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Could nudges reduce health literacy disparities in CVD prevention? An experiment using alternative messages for CVD risk assessment screening

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ABSTRACT

Objective: To explore the effect of SMS nudge messages amongst people with varying health literacy on their intention to get a Heart Health Check.

Methods: A 3 (Initial SMS: scarcity, regret, or control nudge) x 2 (Reminder SMS: social norm or control nudge) factorial design was used in a hypothetical online experiment. 705 participants eligible for Heart Health Checks were recruited. Outcomes included intention to attend a Heart Health Check and psychological responses. *Results*: In the control condition, people with lower health literacy had lower behavioural intentions compared to

those with higher health literacy (p = .011). Scarcity and regret nudges closed this gap, resulting in similar intention levels for lower and higher health literacy. There was no interactive effect of the reminder nudge and health literacy (p = .724).

Conclusion: Scarcity and regret nudge messages closed the health literacy gap in behavioural intentions compared to a control message, while a reminder nudge had limited additional benefit. Health literacy should be considered in behavioural intervention evaluations to ensure health equity is addressed.

Practice implications: Results informed a national screening program using a universal precautions approach, where messages with higher engagement for lower health literacy groups were used in clinical practice.

1. Introduction

Poor health literacy is associated with worse health outcomes, including higher rates of cardiovascular disease (CVD). This includes increased risk factors, less engagement with prevention, and worse disease and mortality outcomes [1]. Health literacy encompasses cognitive and social skills associated with the ability to access, understand, and act on health information [2,3]. We can support the health literacy needs of the community by improving the health literacy responsiveness of services and systems, as well as increasing individual skills [4]. One approach to this issue is "universal precautions", using interventions that meet the needs of groups with lower health literacy for the whole population [5]. Public health efforts in CVD prevention must meet the varying health literacy needs of the target population. Nudges, and *choice architecture* more broadly, could potentially be used to avoid increasing inequity in CVD outcomes.

Nudges have been effective in encouraging more favourable decisions in consumers with lower socioeconomic status, financial literacy and numeracy in areas where specific skills are relevant (e.g., numeracy skills in COVID-19 health decisions) [6]. In nutrition, nudges have demonstrated equalising health inequity between advantaged and disadvantaged groups [7], as well as increasing inequity [8]. These examples suggest the potential applicability in the broader health literacy space. Behavioural economists define nudging as changing the choice architecture, which involves making the desired behaviour easier to choose, without taking away choice [9,10]. There are numerous applications of behavioural economics in improving cardiovascular health behaviours and outcomes, such as increasing physical activity, medication adherence, lipid level and hypertension control [11]. There are different types of nudges that can be used in different situations [12,13]. Although nudges have been criticised as having variable and small effects compared to regulatory approaches [14,15], the concept of a cheap

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Received 25 September 2023; Received in revised form 23 January 2024; Accepted 3 February 2024 Available online 12 February 2024 0738-3991/Crown Copyright © 2024 Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/). and scalable change to the framing of a choice has potential to make a difference at a population level.

Within the nudge literature, several strategies have shown promise in health behaviour contexts. This paper will focus on nudges based on the concepts of scarcity, anticipated regret, social norms, and reminders given prior evidence in the context of health screening [16]. Scarcity nudges work on the assumption that there is more value placed on something that is more difficult to acquire (e.g., "limited spaces available") and have been reported to be the most commonly investigated type of digital nudge [12]. Anticipated regret nudges (sometimes described as "loss aversion") draw on the tendency to overestimate the amount of regret you will experience when making a decision [17]. Medication adherence in patients with CVD and acute coronary syndrome has been improved with anticipated regret nudges in combination with other nudges (small rewards, status quo bias/inertia) [18,19]. Social nudges, which guide the individual's behaviour by providing references to others' behaviour (e.g., "not smoking has become the new social norm over the past 20 years" [17]), thus creating a social norm [13], have shown effectiveness in the context of increasing physical activity [20]. Reminders are another category of nudges, which may work to overcome procrastination or forgetfulness [13]. Text (or short message system; SMS) reminders have demonstrated effectiveness in increasing COVID-19 vaccine follow-up vaccinations [21], slight decreases in non-attendance at appointments by patients with substance use disorders [22], increased attendance at eye examinations [23], and increased participation in cancer screening programs [16,24]. Patients in emergency care settings also view text messages as an accessible, acceptable and preferred way of receiving healthcare reminders [25].

Nudging interventions have demonstrated promise in a variety of healthcare contexts, including CVD, and may be an effective way to increase the response to invitations to attend a Heart Health Check in general practice. Similarly, interventions specific to health literacy levels have demonstrated improvements in behaviour and health outcomes [26]. The relationship between different types of nudges and different levels of health literacy is unknown, and exploring how health literacy interacts with nudges could support the development of health literacy-responsive interventions.

1.1. Aim

This study aimed to test different SMS messages inviting patients for a Heart Health Check with their GP. We also assessed how health literacy moderated these effects, to inform an Australian CVD risk screening program. Specifically, we tested a control message used in a previous trial [27] against different types of nudges: the initial message used the concepts of *scarcity* or *anticipated regret*; and the reminder message used the *social norm* concept. We hypothesized that nudges would increase behavioural intentions for all participants but especially for people with lower health literacy. We also sought to explore the effects of these nudges on psychological outcomes.

2. Methods

2.1. Participants

A national sample was recruited via a web-based social research agency that used stratified sampling based on age and gender (5-year age groups from 45 to 74). 705 Australians were initially recruited. Participants were eligible if they were in the target age for CVD risk assessment (45–74 years), had no history of CVD, and had not had a cholesterol check in the last two years. Quota sampling was used to ensure diversity in education levels (50% had no university level of education). 546 participants completed follow-up (22.5% loss from initial SMS) with a mean age of 59.6 (SD=8.61), 50% female, and a majority with high health literacy (87.7%).

2.2. Design

A 3 \times 2 factorial online experiment design was used to explore this study's aims (see Fig. 1). As there was limited literature on which to base the order of nudges, authors started with the nudges that have shown some efficacy in other screening programs, and included an additional type of nudge in case it was effective amongst those who didn't respond to the first type. Participants were randomised via the online Qualtrics survey software to view one of three messages embedded within the survey (Initial SMS): scarcity, regret, or control. After two weeks (Reminder SMS), they were randomised to view one of two messages: social norm or control. Outcomes were measured online immediately after participants viewed each message (see Table 1). Data collection occurred during March 2022. The study received ethics approval from the Human Research Ethics Committee of the University of Sydney (Project number 2022/062).

2.3. Measures

Health literacy was measured with the single item Health Literacy Screener by Chew et al. [28], where higher health literacy was defined as 4–5 and lower health literacy was defined as 1–3 out of 5 in answer to the question "How confident are you with filling out medical forms by yourself?". The primary outcome was intention to attend a Heart Health Check in the next two weeks. Table 2 summarises this intention outcome and the four psychological outcomes measured: perceived message credibility, personal relevance, and emotional response. The emotional response measure was derived from a previous study [29] and all other measures were adapted from a previous study [26]. Mean scores were created by averaging responses to items for message credibility, personal relevance, positive emotional responses, and negative emotional responses respectively and were treated as scales, whereas intention was treated as an individual measure. Higher scores indicated higher levels of the outcome being measured.

2.4. Statistical analysis

Randomisation was balanced based on age and gender as they are key CVD risk factors. Statistical analyses were conducted in IBM SPSS Version 28. Likert scales were treated as continuous variables. Separate exploratory multiple regression models for the Initial SMS conditions were fitted with condition, age, gender, health literacy and condition \times health literacy as explanatory variables for each outcome: intention, credibility, personal relevance, and positive and negative emotional responses. Reminder SMS models were similarly fitted to assess the impact of the reminder on identified outcomes. These models were fitted with the Initial SMS condition outcome variable to control for initial responses, and a three-way interaction term (lower order interactions included) of Initial SMS and Reminder SMS conditions, and health literacy to test the specific effect of the conditions. Model checks of regression models did not reveal any violation of assumptions, and an alpha level of 0.05 was used. Supplemental material provides SPSS output for each regression model.

3. Results

Table 3 provides descriptives statistics for explanatory and outcome variables by condition. Chi-squared tests and one-way ANOVA models indicated no statistically significant differences in age, gender and health literacy between conditions at Initial SMS suggesting randomisation worked well and provided no evidence of issues with the robustness of the randomisation. Similarly, no differences were found at Reminder SMS suggesting that loss to follow-up was similar in terms of these characteristics between conditions. Table 4 provides model fit and significance results for interaction terms at Initial SMS (initial condition \times health literacy) and Reminder SMS (initial condition \times reminder



Fig. 1. 3×2 factorial study design.

Table 1

Initial SMS and reminder SMS content.

Condition	Message
Initial Control	Hi, your doctor at Smith Clinic would like to see you for a short Heart Health Check. Your age and other factors may raise your chance of a heart attack or stroke . Please call 13 11 12 to book. Click here for more information or raphy STOP to ext out
Initial Scarcity	Hi, your doctor at Smith Clinic has allocated time for you to attend a short Heart Health Check in the next 2 weeks. Please call 13 11 12 to book. Click here for more information or reply STOP to opt out.
Initial Regret	Hi, your doctor at Smith Clinic would like to see you for a short Heart Health Check. If you got heart disease, would you regret not making an appointment? Please call 13 11 12 to book. Click here for more information or reply STOP to opt out.
Reminder Control	Seeing your GP for a regular Heart Health Check can help to prevent heart disease, including heart attack and stroke. Please call 13 11 12 to confirm your appointment. Click here for more information or reply STOP to opt out.
Reminder Social Norm	Over 80,000 Australians saw their GP to have a Heart Health Check in the last year to help prevent their risk of having a heart attack and stroke. Please call 13 11 12 to confirm your appointment. Click here for more information or reply STOP to opt out.

condition \times health literacy) for each outcome (see Appendix 1 for full model parameter estimates).

There was evidence for an interaction effect of health literacy and Initial SMS on intention to get a Heart Health Check within the next two weeks (p = .011, see Fig. 2). Participants with lower health literacy, compared to those with higher health literacy, rated their intentions lower in the control SMS condition. Lower and higher health literacy participants were similar in Initial SMS Scarcity and Initial SMS Regret conditions. There was also evidence for an interaction effect of health literacy and Initial SMS on negative emotions (p = .038, see Fig. 2). Participants with lower compared to higher health literacy, had higher levels of negative emotion in the regret condition and were relatively similar in the scarcity and control condition. There were no other significant interactive effects between Initial SMS condition and health literacy. There were also no significant interactive effects at Reminder SMS.

4. Discussion

4.1. Key findings

This study suggests that health literacy is an important variable to

Note: Bolded sentences highlight the differences between conditions.

Table 2

Measures used in the questionnaire after participants viewed initial SMS and reminder SMS messages.

Initial Reminder SMS SMS	
Intention	
Imagine you received this 7-point scale from - text message from your strongly disagree to doctor this morning. How strongly agree	
likely would you be to contact them about a Heart Health Check in the next 2	
weeks?	
Perceived Message Credibility	
How well do the following 7-point scale from .95 .96 adjectives describe the Describes very poorly to message you just read? Describes very well	
a. accurate b. authentic	
c. believable	
Personal Relevance	
I found the message was 7-point scale from .91 .90	
I felt that the message was strongly disagree to	
relevant to me	
I felt that the message was	
designed specifically for me	
Positive and Negative Emotional	
Responses	
The message made me feel: 11-point scale from .97 .97	
a. hopeful None of this feeling to A	
b. optimistic lot of this feeling	
c. enthusiastic	
d. afraid .97 .97	
e. anxious	
f. worried	
Social norms Most people my age would 7 point coole from	
book a Heart Health Check strongly disagree to	
after seeing this message strongly agree	

consider when planning behaviour change interventions. For the Initial SMS conditions, there was a statistically significant difference in intention to get a Heart Health Check for the control message between individuals with high and lower health literacy. Using the 'scarcity' or 'regret' messages appeared to eliminate this gap by increasing engagement in the lower health literacy group, suggesting that these nudges can potentially reduce the gap between groups with high and lower health literacy. There was also a statistically significant effect of health literacy and type of message on negative emotions, for the initial SMS. Based on each group mean, individuals with lower health literacy reported higher levels of a negative emotion to 'regret' themed messages than individuals with a higher health literacy, a reaction not reported for either the scarcity or control themed messages. The effect of follow-up reminders did not appear to provide any additional benefit in this hypothesised scenario.

4.2. Comparison to previous literature

Current findings are consistent with previous literature around the favourable effectiveness of anticipated regret nudges in improving medication adherence [18,19]. The effective of scarcity nudges is consistent with research suggesting humans have an increased desirability for goods that may be scarce [30]. While the prevailing literature suggests reminders may provide incremental effectiveness [16,21-24], this was not the case in the current study, with the observed trends towards a potential negative impact on intention among individuals with higher health literacy. There is some evidence from the context of charity donations that highlights a potential negative impact of reminders: the more frequent an email reminder for donations, the more likely donors were to unsubscribe [31], and this is worthwhile considering in the context of health behaviours. This present inconsistency with previous literature in health behaviours could be due to the current study's hypothetical design, the layering of multiple nudges or even perhaps the length of time between initial and reminder SMS. The effect of SMS reminders will be explored further in a general practice trial.

Previous literature has demonstrated individuals with lower health literacy tend to have higher mortality rates than those with higher health literacy [1]. However, the relationships of health literacy with

Table 3

Group sample statistics at Initial SMS and Reminder SMS questionnaires, per condition.

	Initial SMS				Reminder SMS		
Variable	Scarcity Condition (n = 235)	Regret Condition (n = 235)	Control Condition (n = 235)	Total (<i>n</i> =705)	Social Norm Condition (<i>n</i> =272)	Regret Condition (<i>n</i> =274)	Total (<i>n</i> =546)
Gender (Count, %)							
Male	122 (51.9)	122 (51.9)	109 (46.4)	353 (50.1)	135 (49.6)	138 (50.4)	273 (50.0)
Female	113 (48.1)	113 (48.1)	126 (53.6)	352 (49.9)	137 (50.4)	136 (49.6)	273 (50.0)
Non-binary/Gender Fluid/Other	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Health Literacy (Count, %)							
Low	34 (14.5)	30 (12.8)	30 (12.8)	94 (13.3)	32 (11.8)	35 (12.8)	67 (12.3)
High	201 (85.5)	205 (87.2)	205 (87.2)	611 (86.7)	240 (88.2)	239 (87.2)	479 (87.7)
Age in years (Mean, SD)	59.6 (8.93)	59.0 (8.40)	58.8 (8.43)	59.1	59.6 (8.72)	59.7 (8.53)	59.6
				(8.59)			(8.62)
Intention to get a Heart Health Check within next 2 weeks, Range 1 to 7 (Mean, SD)	4.9 (2.09)	4.7 (2.01)	5.0 (2.02)	4.9 (2.02)	4.2 (2.01)	4.6 (1.99)	4.4 (2.01)
Credibility Score, Range 1 to 7 (Mean, SD)	5.1 (1.44)	4.7 (1.65)	5.1 (1.54)	5.0 (1.555)	4.8 (1.58)	4.9 (1.59)	4.9 (1.58)
Relevance Score, Range 1 to 7 (Mean, SD)	4.0 (1.63)	3.9 (1.62)	4.2 (1.58)	4.0 (1.61)	3.6 (1.55)	3.8 (1.58)	3.7 (1.57)
Positive Emotion Score ^a , Range 1 to 11 (Mean, SD)	5.6 (2.95)	5.2 (2.85)	5.5 (2.83)	5.5 (2.88)	5.4 (2.95)	5.6 (2.86)	5.5 (2.92)
Negative Emotion Score ^b , Range 1 to 11 (Mean, SD)	4.9 (2.92)	4.9 (3.00)	5.4 (2.97)	5.1 (2.97)	4.83 (2.91)	5.0 (2.89)	4.9 (2.90)

^a Positive Emotion Score sample sizes due to missing data for Initial SMS conditions were: Scarcity (n=233), Regret (n=234), and Control (n=234), and for Regret SMS conditions were Social Norm (n=270) and Control (n=274).

^b Negative Emotion Score sample sizes due to missing data for Initial SMS conditions were: Scarcity (*n*=233), Regret (*n*=235), and Control (*n*=235), and for Regret SMS conditions were Social Norm (*n*=270) and Control (*n*=274).

Table 4

Model fit, F-statistics and p-values main experiment effects and health literacy (HL) interactions at first and second questionnaires for each outcome (see supplemental materials for parameter estimates and additional information).

	Initial SMS literacy (Fir Questionnai	× Health st re)	Initial SMS × Reminder SMS × Health literacy (Second Questionnaire)	
Outcome	<i>F</i> (df)	р	F (df)	р
Intention to get HCC within next two weeks (, F ₂₆₉₇ =4.580)	(R ² =.049)		$(R^2 = .488)$	
Condition/s and HL Interaction	4.580 (2697)	.011 *	0.323 (2531)	.724
Initial SMS	1.804 (2697)	.165	-	-
Health Literacy	3.167 (1697)	.076	4.977 (1531)	.026 *
Initial SMS \times Reminder SMS	-	-	0.572 (2531)	.565
Credibility	(R ² =.046)		$(R^2 = .358)$	
Condition and HL Interaction	2.314 (2697)	.100	0.445 (2531)	.641
Initial SMS	0.522 (2697)	.594	-	-
Health Literacy	4.804 (2697)	.029 *	0.026 (1531)	.873
Initial SMS × Reminder SMS	-	-	1.536 (2531	.216
Personal Relevance	(R ² =.016)		(R ² =.479)	
Condition and HL Interaction	1.237 (2697)	.291	0.177 (2531)	.838
Initial SMS	0.262 (2697)	.770	-	-
Health Literacy	0.063 (1697)	.802	4.407 (1531)	.036 *
Initial SMS × Reminder SMS	-	-	0.350 (2, 351)	.705
Positive Emotion	(R ² =.009)		(R ² =.491)	
Condition and HL Interaction	1.320 (2693)	.268	0.341 (2529)	.711
Initial SMS	(2693)	.279	-	-
Health Literacy	0.025 (1693)	.874	0.272 (1529)	.602
Initial SMS × Reminder SMS	- (P ²	-	(2529)	.877
	(R ⁻ =.039)	000 *	(R ⁻ =.427)	-
Condition and HL Interaction	(2693)	.038 ^	0.303 (2529)	./39
Initial SMS	0.278 (2693)	.758	-	-
Health Literacy	3.729 (1693)	.054	0.658 (1529)	.417
Initial SMS \times Reminder SMS	-	-	1.728 (2529)	.179

* *p* < .05.

intermediate health outcomes (clinical, behavioural, emotional, perceptual) do not demonstrate expected relationships in a consistent manner (e.g. increasing favourable behaviours, emotions, or perceptions does not always lead to better health outcomes) [32]. This may be because of treating truly mediating variables as confounders or vice versa based on theoretical understandings and statistical applications [32]. Emotions for example play an important role in decision making and much of this research is conducted outside of health, however research is accumulating within the health context [33]. In this context, the affective state most likely to be investigated is stress [34]. Fear messaging has a long history in public health, and has been used in domains such as tobacco and HIV/AIDs prevention to change

behaviours, which varying levels of efficacy [35]. This study highlighted that those with lower health literacy (compared to higher health literacy) had more negative emotional responses in the regret condition, compared to scarcity and control. These individuals may either engage or disengage in preferred health behaviour depending on other factors such as self-efficacy beliefs and stigmatisation [35,36]. This raises the importance of considering the negative emotions elicited by messaging in reducing health inequities, and builds on previous work exploring the mediating and moderating effect of emotions on health behaviour [37]. In the health literacy space, the current findings provide insights on the differential effects of types of nudges. The impact of nudges may be further moderated by levels of health literacy, an area that would benefit from further research.

4.3. Practice implications of current findings

The relationship between behaviour and intention is an important aspect to consider in the context of practice implications. Reviews based on the theory of planned behaviour have demonstrated that intention is a major predictor of behaviour across a wide range of issues, however, a behaviour-intention gap remains [38,39]. Addressing different health literacy levels via tailored messaging could be of benefit, but this would be difficult to implement practically within general practice for the Heart Health Check screening program. A more pragmatic approach may be to select the type of message by geographical area based on proxy demographic measures, such as education or socio-demographic status. For example, the message could be chosen based on the patient catchment of the general practice (e.g. selecting between low or high health literacy messages depending on average education level). A simpler approach would be to prioritise the message that benefits those with lower health literacy regardless of whole population characteristics. This "universal precautions" approach is being tested further in a larger scale randomised controlled trial, aiming to increase the uptake of Heart Health Checks in Australian general practice after a pilot showed that the SMS approach to screening was feasible and acceptable [27].

4.4. Limitations

These models only account for very small proportion of the explained variance in each outcome (Reminder SMS models explain more variance because of baseline outcome information), though, nudges are relatively low-effort and low-cost to support scalability [14,15]. Objective behaviour was also not measured in this study, however it has been measured in a related trial following this experiment, which also demonstrated that SMS recall can lead to a 14-fold increase in attendance for heart health check at a general practice level [27]. The lower health literacy groups in this study were small compared to the higher health literacy groups, reducing power. We also used a simple measure of health literacy that may be less sensitive in detecting lower health literacy than objective skills-based measures. Intention was also measured with a single-item and subject to the same limitations as the health literacy measure. This suggests follow-up research may be worthwhile to explore further differences that this study may have not been able to detect. For example, for the Reminder SMSs, those with lower health literacy reported higher intentions in control compared to social norm nudges irrespective of Initial SMS condition, suggesting reminder social norm message could potentially have an unfavourable impact on intention. Similarly, control conditions often scored lower compared to other conditions across outcomes for individuals with lower health literacy, and while not always significant, the trend overall suggests a 'business per usual' approach could continue to contribute to health inequities. Social norm messages also seem to have an equalising effect on negative emotions when they have been raised by a scarcity nudge (see Supplemental Fig. 1). Moreover, as the control condition was active, it is not a control in the purist sense, therefore it is just as feasible that the effects of the control condition increase the gaps between low



Fig. 2. Group means per Initial SMS condition by Health Literacy for intention, credibility, personal relevance, positive emotion, and negative emotion scores with 95% confidence intervals (*interaction effect p < 0.05).

and high health literacy. In the context of this study however, the active control was considered a valid comparator given previous research around nudges in this space [24,40,41]. For the significant effects observed in this paper, the clinical relevance remains unclear and would benefit from additional follow-up on health outcomes given the inconsistency of effects between intermediary outcomes (such as intention) and patient health outcomes [32].

4.5. Conclusion

This study shows that CVD screening programs using SMS messages may benefit from using nudge approaches to reduce health literacy disparities. More broadly, this research highlights the importance of considering health literacy differences in behaviour change interventions to avoid increasing inequity in cardiovascular disease outcomes.

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CRediT authorship contribution statement

Knight Joshua: Writing – review & editing, Methodology, Formal analysis, Conceptualization. McKinn Shannon: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. Ayre Julie: Writing – review & editing, Methodology, Conceptualization. Batcup Carys: Writing – review & editing, Methodology, Data curation, Conceptualization. Bonner Carissa: Writing – review & editing, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. Nelson Adam James: Writing – review & editing, Conceptualization. Brims Kerryn: Writing – review & editing, Methodology, Funding acquisition, Data curation, Conceptualization. Raffoul Natalie: Writing – review & editing, Methodology, Funding acquisition, Data curation, Conceptualization. Fajardo Michael Anothny: Writing – review & editing, Writing – original draft, Formal analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.pec.2024.108192.

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