare system and allow for better long-term control of diabetes.

Nudge theory is a new behavioural economic concept which influences the behaviour and decision making of patients through choice architecture [9]. By definition, a nudge must not be mandatory and does not forbid any options [10]. While it seems logical that individuals will make right decisions relating to their health, many still choose short-term pleasures despite knowing the long-term detrimental effect on their health [11]. Prompt patients to make choices that prioritize long-term interest over short-term pleasures have been of increasing interest, especially in the health domain [12]. For instance, people tend to dislike losses more strongly than they enjoy an equivalent gain [12]. By focusing on the losses that can be incurred through a behaviour, the patients may tend to refrain from such behaviours to avoid losses. Such a nudge strategy has already been widely implemented as seen in the picture warnings on cigarette boxes to discourage people from smoking [13]. Nudges have also shown promising results in changing peoples' behaviour and improving self-management of chronic diseases, such as Type 2 diabetes [14].

Although some studies have shown the effectiveness of nudges in modifying patients' lifestyle choices such as diet [15], adherence of medication [16], and levels

of physical activity [17], the context in which these interventions works remain unexplored. Behaviour and decision making depends largely on the environment that the patients are located [18]. For example, individuals from different countries may make different decisions when exposed to the same intervention. Even individuals within the same country may have different responses to an intervention if they have been exposed to different physical, social and cultural environments [18]. Taking the context into account will allow an understanding of the process of interventions and why a particular intervention works.

This systematic review will present a list of behavioural cues and nudges that promote good self-management practices in a patient with diabetes as well as the context in which the nudges were applied. Understanding contextual aspects of behavioural nudgesmayhelp policy-makers, clinicians and researchers develop and implement effective nudge interventions that can modify the behaviour of patients with diabetes.

Method

We anchor this systematic review to the guidelines of Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA).

Nudge theories

We presented selected examples of the 5 different nudges in Table I.

(1) Framing modifies the presentation of a subject matter in order to subtly influence an individual's choice and behaviour. In general, there are two types of framing: frame in thought and frame in communication [19]. Frame in thought focuses on what an individual is thinking and tries to shape their mental representation of a subject matter. Frame in conversation focuses on how a subject matter is presented to an individual.

(2) Reminders serve to overcome barriers and nudge individuals into action. Barriers in performing a certain action include competing obligations, procrastination, inertia or simply forgetfulness [20].

(3) Gamification, which uses game design elements in non-game contexts [21], taps on an individual's desire to progress and earn points in a game setting to change health behaviour.

(4) Social modelling is based on the social learning theory which proposes that new behaviours can be acquired by observing and imitating others [22].

(5) Social influence refers to the way in which an individual change his or her behaviour to meet the demands of a social environment [23]. Social influence can be described as conforming to the expectation of others or conforming to a social trend.

Literature search strategy

We adopted a two-arm search strategy comprising the search of literature databases and snowballing. We searched PubMed, Medline, Embase, Scopus, PsycINFO and EconLit for relevant articles. The search strategy was based on carefully selected keywords and terms after discussion with a medical librarian (Table S1; see supplementary materials associated with this article on line). The search filter was set to human beings, and language was restricted to English only. We also reviewed the bibliographies from all eligible full-text articles. Duplicates were identified and eliminated using the reference manager EndNote X9. Further de-duplication was done manually.

Inclusion and Exclusion Criteria

We included English studies of all study design that have a suitable control group, and included participants of more than 18 years old with either Type 1 or 2 diabetes. We also included studies with nudges thatsubtly prompted patients towards making

better self-management decisions, without restricting the patient's autonomy for choice. We used the framework on nudging by Meske et al. 2017 [24] and Sunstein et al. 2014 [20] to guide our definition of nudge interventions. To ensure that these frameworks were relevant to our study, a panel of experts comprising a psychologist, clinicians and a research methodologist was convened for further agreement. Comparator for inclusion will be non-nudging intervention such as usual care. Behavioural change in medication adherence, physical activity, diet, self-efficacy, foot check, blood glucose monitoring, quality of life and change in HbA1C were included in this study. Studies on gestational diabetes and diabetes insipidus were excluded. Case reports, case series and studies without results reported were also excluded, as were non-English publications and animal research.

Screening

The entire screening process was done by two independent reviewers (CW Huang and TY Cheng). A third reviewer (YH Kwan) was also included in determining the relevance of the studies screened by two independent reviewers.Studies were screened by reading the title and abstract for inclusion criteria or exclusion criteria. A second round of screening was further completed by reading the full-text of the article.

Data extraction

The data was extracted using a predetermined data extraction form. We extracted information on the author, year of publication, title,sample size, country, population, mean age, diabetes type, mean disease duration, other comorbidities, objectives of study, study design, platform of administration,intervention, control, clinical outcome, targeted behaviour, duration of intervention, health behaviours outcome measure and limitations.

Quality assessment

To assess the bias of the included studies, the Effective Practice and Organization of Care (EPOC) risk of bias tool was used [25]. The risk of bias was assessed by at least two independent reviewers, with nine criteria included for risk of bias assessment: random sequence generation; allocation concealment; baseline outcome measurement; baseline characteristics similar; incomplete outcome data; knowledge of the allocated interventions adequately prevented during the study; protection against contamination; selective outcome reporting; other risk of bias. Each criterion was rated as low risk, high risk or unclear risk.

Data synthesis

Due to the heterogeneity of interventions and outcomes used, a meta-analysis was not feasible. Instead, a narrative synthesis was adopted to summarize the results. A systematic review was performed to identify the context in which the nudge intervention was effective.

Results

As shown in Figure 1, 11,494 articles were retrieved by our searches after the exclusion of 5100 duplicates. After screening the title and abstract, 11,070 articles did not fulfill the inclusion criteria and were excluded. 424 articles were included for full-text screening, of which 390 were excluded. Snowballing was carried out to yield 5 additional articles. The final number of articles included for the review was 38.A summary of the patient characteristics is presented in Table II with a more detailed version available in Table S2; see supplementary materials associated with this article on line. The detailed characteristics of the nudge interventions are presented in Table S3; see supplementary materials associated with this article on line.

Quality assessment

The results from the methodological risk of bias assessment of the included studies using EPOC are reported in Table S4; see supplementary materials associated with this article on line. The overall inter-rater agreement was 90%. A total of 16 studies were rated as high risk: two for selection bias, twelve for incomplete outcome data due to high attrition rate, and two for lack of protection against contamination between intervention and control groups.

Intervention

We presented five different nudge interventions in Table III: framing (n=5), reminders (n=10), gamification (n=2), social modelling (n=5) and social influence (n=16). Out of the 38 included studies, 21 were multi-component interventions. Besides using nudge as interventions, these studies utilized other types of interventions such as education, financial incentives, goal setting, problem-solving and condition monitoring to change the health behaviour of patients with diabetes.

Out of the 5 studies using framing, the mode of deliver included pedometer (n=3) [26-28], one-on-one counseling (n=1) [15], and email (n=1) [29].Reminders were mainly delivered via text messages [30-36]. Other delivery modes included websites [37] and reminder device [38,39]. For the 2 studies which employed gamification, the strategy was delivered through mobile application [40] and Wii console [41] respectively. Interventions on social modelling were delivered through video screenings [42,43] and group meeting sessions [44-46]. Interventions making use of social influence were delivered via text messages [47,48], mobile application [49], and group meetings [50-62].

The ten studies that employed reminders as a nudge intervention targeted mainly medication adherence, followed by physical activity, diet and foot care. The two

studies on gamification were designed to increase the level of physical activity in patients. Studies that used social modelling aimed to change patients' diet, level of physical activityand blood glucose monitoring. For studies that used social influence, they aimed to nudge patient towards healthy eating, increasing the level of physical activity, and improving adherence to medication and self-efficacy.

Characteristics of effective nudgingmeasured

We summarized the resultsof included studies in Table IV. The characteristics of effective nudging interventions (n=38) are presented in Table V.

Notable patterns for the effective interventions showing a statistically significant change in outcomes due to nudging were observed under various conditions. Studies using reminders as a nudge intervention to improve medication adherence, HbA1C control, and increase frequency of foot check were effective across all delivery modes. Reminders delivered through a device were successful in increasing a patient's level of physical activity, improving medication adherence and HbA1C controls. Studies using social modelling delivered through group meeting sessions were effective in modifying patient's diet, level of physical activity, self-efficacy and HbA1C control. The two studies using gamification were effective in increasing the patient's physical activity levels. All five studies using social influence delivered through group meeting session were effective in increasing patient's self-efficacy. Methods that were found to be effective also included framing text messages [29], mobile game applications [40], the use of pedometers [27] and group meetings [57]. These methods were used in various aspects of diabetes management including, but not limited to – healthy diet (framing text message), improving HbA1C control (mobile game application), and improving the patient's quality of life (pedometer).

Patterns were also observed for the studies reporting ineffective intervention. Framing was ineffective in changing the levels of physical activity inpatients with diabetes. Framing delivered through one-on-one counseling and social modelling

delivered through video screening was also ineffective in changing patient's health behaviours. Reminders via text were ineffective in increasing self-efficacy and frequency of blood glucose monitoring [30]. Alert sent through a device to remind patients to eat fewer calories were ineffective [39]. Group meeting has failed to increase medication adherence [52,58] in patients, and social influence was ineffective when delivered through a mobile application [49].

Under the social influence nudge element, there were inconsistent results for studies investigating the use of text or email to modify medication adherence and for studies investigating the use of group meeting to modify diet, physical activity and HbA1c.

Discussion

We performed a comprehensive review of English studies that employed nudges strategies to modify the health behaviour of patients with diabetes. This review identified two possible factors that affect the effectiveness of the nudge intervention, the delivery mode of a nudge intervention and the patients' characteristics. A recent study published by Mollenkamp et al. revealed similar findings as our systematic review. However, our systematic review encompassed more sensitive keywords specific for diabetes and therefore, we included 38 articles for review, which is more than Mollenkamp et al which included 26 articles [63]. Furthermore, we also explored the effect of delivery mode on the effectiveness of the nudge intervention, which may provide greater insight for future implementation.

The delivery mode of a nudge intervention has an impact on changing patients' behaviour. For example, in social modelling, interventions delivered through group meeting sessions [44-46] reported change in patients behaviour while those delivered by video screening [42,43] reported non-significant change. Given the similarities in study design and patient characteristics, the mode of delivering nudges in social modelling might have played an important role in determining its effectiveness. For other nudge interventions, the number of studies was insufficient

to determine the relationship between the delivery mode and the effectiveness on changing health behavor. Hence, further studies are warranted to validate the effect of delivery modes on the health behavioural change of the other forms of nudge interventions.

Patient characteristics such as country of residence and baseline self-efficacy may contribute to the conflicting results reported. Mahdizaeh et al.2013 [55] and Yang et al.2015 [58], which used social influence via group meeting sessions as a nudge intervention in Iran and Taiwan respectively, reported a significant difference in health behaviour between intervention group and control group. However, studies with similar delivery modes and nudge interventions conducted in the United States such as Rickheim et al.2002 [61], Tang et al. 2012 *[52]* and Samuel-Hodge et al.2009 [51] reported non-significant difference in health behaviour between intervention group and control group. The country in which intervention was carried out may have different culture, resulting in the difference in patients' responses to the intervention.Therefore, nudge intervention should also take into account potential cultural influence.

The baseline self-efficacy, conscientiousness and consideration of their future consequences may also affect the extent of health behavioural change. In the study by Louch et al.2013 [47], nudging through social influence was found to be more effective in improving patients' adherence to insulin injections for patients with low conscientiousness or low consideration of consequences. For patients with higher baseline of self-efficacy or conscientiousness, they may already be more adherent to the treatment. Therefore, behavioural change interventionsmay not have a significant impact on these patients who are already proficient in self-management.

The outcomes measured across all studies are heterogeneous. Some studies measured the effectiveness with HbA1C readings while others conducted pre-post intervention survey to measure the change in diet, level of physical activity and adherence to medication. Even though HbA1C is a more objective measurement which we can use to compare across studies, it does not show the efficacy on

individual health behaviours. Even when there is no significant change in individual health behaviour, there may be change in HbA1C due to other factors. This can be observed in Samuel-Hodge et al. 2009 [51] which reported effective reduction in HbA1C level despite non-significant change in patient's dietary habits and level of physical activity. The heterogeneity in the questionnaire used may also increase the difficulty in comparing the effectiveness of the intervention across studies [64].

The study design and methodologymay affect the extent of change in patients' health behaviour. Several studies reported changes in patients' health behaviour of identical nudge interventions drew differing conclusions. These studies focused on similar behavioural health outcomes, and the nudge interventions were delivered via similar modes. In studies without a control group such as Nundy et al.2014 [31] and Tang et al. 2012 [52], significant changes in health behaviour were observed within the intervention group. Nundy et al.2014 [31] reported improvement in dietary habits and increased level of physical activity. However, other studies [30,39,51,58] with a similar delivery mode and targeted behaviour outcome reported otherwise. In the absence of a control group, we are unable to eliminate the possibility that the improvement in health behaviour could be attributed to usual care. For example, in a study by Dobson et al. 2018 [30], patients in the control group showed a significant improvement in their diet and physical activity even though they were only receiving standard diabetic care.

This study is not without limitations. Most of the included studies did not explicitly define the interventions as a nudge. These papers used terms that correspond to the strategy adopted, such as framing, reminders and modelling. As such, we based our definition of nudges on preexisting frameworks [20,24] on nudging during the screening phase to pick out the relevant studies. To ensure that a wide range of publications on nudges was captured, we included many additional keywords such as encourage, motivate and persuade in our search terms, resulting in less concise searches. However, this was necessary as we speculated that there would be few publications on nudge interventions in patients with diabetes due to nudge being a

new intervention defined only in 2008 by Thaler and Sustein [10]. Hence, we decided to expand our search to capture as many relevant studies as possible. Next, as the outcomes measured across all studies are heterogenous, a meta-analysis is not possible. Finally, 16 out of 38 of our studies included were rated as high risk of bias. This is primarily due to high attrition rate and also selection bias, which is similar to the paper by Mollenkamp et al whereby most of their studies were at high risk of bias due to lack of blinding [63]. Although the impact of such bias is unclear upon implementation of such nudge intervention,we expect that attrition and selection bias will remain and the findings will largely be applicable in the real-life setting [65].

Conclusions

We assembled a list of nudge interventions: framing, reminders, gamification, social modelling and social influence. Reminders were effective in improving medication adherence in patients. Social modelling was more effective when delivered through group meeting sessions. Gamification was effective in changing the physical activity of patients with diabetes. When considering the relationship between the contexts in which the intervention applied and the effectiveness of the intervention, we identified two possible factors (delivery mode and patient characteristics) that may affect the effectiveness. Future studies can test the effectiveness of different nudge strategy within the same context. This can be done by testing different nudge strategy on the same group at a different time frame to and measure the effectiveness. Studies can also look into the effect of patient characteristic on the effectiveness of the nudge intervention. This can be done by stratifying groups into their gender, age, ethnicity and religion.

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Figure Legend:

Figure 1 : Flow chart of intervention studies included and excluded from the study

Appendix supplementary material

Supplementary materials (Tables S1 to S4) associated with this article can be found at

http://www.scincedirect.com at doi . . .