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A quasi-experimental study

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In-hospital nudging intervention increases patients' healthy dietary choices: a quasi-experimental study

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ABSTRACT

Aims Most hospitals still lag behind in their policies to stimulate healthier dietary choices by their patients. This study investigates whether a multicomponent nudging intervention, designed to prompt healthy food choices, can influence dietary choices of hospitalised patients.

Methods This pre-postintervention study included a baseline phase and an intervention phase (7+7 months) and was carried out at the cardiology ward of a large hospital. All 2419 cardiac patients admitted to the ward during this period, and their 7559 meals were part of this study. The nudging intervention consisted of choice architecture, visual cues and informational nudges (eg, traffic light menus, posters). Data on dietary choices (vegetarian, fish, meat, side salad and fruit salad) were collected from the electronic food ordering system. As a secondary outcome, the intention to eat healthy after discharge was measured using the 20-item long Dutch Dietary Intention Evaluation Tool.

Results During the intervention period, there was a statistically significant increase in the selection of vegetarian meals (20.1% vs 16.3%, p<0.001), fish meals (24.6% vs 18.7%, p<0.001), side salads (54.5% vs 49.5%, p<0.001) and fruit salads (12.8% vs 8.6%, p<0.001) when compared with the baseline period. In addition, patients in the intervention period expressed a significantly higher intention to eat healthy after discharge compared with the baseline period (β=0.167, SE=0.083, p=0.045).

Conclusion This study demonstrates that a straightforward, easily implementable nudging intervention effectively promotes healthy dietary choices among in-hospital cardiac patients and enhances their intention to eat healthy after discharge.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Diet is a cornerstone of cardiovascular disease treatment and prevention.
⇒ Hospitals can play a role in facilitating and stimulating healthier diets in their patients.
⇒ Nudging is an effective technique to influence dietary behaviour.

WHAT THIS STUDY ADDS

⇒ We designed an easily transferable nudging intervention that stimulated healthier dietary choices among cardiac patients.
⇒ Patients started opting for more vegetarian and fish meals, along with salads and fruit.
⇒ They also expressed a stronger desire to continue eating healthier after leaving the hospital.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Hospitals and other healthcare facilities can (and should) adopt nudging strategies to encourage healthier eating.

INTRODUCTION

Cardiovascular disease (CVD) remains the most common cause of death in Europe.[1] Annually, more than 60 million potential years of life are lost to CVD in Europe.[1] In 2017, CVD was estimated to cost the European Union (EU) economy €210 billion a year.[2] A healthy diet is a cornerstone of CVD treatment and prevention.[3] Adopting healthier diets could reduce CVD incidence by as much as 30%.[4] This effect is mainly accomplished through reduction of CVD risk factors such as hyperlipidaemia, hypertension, increased body weight and diabetes mellitus.[5] Therefore, healthy diets have the potential to reduce individual disease burden and to curb the rising societal costs of healthcare. To facilitate healthier eating, healthy heart-specific eating guidelines have been established.[3] Sadly, the adoption of the general population to these guidelines is very low.[6–8] For example, in 2019, in the EU, only one in eight people reported to consume the recommended amount (five portions) of fruit and vegetables.[6]

The meagre adherence to dietary guidelines can be partly explained by our environment, which influences our dietary choices to a great extent.[9] The increasing overabundance of cheap, highly processed, convenient, energy-dense and nutrient-poor foods and drinks contributes to adverse dietary

choices.[10] Strategically influencing decisions through changes in the setting or environment are called 'choice architecture'.[9] These influences can be overt (eg, a big sign of 'Healthy option' in supermarket) or more subtle (eg, placing healthy options at eye level). The more subtle changes are also known as 'nudges'.[11–14] A meta-analysis showed that choice architecture is especially effective in influencing dietary choices.[15]

Although stimulating healthy lifestyle behaviour is especially relevant in healthcare, many hospitals fail to implement adequate strategies to accomplish this goal. An independent report of the NHS Hospital Food service in England in 2020 revealed that examples of harmful dietary policies prevailed (eg, low nutrient foods, many additives used, no fresh meals).[16] Furthermore, it was found that a considerable amount of patients as well as staff considered hospital food quality to be 'poor'. This is a missed opportunity, as hospitals can influence the health of patients, visitors and employees, for example, by using choice architecture.[17 18] As such, healthy nutrition has the potential to reduce recovery times, improve patient outcomes and reduce costs.[16] Therefore, the NHS has been called on to provide healthy food to patients during their time in hospital.[16]

Fortunately, also, some good examples of healthy hospital dietary policies exist. A number of hospitals have completely switched to plant-based meal services.[19] Changing the contents of menus in a larger organisation oftentimes takes mandate, money and time. Nevertheless, smaller, cheaper and easier interventions, such as nudges, are also used effectively.[20] However, to our knowledge, no studies have examined the effect of nudging on dietary choices of patients admitted to the hospital ward yet. In general, priming and changing ease of option (such as a healthy default option) have been shown to be effective nudging techniques.[15 21 22] The primary objective of this study was to examine how a multicomponent nudging intervention influences the dietary choices of patients throughout their hospitalisation. Additionally, we aimed to assess the patients' intention to adopt healthier eating habits after being discharged.

METHODS

Design, setting and participants

This quasi-experimental study with a pre-postdesign was conducted at the Cardiology ward of the Leiden University Medical Center (LUMC) in the Netherlands between July 2020 and January 2022. All 2419 patients admitted to the cardiology ward of the LUMC who had ordered at least one evening meal were part of this study.

The study had two phases: a 7-month baseline phase (from 1 July 2020 to 31 January 2021) and a 7-month intervention phase (from 1 July to 31 January 2022) (figure 1). During the baseline phase, the traditional standard menu was in place to guide the patients' choice, and a service cart was used to distribute meals on the ward. No additional information or instruction was given to patients. No nudge intervention was performed at this stage. The informed consent described a 'food study' and did not reveal that it was about healthy diets specifically. As usual, meal orders were taken by food assistants using the standard LUMC electronic meal ordering system.

Materials

Intervention

In the intervention set-up phase, a multicomponent nudging intervention was implemented in the meal services at the cardiology ward of the LUMC. Combining proven nudging principles including rearrangement of menu charts and default options,[15 21] traffic light labelling[20 22 23] and informative nudges and reminders,[21 24] we developed a novel multicomponent dietary choice intervention. The intervention consisted of four components:

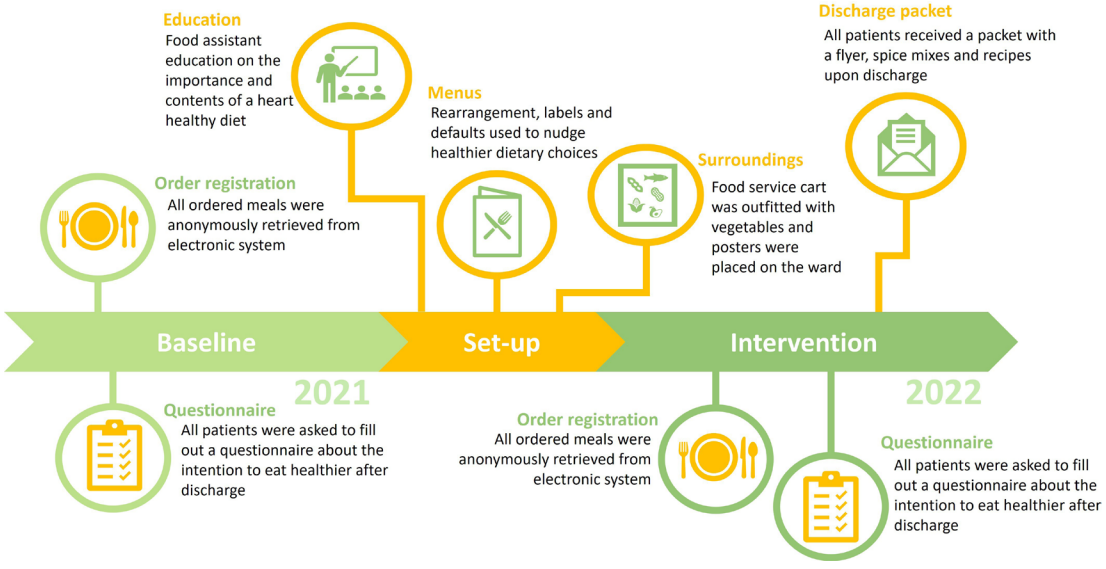

Figure 1 Overview of the study design showing the baseline, set-up and intervention phase, including the data collection methods and the four components (orange circles) of our intervention.

Table 1 Nudging techniques used in the multicomponent intervention based on the MINDSPACE framework

Nudge	Interventional component	Elaboration
Messenger	Discharge package Menu	A picture of a cardiologist with the quote: 'healthy diet is an essential part of your treatment'. The phrase: 'we find it important that you eat healthy'. 'We' refers to the Cardiology ward/hospital.
Incentive	Environment Menu Discharge package	All three components focused on delivering the message: 'eat yourself fit'. Included: 'a healthy diet will make you feel fitter and help you recover faster after illness'.
Norms	Discharge package	A cardiac patient's story who changed to a healthier diet and his advice to peers.
Default option/ changing ease of option	Menu Education food assistants Discharge package	Four healthy default evening meal variations. The dessert showed a photo and text of fruit salad and yoghurt; the unhealthier options were in smaller print without pictures. Food assistants were stimulated to help patients choose healthily. Set of two spice mixes with matching healthy and budget recipes to make the choice of a healthier meal at home easier. Included 'food swaps' where simple pictures showed food components that can easily be swapped for a healthier alternative.
Salience	Menu	Healthy options on the menu were highlighted with labels.
Priming	Menu Environment	Rearranged the lunch menu into a traffic light system. Added attractive pictures of yoghurt and fruit salad as dessert. Remove attractive pictures of unhealthy desserts. Posters and service trolley showed pictures of healthy fruits and vegetables.
Affect	Environment Discharge package	Rebranding a healthy diet to: 'eating yourself fit!' Gain-framing in the text on the flyer to associate a healthy diet with positive feelings.
Commitments	Discharge package	List of dietary advice from the Dutch Health Council (Gezondheidsraad) that can be ticked off Short set-up of a personal dietary plan for patients to commit to: 'why do I eat what I eat? How will I adjust my diet? When will I start? What is my goal?'
Ego	Menu Environment Discharge package	In all three components, labels with a heart-healthy logo and the text: 'I choose healthily!'
Informing	Menu Discharge package	Information about processed food and whole meal food on the lunch menu Advice from the Dutch Health Council, and general health behaviour change information such as 'changing behaviour takes time' or 'small changes are lasting'.
Reminder	Discharge package	The package itself was a reminder for the patients that the LUMC wants them to eat healthier.

adaptation of the menus, adaptation of the environment, providing a discharge package and providing specific education for food assistants. Below, we described the individual components and the nudging techniques used based on the MINDSPACE framework in more detail.[25] An overview of the MINDSPACE framework and the intervention components can be found in table 1. A visual overview can be found in online supplemental appendix 1.

Menus. On the dinner menu, we rearranged the options presenting four healthy meal variations on the front (figure 2, right side). Patients could also mix and match their own meal. In this menu, we highlighted the healthy components using green labels. Two dietitians and a researcher separately assessed the food options as healthy or unhealthy based on healthy eating guidelines. In case of discrepancy, the majority won. The healthy components included the vegetable options (except, eg, spinach in creme), the wholegrain carbohydrate options, the vegetarian meat replacers, the fatty fish options and the unprocessed white meat options. The healthy meal variations were comprised of these healthy options. The unhealthy options were the processed red meats, fried fish, refined carbohydrates and the meat replacers that used too much saturated fat. The green labels used on the healthy options read 'I choose responsibly' to stimulate healthier choices and to make patients feel better when they decided for the healthier option. In the dessert section, we covered the standard pictures of the unhealthier desserts with a sticker presenting a favourable picture of the healthy options, including the unhealthy desserts in small print (online supplemental figure 1. A preface in the new menu also stressed that eating healthier is a crucial part of a healthy life and that we find it important that patients eat healthy, thereby using the hospital/the doctors of the cardiology department as 'messenger'. In doing so, we employed both an incentive and a messenger perceived as authoritative to nudge patients to healthier choices. The lunch menu was redesigned into a traffic light labelling system (supplemental

Figure 2 On the left, the standard menu preface (baseline period), and on the right the new, nudging menu preface (intervention period).

figure 2), using headings 'preference' (green), 'compromise' (orange) and 'exception' (red). Also, we added information about whole grains and unprocessed foods.

Surroundings. We adapted the clinical Cardiology ward environment to prime patients into making healthier dietary choices. More specifically, we used wall posters endorsing healthy food and a restyled meal service trolley stickered with images of fruits and vegetables replacing the original plain dark blue colouring (online supplemental figure 3). We designed the posters using gain-framing and rebranded 'Eat healthy!' into 'Eat yourself fit!' to target patients' affect.

Discharge package. As a reminder for patients to eat healthy after discharge, we provided them with a discharge package containing a flyer, two sodium-free spice mixes and four healthy budget recipes (figure 3). The flyer included the messenger nudge (a cardiologist stressing the importance of a healthy diet), the incentive nudge (stating the health benefits of a healthy diet and asking the patient to formulate a goal), a norms nudge (a short paragraph from a cardiac patient on the benefits of a healthy diet), a change in ease of option (the sodium-free spice mixes and matching recipes simplify a healthy meal option at home), a commitment nudge (health counselling advice can be ticked off from a list) and informative nudges (advice from the Dutch Health Council regarding a healthy diet and information about changing health behaviour).

Education on the importance and contents of a heart-healthy diet was given to all food assistants, aimed to

Figure 3 The nudging packages given to patients on discharge. On the left, the front and back of the informational flyer; on the right, an example of a recipe which is accompanied with a sodium-free spice mix.

enable the food assistants to stimulate patients into healthier dietary choices. Food assistants take patients' menu orders on the ward. They were told the basics of a heart-healthy diet (unprocessed, varied, vegetables, fruits, legumes, whole grains), so they could answer sensibly when patients asked them. Throughout the development of the intervention, we kept in mind that the intervention should be easily transferable to other healthcare institutions. The entire intervention is nudge-based, so patients admitted to the cardiology ward of the LUMC were not instructed or advised to make healthier dietary choices.

Surveys

The 20-item long Dutch Dietary Intention Evaluation Tool (DIETI) was used to assess the healthy eating intention postdischarge (online supplemental file 2). This questionnaire has been specifically developed to assess healthy eating intentions of hospitalised patients and has been found to be reliable.[26] The DIETI is based on the Theory of Planned Behavior and consists of the following subscales: intention (four items), attitude (five items), self-efficacy (three items), subjective norm (three items) and normative referent (five items). For the intention, attitude, self-efficacy and subjective norm subscales, 7-point Likert scales were used with higher scores representing stronger intentions, more positive attitudes, higher self-efficacy and higher subjective norms. A scale of 1–10 was used for the normative referent subscale where a higher response endorsed a higher influence.

Demographic data included gender, age, reason for admittance, history of cardiac ischaemia, healthiness of current diet (single item) and number of meals consumed and were obtained from a self-report questionnaire. The healthiness of the current diet and the influence of different healthcare professionals on eating behaviour were measured using a 10-point scale.

Procedure

Type of meals ordered

All evening meals ordered by patients on the cardiology ward during the study period were retrospectively and anonymously retrieved from the standard electronic meal ordering system of the hospital. From this data set, the number of vegetarian meals, fish meals, meat meals, side salads and desserts ordered was obtained. Ordered meals were recorded into 'ordered vegetarian option (no meat, no fish, eggs allowed)' (Yes/No), 'ordered fish option' (Yes/No), 'ordered meat option' (Yes/No), 'ordered with side salad' (Yes/No), 'ordered dessert' (Yes/No), and 'if ordered dessert, ordered fruit salad without whipped cream' (Yes/No). All other dessert options were grouped as unhealthy. Due to privacy regulations, we could not link meals ordered to corresponding patients.

Inclusion of patients

We aimed to screen all patients admitted to the cardiology ward of the LUMC for eligibility to fill out our survey. Inclusion criteria were being over 18 years of age and having had at least one evening meal in the LUMC. Exclusion criteria were not having an e-mail address, already having filled out the survey before and not having adequate understanding of the Dutch language. Eligible participants were asked to fill out a single, anonymous survey consisting of the DIETI and demographic items. After verbal consent, a link with the online survey was sent to their e-mail address. Participants were asked to fill out the questionnaire after their last evening meal in the hospital; this could be done in the hospital or at home.

Data management

The Castor Electronic Data Capture system (Castor, Amsterdam) was used to send and manage the questionnaires.[27] Data cleaning was performed to identify and correct lack or excess of data. Data entry validation, statistical outlier detection, flatliner detection and fixed algorithms for logical inconsistencies were used. Examples of these algorithms are; age>100 years or a difference of > 3 between the number of breakfast, lunch or evening meals.

Data analysis

To test our primary research question, $\chi 2$ tests were used to compare the number of vegetarian meals, fish meals, meat meals, side salads and fruit salads ordered in the intervention period to the baseline period. Power analysis for the percentage of vegetarian and fish meals being ordered compared with meat meals was performed using sealed envelope, an online power calculator.[19] The analysis revealed that 6550 meals were required to have a 90% chance of detecting, as significant at the 5% level, an increase in the primary outcome measure amount of meat meals from 50% in the baseline period to 54% in the intervention period (a clinically relevant change). The final sample satisfied these requirements. As the meals ordered could not be linked to specific patients due to privacy regulations, we reviewed the outcomes of the DIETI and the ordered meals separately.

To evaluate the intention of patients to eat healthier after discharge, we completed a confirmatory factor analysis (CFA) on the intention scale of the DIETI, that is measured by four items: 'the next month, I will eat healthy/healthier on a regular basis', 'the next month, I am planning to eat healthy/healthier', 'how strong is your intention to eat healthy/healthier in the next month? (very weak–very strong)', 'of how many meals, of the 10 upcoming meals, do you have the intention to eat healthy/healthier?'. The intention score is the average of these four items. In a previous study conducted by our team, the scale with the four items was found reliable, with good psychometric properties.[26] More details can be found in the development paper in the DIETI. Subsequently, the intention scale was related using a simple structural equation model to the intervention period (Intervention group variable), by adding the group as a predictor to the intention factor measured by the four items listed above.

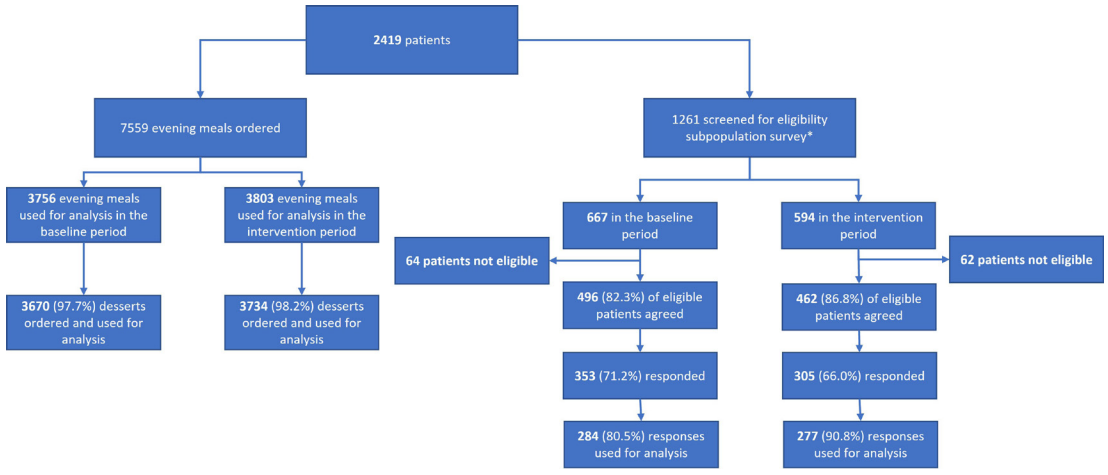

Figure 4 A flowchart of the 2419 patients admitted to the cardiology ward of the Leiden University Medical Center who had at least one evening meal between July 2020 and January 2022. The flowchart shows the number of meals (left) and the number of patients included in the survey subpopulation (right). *1158 patients not screened due to practical reasons.

RESULTS

The 2419 patients included in this study ordered a total of 7559 meals (3756 in the baseline period and 3803 in the intervention period) (figure 4). On admittance, there were no statistical differences in the amount of meals ordered by patients with a low sodium diet (p=0.082) or a vegetarian diet (p=0.755) at baseline versus intervention (table 2).

Meal choices

During the intervention period, there was a decrease in the selection of meat options (55.3% vs 65.0%). Concurrently, there was an increase in the choice of vegetarian dishes (20.1% vs 16.3%, $\chi 2$ (1, n=7559)=17.993, p<0.001) and fish dishes (24.6% vs 18.7%, $\chi 2$ (1, n=7559)=39.044, p<0.001) compared with the baseline period group (figure 5).

The quantity of vegetarian meals ordered (764 and 612 in the intervention and baseline periods, respectively) exceeded the number of meals ordered by patients strictly adhering to a vegetarian diet (242 and 221 in the intervention and baseline periods, respectively). It is also clear that relatively more side salads were ordered with meals compared with the baseline period (54.5% vs 49.5%, $\chi 2$ (1, n=7559)=19.245, p<0.001). Also, when desserts were ordered, in the intervention period, more fruit salads were ordered compared with the baseline period (12.8% vs 8.6%, $\chi 2$ (1, n=7404)=34.352, p<0.001).

Table 2 Meals ordered and the patient reported diet preference on admittance

Characteristic	Baseline period	Intervention period	Statistics
Total meals ordered (*n*)	3756	3803	
Special diets (*n*, %)			
No special diet	2721 (72.4)	2737 (72.0)	p=0.212
Low sodium diet	670 (17.8)	688 (18.1)	p=0.082
Vegetarian diet	221 (5.9)	242 (6.4)	p=0.755

Intention to eat healthy postdischarge

We aimed to invite all 2419 patients to fill out our survey on dietary health behaviour. However, due to the availability of research staff and patient turnover outside office hours, only a subgroup of 1261 patients underwent eligibility screening (667 in the baseline phase and 594 in the intervention phase) (figure 4). No selection was involved; the ward was visited on a daily basis on weekdays. Of the screened patients, 603 were eligible in the control phase, and 532 were eligible in the intervention phase. Reasons for exclusion in the control group and intervention group, respectively, were absence of email address (32 vs 43), no evening meal consumption (15 vs 7), already filled out before (11 vs 13) and a language barrier (6 vs 9). Of eligible patients, 496 participants agreed to participate in the baseline phase, and 462 participants agreed to participate in the intervention phase. We received 353 responses (71.2%) in the baseline phase and 305 responses (66.0%) in the intervention phase. This led to 284 (80.5%) usable responses in the baseline phase and 277 (90.8%) usable responses in the intervention phase (rejected responses were incomplete, incorrect or extremely illogical).

No statistically significant differences were found between the groups with regard to age, gender, admission duration, dietary preference, medical history of myocardial infarction and self-reported dietary health score (table 3).

The CFA model shows that the intention scale fits the data well ($\chi 2$=22.07, df=2, p<0.001, comparative fit index (CFI)=0.983, Tucker Lewis index (TLI)=0.948, root mean square error of approximation (RMSEA)=0.13), while the $\chi 2$ and RMSEA show some evidence for lack of fit, the $\chi 2$ is sensitive to sample size and the overall fit measures show a good fit; as such, the model can be accepted. Items 1 to 3 have very high standardised loadings (item 1=0.86, item 2=0.90, item 3=0.78), while item 4 has the lowest loading (0.56) that is still marginally acceptable.

In the next step, the intention scale was regressed on the intervention group. There was a significant positive

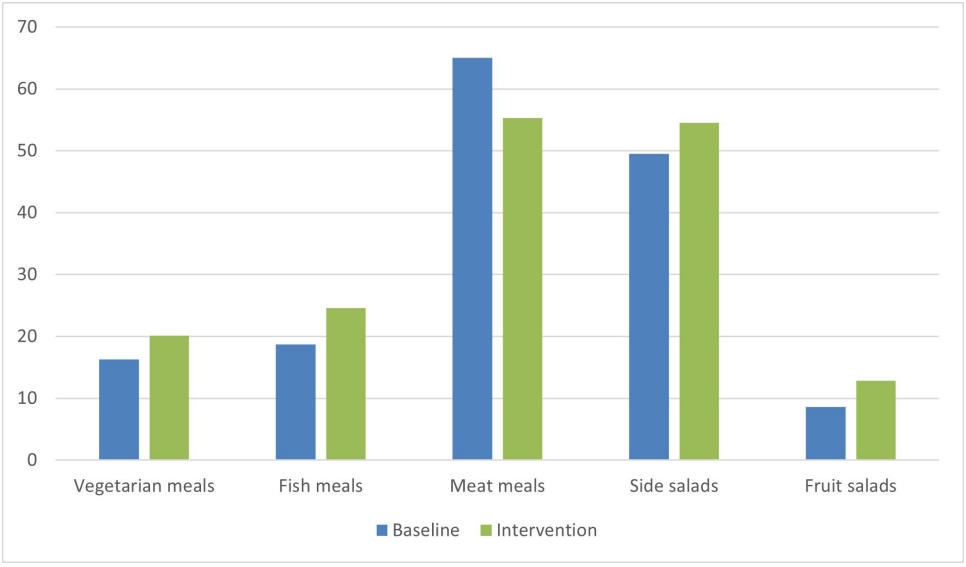

Figure 5 The percentage of vegetarian meals, fish meals, meat meals, side salads and fruit salads, in both the baseline period (blue) and the intervention period (green). All differences were significant at significance level p<0.001.

effect on the intention to eat healthy after discharge of being in the intervention period compared with being in the baseline period (β=0.167, SE=0.083, p=0.045). Adding the grouping effect to the model further improved model fit (χ2=25.68, *df*=5, p<0.001, CFI=0.982, TLI=0.965, RMSEA=0.086).

DISCUSSION

Main findings

This study demonstrates that hospitalised patients who underwent a multicomponent nudging intervention chose more vegetarian meals, fish meals, side salads, and fruit salads and fewer meat meals compared with those who were not exposed to the intervention. It also increased their intention to eat healthier after discharge. This study is the first dietary nudging study conducted in a hospital ward.

Table 3 Baseline characteristics of the subgroup with intention to eat healthy after discharge evaluated

Characteristic	Baseline	Intervention	Statistics
Total	284	277	
Age (years), mean (SD)	63.09 (12.7)	64.45 (12.9)	p=0.208
Age, n (%)			
<50	39 (13.7)	27 (9.7)	
50–69	138 (48.6)	142 (51.3)	
70–89	107 (37.7)	108 (39.0)	
Gender, n (%)			
Female	89 (31.3)	90 (32.5)	p=0.770
Male	195 (68.7)	187 (67.5)	
Reason for admission, n (%)			
Arrhythmia	120 (42.3)	120 (43.3)	p=0.05
AP/MI	72 (25.4)	47 (17.0)	
Heart failure	17 (6.0)	27 (9.7)	
Other	75 (26.4)	83 (30)	
Admission duration (days), mean (SD)	3.30 (3.8)	3.74 (3.9)	p=0.172
Special diet, n (%)	30 (10.6)	35 (12.6)	p=0.443
Myocardial infarction in medical history, n (%)	77 (27.1)	80 (28.9)	p=0.641
Diet health score, mean (SD)	7.32 (1.2)	7.32 (1.3)	p=0.979

AP/MI, angina pectoris (chestpain)/myocardial infarction.

While the effect was statistically significant, its size may not have a clinically relevant impact on patient outcomes. Therefore, we emphasise that this nudging intervention is just one piece of the puzzle. To make healthy eating the norm globally, other complementary interventions are needed. However, due to its simplicity, affordability and effectiveness, we advocate implementing similar nudging techniques in healthcare facilities.

Comparison with literature

Our results are in line with other studies reporting positive effects of nudging interventions in hospital settings. However, these studies focused on hospital shops, not patients admitted to a ward, as our study does. Allan and colleagues demonstrated that simple purchase prompts in hospital shops reduced the average energy content of sold snacks.[11] Similarly, a cafeteria study revealed that traffic light labelling and choice architecture reduced unhealthy sales and increased healthy sales among customers and employees.[20] Our study extends these findings by demonstrating that nudging can positively influence food choices of patients on a hospital ward.

In contrast, a hospital-based study targeting employee obesity reported a reduction in sugar and high-fat food consumption but an unexpected decline in fruit and vegetable intake.[28] Explanations included an overall decrease in food consumption, limited fruit and vegetable options, high baseline intake or increased awareness of food choices. The discrepancy with our results may stem from our use of objectively measured consumption data, which is less influenced by participants' awareness leading to different outcomes.

Strengths and limitations

A limitation of our study is its single-centre design focused on cardiac patients, which limits the generalisability to other healthcare settings. Cardiac patients, often given heart-healthy dietary guidelines and restrictions, may be more aware of the need for healthy eating, potentially skewing results. However, other patient groups, such as those with renal disease, diabetes or cancer, also receive dietary instructions and could benefit from healthy dietary habits. Furthermore, drawing from nudging interventions in hospital cafeterias, we posit that patients in different wards may respond similarly to a nudging intervention.[11 20 28] Another limitation is the reliance on self-reported measures for the secondary outcome, making postdischarge intentions susceptible to bias. While measuring actual post-discharge dietary choices could reduce this, logistical and financial constraints prevented it. Additionally, the baseline group had more angina/myocardial infarction patients, which could skew results due to unhealthy pre-existing lifestyle patterns and dietary improvements after diagnosis. All in all, we think the influence on the secondary outcome will be limited.

Using the number of meals as a unit of analysis also has limitations, as a single person, ordering many healthy meals could skew the results. However, the ratio of evening meals to patients (roughly 3:1) minimises this bias. Furthermore, we focused on specific endpoints, disregarding the carbohydrate option and the vegetable option. This could limit our understanding of overall dietary patterns (eg, selecting a healthy vegetarian meal but pairing it with refined carbohydrates).

The before-after design could be seen as a limitation, as large events like the COVID-19 pandemic may have influenced dietary choices of patients. The pandemic coincided with the baseline phase, potentially affecting results. The literature shows that the pandemic can lead to more healthy dietary behaviour, but also to more unhealthy dietary behaviour.[29 30] This should be taken into account when interpreting these results. However, the food options in the hospital did not change significantly during the study.

Despite these limitations, our study's large sample size (2419 patients) and objective measures strengthen the robustness of the findings. The simplicity of the nudging intervention, being low cost and low maintenance, makes it easily implementable on a broad scale in healthcare facilities. Its multi-component approach likely contributed to its effectiveness.

Implications for research and practice

Future research could identify the most effective components of nudging interventions for in-hospital patients and improve their effectiveness, as there is still room to enhance dietary choices. Additionally, implementation studies could explore facilitators and barriers for policymakers and food service staff in incorporating nudging interventions into hospital food services.

This study highlights the effectiveness of nudges in promoting healthier dietary choices in a hospital setting. Hospitals have the potential to influence the health of patients, visitors and staff through choice architecture.[16–18] However, a 2020 report on NHS Hospital Food services in England revealed shortcomings in dietary policies.[16] This represents a missed opportunity, as better nutrition can enhance patient outcomes, speed up recovery and reduce costs.

CONCLUSION

This study demonstrates that a straightforward multicomponent nudging intervention can positively influence dietary choices among in-hospital cardiac patients while also enhancing their intention to maintain healthier eating habits after discharge. This user-friendly approach can be effectively implemented across diverse healthcare settings.

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REFERENCES

1 Townsend N, Kazakiewicz D, Lucy Wright F, *et al*. Epidemiology of cardiovascular disease in Europe. *Nat Rev Cardiol* 2022;19:133–43.
2 Wilkins E, Wilson L, Wickramasinghe K, *et al*. *European cardiovascular disease statistics 2017*. Brussels: European Heart Network, 2017.
3 Visseren FLJ, Mach F, Smulders YM, *et al*. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J* 2021;42:3227–337.
4 Barbaresko J, Rienks J, Nöthlings U. Lifestyle Indices and Cardiovascular Disease Risk: A Meta-analysis. *Am J Prev Med* 2018;55:555–64.
5 Eilat-Adar S, Sinai T, Yosefy C, *et al*. Nutritional recommendations for cardiovascular disease prevention. *Nutrients* 2013;5:3646–83.
6 Eurostat. *How Much Fruit and Vegetables Do You Eat Daily*. European Union, 2022.
7 Food and Agriculture Organization of the United Nations OECD. OECD-FAO Agricultural Outlook 2021-2030. Paris: OECD Publishing, 2021.
8 EUC (2018). EU consumer habits regarding fishery and aquaculture products. In: *Directorate-General for Maritime Affairs and Fisheries of the European Commission*. Brussels, 2018.
9 Ensaff H. A nudge in the right direction: the role of food choice architecture in changing populations' diets. *Proc Nutr Soc* 2021;80:195–206.
10 Jackson SE, Llewellyn CH, Smith L. The obesity epidemic - Nature via nurture: A narrative review of high-income countries. *SAGE Open Med* 2020;8:2050312120918265.
11 Allan JL, Powell DJ. Prompting consumers to make healthier food choices in hospitals: a cluster randomised controlled trial. *Int J Behav Nutr Phys Act* 2020;17:86.
12 Richardson S, McSweeney L, Spence S. Availability of Healthy Food and Beverages in Hospital Outlets and Interventions in the UK and USA to Improve the Hospital Food Environment: A Systematic Narrative Literature Review. *Nutrients* 2022;14:1566.
13 Mazza MC, Dynan L, Siegel RM, *et al*. Nudging Healthier Choices in a Hospital Cafeteria: Results From a Field Study. *Health Promot Pract* 2018;19:925–34.
14 Pineda E, Bascunan J, Sassi F. Improving the school food environment for the prevention of childhood obesity: What works and what doesn't. *Obes Rev* 2021;22:e13176.
15 Mertens S, Herberz M, Hahnel UJJ, *et al*. The effectiveness of nudging: A meta-analysis of choice architecture interventions across behavioral domains. *Proc Natl Acad Sci U S A* 2022;119:e2107346118.
16 Shelley PL. *P. Report of the Independent Review of Nhs Hospital Food*. 2020.
17 Tinney M, Rittinger R, Tomlinson K, *et al*. Removal of sugar sweetened beverages from sale in a hospital setting-Consumer opinion and influence on purchasing behavior. *Health Promot J Austr* 2022;33:677–85.
18 Derrick JW, Bellini SG, Spelman J. Using the Hospital Nutrition Environment Scan to Evaluate Health Initiative in Hospital Cafeterias. *J Acad Nutr Diet* 2015;115:1855–60.
19 Sealed Envelope Ltd. Simple randomisation service, 2022. Available: https://www.sealedenvelope.com/simple-randomiser/v1/
20 Thorndike AN, Riis J, Sonnenberg LM, *et al*. Traffic-light labels and choice architecture: promoting healthy food choices. *Am J Prev Med* 2014;46:143–9.
21 Lamprell K, Tran Y, Arnolda G, *et al*. Nudging clinicians: A systematic scoping review of the literature. *J Eval Clin Pract* 2021;27:175–92.
22 Lindstrom KN, Tucker JA, McVay M. Nudges and choice architecture to promote healthy food purchases in adults: A systematized review. *Psychol Addict Behav* 2023;37:87–103.
23 Kroese FM, Marchiori DR, de Ridder DTD. Nudging healthy food choices: a field experiment at the train station. *J Public Health (Oxf)* 2016;38:e133–7.
24 Kwan YH, Cheng TY, Yoon S, *et al*. A systematic review of nudge theories and strategies used to influence adult health behaviour and outcome in diabetes management. *Diabetes Metab* 2020;46:450–60.
25 Dolan P, Hallsworth M, Halpern D, *et al*. Influencing behaviour: The mindspace way. *J Econ Psychol* 2012;33:264–77.
26 de Frel DL, Wicks H, Bakk Z, *et al*. Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI). *Nutr Metab Cardiovasc Dis* 2023;33:56–64.
27 EDC C. Castor electronic data capture. In: *online: Castor EDC*. 2019.
28 LaCaille LJ, Schultz JF, Goei R, *et al*. Go!: results from a quasi-experimental obesity prevention trial with hospital employees. *BMC Public Health* 2016;16:171.
29 Farrugia F, Refalo D, Bonello D, *et al*. The impact of the COVID-19 pandemic on Mediterranean diet adherence: A narrative systematic review. *Nutr Health* 2024;30:02601060231187511:215–33:.
30 Nindenshuti PM, Caire-Juvera G. Changes in Diet, Physical Activity, Alcohol Consumption, and Tobacco Use in Adults During the COVID-19 Pandemic: A Systematic Review. *Inquiry* 2023;60:469580231175780:00469580231175780.