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Nudges at the Dentist

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ABSTRACT

Nudges at the Dentist*

We implement a randomized field experiment to study the impact of reminders on dental health prevention. Patients who are due for a check-up receive no reminder, a neutral reminder postcard, or reminders including additional information on the benefits of prevention. Our results document a strong impact of reminders. Within one month after receiving a reminder, the fraction of patients who make a check-up appointment more than doubles. The effect declines slightly over time, but remains economically and statistically significant. Including additional information in the reminders does not increase response rates. In fact, the neutral reminder has the strongest impact for the overall population as well as for important subgroups of patients. Finally, we document that being exposed to reminders repeatedly does neither strengthen nor weaken their effectiveness.

JEL Classification: D03, I11, C93

Keywords: field experiment, reminders, nudges, memory limitations, prevention, dental health, framing

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1 Introduction

A vast body of evidence documents that limitations in self-control, memory, and attention can lead people to act against their long-run self interests (see Rabin 1999, Frederick *et al.* 2002, and DellaVigna 2009 for excellent reviews). These findings have spurred the interest in how subtle changes in choice architectures can improve 'Decisions About Health, Wealth, and Happiness' (Thaler and Sunstein 2008). Choice-preserving changes in seemingly minor institutional details – nudges – hold the promise to help some people avoid making mistakes in intertemporal decisions, without distorting choices of others. Examples of nudges that have been shown to strongly affect decisions include the specification of default options, information disclosure policies, or the framing and labeling of policy instruments (see, e.g., Madrian and Shea 2001, Wisdom *et al.* 2010, Abeler and Marklein 2010).

In this paper, we study whether simple reminder messages can be used as a nudge to encourage dental health prevention. Preventive health care constitutes a potential hot spot for procrastination. Investments in prevention typically entail short-run costs but yield benefits only in the long run. Present-biased preferences may thus lead to an under-investment in preventive health care (Laibson 1997, Loewenstein *et al.* 2007). Moreover, activities such as screenings and routine check-ups should be conducted regularly, but at a relatively low frequency. As a consequence, these key elements of effective health prevention are vulnerable to limitations in memory and attention (DellaVigna and Pollet 2009, Karlan *et al.* 2011): people may simply forget about scheduling the next check-up. Reminders about check-ups represent a low-cost, and unobtrusive nudge in that they let people schedule their check-ups whenever they want to. A person who rationally postpones a check-up can thus simply ignore the reminder. Someone who procrastinates a check-up due to behavioral biases, however, might benefit from receiving a reminder.

In cooperation with a German dentist, we implemented a randomized field experiment to examine the impact of reminders on the frequency of dental check-ups. Regular check-ups are associated with improved periodontal health and ensure that oral diseases are discovered early – which typically makes treatment less painful and less costly (e.g., Lang *et al.* 1994). In addition, healthy teeth yield economic returns (Glied and Neidell 2010). To identify the causal effect of reminders, we exogenously vary whether people are reminded to schedule a new check-up appointment. Within the group of people who receive a reminder, we additionally randomize the informational content of the reminder messages. In particular, we vary whether the reminder includes a paragraph on the benefits of prevention, and whether this information is framed positively or negatively, as it is predominantly the case with health warning messages for tobacco and other potentially harmful products.

We find that reminders cause a substantial increase in the number of check-ups. Within one month after receiving a reminder, the fraction of people who contact the dentist and schedule a check-up appointment is more than twice as high as in our control group (19.3% vs. 8.9%). Similarly, the fraction of patients that visit the dentist and have a check-up is more than 10 percentage points higher in the treated group. The magnitude of the reminder effect is remarkably persistent over time. Even 100 days after the intervention, the fraction of patients that had a check-up is 8 percentage points higher in the treated group (30.5% vs. 22.4%). This indicates that reminders activate people who would otherwise not have made an appointment, or who would have delayed their check-up substantially. Hence, reminder nudges succeed in encouraging dental health prevention.

In contrast to the strong overall impact of being reminded, the specific type and content of the reminder seems to matter relatively little. Adding additional information does not increase patients' response relative to a neutral reminder. Hence, limited awareness about the benefits of dental health prevention does not seem to be a major driver of people's check-up frequency. In addition, we find no systematic difference in responses to a positive or negative framing of the reminders' content.

We also gathered information on a rich set of patient background characteristics, including individuals' health insurance status, patient history, and information on people's residential areas (e.g., local housing prices). The data allow us to study whether certain groups of people are especially responsive to reminders, and whether particular types of reminders have stronger effects for some subgroups. Our findings show that simple nudges seem to work best for a wide range of people: the neutral reminder message triggers the highest rate of check-ups among almost all groups of patients. In fact, the evidence suggests that a neutral and uniform reminder might be preferable to targeting specific groups with different reminder nudges. This is the case as framed reminders sometimes backfire and completely erode the positive reminder effect in certain subgroups.

A further important contribution of our paper is an analysis of how people behave when they are repeatedly exposed to nudges. Over the course of our experiment, several patients are treated twice as they are due for a further check-up. Our randomization procedure ensures that we obtain random treatment sequences, in terms of whether and how a given person is reminded the first and second time that she is up for a check-up. Exploiting these sequences, we examine whether applying nudges repeatedly strengthens or weakens their effect. In addition, we study the consequences of taking away reminders. This allows us to address the concern that people get used to being nudged and rely too heavily on receiving further nudges – a point that has been raised by critics of libertarian paternalistic interventions (see, e.g., Rizzo and Whitman 2009). We find that patients who receive multiple reminders exhibit very similar response rates as patients who receive the first reminder in our experiment. At the same time, the data show no detrimental effect if one stops sending a reminder at a later check-up interval. This indicates that reminders do *not* come at the potential cost of a decline in people's active choices, once the nudge is taken away. The evidence further shows that reminders do not solely provoke one-time responses due to a 'surprise' effect.

Applying insights from behavioral economics to promote healthy behavior has been highlighted as one of the most promising avenues for public policy (e.g., Behavioural Insights Team 2010, Darzi *et al.* 2011). There are only a few studies that follow this avenue by examining nudges in the domain of health prevention. Two recent papers analyze the impact of planning prompts on influenza vaccinations (Milkman *et al.* 2011) and colonoscopies (Milkman *et al.* 2012). They find that asking patients to form a more detailed personal plan significantly increases the take-up of these activities. Calzolari and Nardotto (2011) study whether attendance rates at health clubs can be increased through reminders and feedback provision, and find positive effects of reminders. For the domain of dental health, some clinical trials on the effectiveness of reminder systems have provided mixed evidence (e.g., Reekie and Devlin 1998, Bos *et al.* 2005). It is difficult to compare these studies to ours, however, as they are exclusively concerned with reminding people about already *existing*, pre-scheduled appointments. In contrast, we analyze whether reminders encourage people to engage more strongly in preventive health care by making *new* appointments.

Reminders are widespread in decision environments beyond health prevention: software companies remind customers about the availability of updates, research institutes remind survey participants to fill in questionnaires (Groves *et al.* 2002), and conference organizers remind participants about upcoming registration deadlines. With some notable exceptions, the impact of such reminder systems has rarely been evaluated. The results from the few existing studies (Karlan *et al.* 2011, Apesteguia *et al.* 2012, Kast *et al.* 2012) suggest that our main findings might generalize to other decision environments. First, these papers all document strong reminder effects. Kast *et al.* (2012), for instance, compare reminder messages to other activities designed to increase savings, such as meetings in self-help groups. They observe that simple reminders have an equally strong effect as the more elaborate interventions. Second, the previous studies also find little or no evidence on content- or framing-specific differences in the effectiveness of reminders. Karlan *et al.* (2011), who study the influence of reminders on savings behavior, find no differences between reminders that are framed in terms of gains and losses, paralleling our findings from the positively and negatively framed treatments. Apesteguia *et al.* (2012) show that adding additional content to a simple reminder does not further increase the frequency at which library customers return borrowed items in time.

The remainder of the paper is organized as follows. In the following section, we provide an overview of the institutional framework and discuss how different biases might affect patients' decisions in dental health prevention. Section 3 outlines the setup and procedures of the experiment. In Section 4, we present our empirical results, and Section 5 concludes.

2 Check-ups and dental health prevention

Health prevention is a non-trivial inter-temporal problem. In the case of dental health, brushing one's teeth regularly, flossing, and avoiding sugary food is costly today – in terms of time, effort and foregone pleasure. However, investments in prevention generate potentially high returns through improved future health. In addition to these direct, health-related payoffs, healthy teeth might yield higher wages (Glied and Neidell 2010) and other benefits associated with beauty (e.g., Mocan and Tekin 2010, Belot *et al.* 2012). Superior dental health can also have positive externalities, since individuals with healthy teeth miss fewer days at work than people regularly suffering from excruciating toothache.

One key factor in dental health prevention are routine check-ups. Regular check-ups are associated with improved periodontal health and ensure that oral diseases are discovered early, which typically makes treatment less painful and less costly (e.g., Lang *et al.* 1994). Recommendations for check-up intervals vary between three months and more than a year, depending on patients' risk factors and dental health status (see, e.g., National Institute for Health and Clinical Excellence 2004). In Germany, the recommended check-up interval for healthy patients is six months. High-risk groups (e.g., diabetes mellitus patients who face increased parodontitis risks) are recommended more frequent check-ups.[1] Acknowledging the importance of dental prevention, many health care providers use economic incentives to encourage regular check-ups. Patients covered by the German public health insurance (more than 80% of our sample), for instance, are eligible for free dental check-ups and receive 20% [30%] allowance on treatment costs if they had at least one annual check-up over the last 5 [10] years.[2]

[1]There is an ongoing debate in the medical literature about best practices for check-up intervals. The debate reflects the lack of causal evidence on how different intervals affect long-run health outcomes (see, e.g., Mettes 2005). Motivated by the missing evidence, a large-scale randomized trial on different check-up intervals has been launched recently in the UK (see https://viis.abdn.ac.uk/HSRU/Interval/).

[2] Private health insurance contracts are more heterogenous. Generally, the incentives to regularly attend check-ups tend to be weaker than under the public insurance system. In addition, the costs for check-ups are higher for privately insured patients.

In our setup, there are two steps to a dental check-up. First, a patient has to contact her dentist to schedule an appointment. To make an appointment that is in line with the recommended check-up interval, people therefore have to remember their last check-up date. Beyond the cognitive costs of remembering, contacting the dentist entails only modest transaction and opportunity costs.[3] Second, once a date for the check-up is arranged, the patient has to keep the appointment and go to the dentist. This second step involves further transaction and opportunity costs (traveling to the dentist, waiting costs, etc.). Repeatedly carrying out the two steps determines an individual's check-up frequency.

Fully rational patients with perfect knowledge about their benefits and costs from check-ups will attend check-ups at an individually optimal frequency. However, a growing body of research suggests that some people may be prone to make sub-optimal decisions in the context of health prevention (see, e.g., Loewenstein *et al.* 2007, Thaler and Sunstein 2008). In particular, present-biased preferences and memory limitations may contribute to the procrastination of check-ups.

People with present-biased preferences might defer check-ups, in order to avoid the short-run costs of check-ups (Laibson 1997). In addition to the transaction costs mentioned above, these costs might involve people's fear of going to the dentist. People will also invest too little in prevention if they underestimate its net returns. This could be the case if individuals are not fully aware of the future benefits of prevention, or if they underestimate the costs of future treatments. Finally, people with memory limitations will have fewer check-ups as they forget about their last check-up date and do not have the task of making the next appointment on the 'top of their minds' (see, e.g., Karlan *et al.* 2011 and Altmann *et al.* 2012 for formal treatments of limited memory and task delay).

3 The field experiment

Evaluating whether people choose check-up frequencies that are optimal from an personal or public-policy perspective is inherently difficult, since almost all potential benefits and costs of check-ups are uncertain and individual-specific. Moreover, the factors that might contribute to delaying check-ups vary in the patient population and are typically unobservable. Rather than trying to induce optimal check-up schedules, we implement an unobtrusive change in patients' choice architecture: we study whether simple reminder messages encourage patients to have dental check-ups.

[3] Some dentists assign a date for the next check-up already at the previous appointment. With this procedure, it is less important to remember the date of the last appointment, however, it is crucial to keep in mind the date of the future, pre-arranged appointment.

Our approach is not based on the presumption that all people exhibit sub-optimally long check-up intervals. Rather, reminder messages constitute a nudge that preserves patients' freedom to schedule check-ups whenever they want to. A patient who rationally postpones a check-up (e.g., because she faces a period of high opportunity costs, or because she is 'rationally inattentive') can simply ignore the reminder message. Reminders might, however, help people who would otherwise procrastinate check-ups due to memory limitations, limited awareness, or present-biased preferences.

3.1 Treatments

We examine a nested experimental design with two layers of randomization. First, we exogenously vary whether individuals who should make a new check-up according to their recommended check-up interval receive a reminder postcard. Second, within the treated group, we randomize design, content, and framing of the reminder postcards. Overall, we consider six treatments. The group of patients who receive no reminder (*No-Reminder*) serves as our main control group. Patients in treatment *Neutral* receive a reminder postcard that asks to make a new check-up appointment. In addition, the postcard provides the dentist's name, phone number and address. This content is also included in all further reminder treatments, which contain additional information about the benefits of dental health prevention. Two treatments provide positively framed information that emphasizes the long-run health benefits as well as the potential pecuniary advantages of prevention. The final two treatments provide the same information, but the text stresses the negative consequences of not taking care of dental health (see Table A.1 in the Appendix).

Together with the text manipulations we vary the cover design of the postcards. The neutral postcard displays a picture of a calendar, with the word 'Dentist' written on one of the dates. In the positively framed treatments, the postcard shows either a smiling female or male face with healthy teeth (treatments Pos^F and Pos^M, respectively). In the treatments with negative framing of information, the cover displays a female or male patient with toothache (Neg^F, Neg^M). The cover designs of the postcards are presented in Figure A.1 in the Appendix.

An overview of the treatments is presented in Figure 1. Testing the top row against the bottom row of treatments allows us to identify whether reminders affect patients' check-up behavior. There are two main reasons why we expect people to make more check-up appointments in response to reminders. First, reminders increase patients' attention by making the need for dental prevention salient. They should therefore encourage check-ups of people with memory limitations, who would otherwise forget about the date of their last visit, their recommended check-up interval, and the need to arrange a new appointment. Second, all

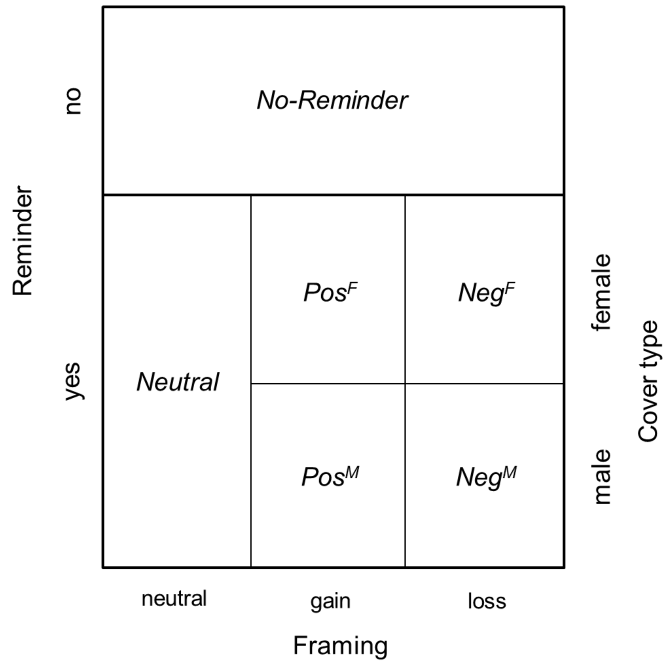

Figure 1: *Overview of treatments.*

reminders provide the dentist's contact details, and thereby reduce the immediate transaction costs of calling and scheduling an appointment. While this should affect all decision-makers, one might argue that the reduction in immediate costs is particularly relevant for present-biased people. Note, however, that the main costs of a check-up originate from the actual visit at the dentist, rather than from scheduling the appointment. The impact of reminders on the *actual* check-up frequencies of present-biased people might therefore be limited.[4]

The different treatment cells in the bottom part of Figure 1 reflect our second layer of randomization. Comparing these treatments, we can analyze whether the design and content of reminders matters, and which reminders are particularly effective for specific subgroups of the patient population. As compared to the neutral reminder, one might expect the reminders containing additional information to further increase patients' awareness about the benefits of check-ups (or the risks of not going to check-ups). Observing a higher frequency of check-ups in the treatments with additional information would thus indicate that limited awareness is a driving force in people postponing check-ups.

[4]More precisely, the reduction in transaction costs through reminders might induce a present-biased decision-maker who is naïve about his bias to contact the dentist and arrange an appointment. On the day of the check-up appointment, however, the higher immediate costs of going to the dentist and having the check-up might dominate. Observing an increase in scheduled check-ups, but also an increase in the frequency of missed appointments in the reminder treatments, would thus be indicative of present-biases (and naïveté).

Despite the frequent use of policies that apply framing in the domain of risky behaviors (e.g., negatively framed warning messages on tobacco packages), little is known about the influence of framing on health prevention. Evidence from other domains shows that positive and negative frames can alter people's perception of information (Tversky and Kahneman 1981). Earlier survey evidence also indicates that gain/loss framings affect *intentions* for adopting different strategies in health prevention (Rothman *et al.* 1999). Comparing treatments Pos^F and Pos^M against Neg^F and Neg^M, we can test whether the framing of information in terms of gains or losses actually influences check-up *behavior*. Finally, by comparing treatments Pos^F and Neg^F against treatments Pos^M and Neg^M, we can study whether the gender of the persons depicted on the message cover influences responses, as suggested by Bertrand *et al.* (2010).

3.2 Sample and randomization

We conducted the experiment in cooperation with a dentist in Bonn, Germany, who uses a computer-guided reminder system. At the first visit at this dentist, patients are classified according to their dental health status as 'regular' or 'at-risk' patients. The classification implies a recommended check-up frequency of 6 or 4 months, respectively. The dentist's computer system keeps track of each patient's visits. If a patient with a recommended m-month check-up frequency has not been at the dentist since m months, a reminder flag is generated by the system. Every month, we randomly assigned all patients with a reminder flag into one of our six treatments.[5] When a patient is treated (or stays untreated in case she is assigned to the control group), or when a patient comes to a check-up, the reminder flag is switched off for another m months. Hence, a patient will receive reminders in intervals of at most m months.[6]

Several aspects of the procedure are worth noting. First, one has to bear in mind that we randomize within a selected sample of patients. Patients who schedule their check-ups in a particularly timely manner are less likely to be part of our sample, whereas patients who are not sticking to their recommended check-up schedule have a higher likelihood of participating in the experiment. From a policy perspective, our experimental sample seems

[5]If a patient visits the dentist after the flag is generated but before we randomize, the flag is switched off. As discussed below, such a patient self-selects out of the sample.

[6]Suppose Mr. A, a patient with a recommended check-up interval of 6 months, had a check-up on 15 January 2010. He does not visit the dentist in the following 6 months. Starting with 16 July 2010, the database flags Mr. A for his next check-up. Suppose that he is randomly assigned to a reminder treatment on 1 August 2010. If Mr. A responds to the reminder and comes to a check-up appointment on, say, 20 August, the reminder flag would pop up again on 21 February, 2011. If Mr. A does not respond to the reminder and has no check-up in the following six months, the flag pops up on 2 February 2011 – 6 months (and one day) after sending the last reminder.

to be interesting for implementing nudge-based policies, since it pools procrastinators with others that might rationally postpone check-ups.

Second, we randomize at the household rather than at the individual level: in any randomization wave, members of the same household are assigned to the same treatment. In this way, we try to avoid possible treatment spillovers (Miguel and Kremer 2004) and minimize patients' consciousness of an ongoing experiment. Third, during the 11 months in which the experiment was conducted, several patients are treated repeatedly. This is the case since some patients will be flagged for a check-up at two points in time during the experimental period. We independently randomize each time a patient is up for a check-up. This procedure generates random treatment sequences, which allows us to study the impact of repeatedly treating patients and the role of different treatment orders.

Finally, and related to the previous point, one has to bear in mind that the dentist operated a system of reminder postcards already before the start of our experiment. This affects the interpretation of some of our findings, as we do not introduce reminders for the first time in the entire patient population. However, we have access to patients' reminder history before the start of the experiment, and we can further exploit the randomized treatment sequence in our experiment. This allows us to assess potential differences in response rates upon receipt of the first versus subsequent reminders in more detail (see Section 4.4).[7]

3.3 Implementation and measures

The experiment was conducted between April 2010 and March 2011. Overall, our sample covers 1227 instances in which a patient was up for a check-up appointment. These cases spread over 817 individuals from 713 households. For roughly half of the patients, we have data on repeated treatment sequences. Randomization was implemented in 11 waves, with reminders being sent out on average every five weeks. All postcards were sent out by the dentist on Fridays, immediately after randomization took place. According to *Deutsche Post*, postcards should be delivered on Monday at the latest. We therefore measure response time (in days), starting with the Monday after a randomization wave as day 1.[8] For the response duration in the control group, we use the same starting day.

[7] A priori, it is unclear whether the *initial* or the *repeated* application of reminders triggers stronger responses. On the one hand, the introduction of a reminder system could initially yield particularly high response rates due to a 'surprise effect'. On the other hand, routinely applying reminders could increase patient responses through a 'habituation effect'.

[8] Patients receiving a postcard on Saturday could send an email or leave a message on the dentist's answering machine over the weekend. However, there was not a single response via email or the answering machine.

Our main variable of interest is whether or not a participant calls the dentist for scheduling an appointment. The date of the call measures the first point in time at which people respond to our intervention. In a second step, we study patients' actual show-up at the dentist. Considering the date of the first contact rather than the actual check-up (which is, on average, scheduled 14 days after a patient called) has the advantage that it avoids potential congestion in check-up dates due to the dentist's capacity limits. More precisely, one might worry that finding longer delays in check-up dates for the *No-Reminder* condition might be the result of the response of patients in the reminder treatments, who 'block' dates for earlier appointments.

In addition to our main outcome variables, we compiled a rich set of patient background characteristics. Next to the patient's gender, age, and risk classification (i.e., the recommended check-up interval), we know whether a patient is covered by private or public health insurance (*Private HI*).[9] In addition, we observe whether a patient lives in a household in which other household members took part in the experiment (*Family*).[10] We further measure when a patient first visited the dentist, and derive information about individuals' check-up and dental treatment history before the experiment. For people with a *Patient retention* of more than 12 months, we also construct an indicator whether a patient attended at least two check-ups in the year prior to a randomization wave (*Regular*). Furthermore, we construct a binary variable, *Pain*, which captures whether a patient was exposed to a major root canal treatment or other painful dental treatments in the past.[11] Beyond the information from the dentist's database, we matched patients' precise address with data obtained from *immobilienscout24.de*, Germany's largest real estate platform. In this way, we obtain the average rental price in the patients' neighborhood (*Rental price*). From the address data, we also compute the spatial distance between each patient's home and the dentist (*Distance*).

Table 1 presents the descriptive statistics of our data and summarizes the outcomes of randomization. Patients in our sample are on average 38 years old (with age varying between 15 and 92 years), 59% of them are female, and about 12% belong to households in which additional family members are patients at the dentist. As noted above, about 20% of patients are covered by private health insurance. On average, individuals in our sample have been

[9] Controlling for insurance status is important since contractual terms might differ under private and public health insurance (see above). Moreover, in the German health system, the privately insured are a selected sample since only persons with a gross yearly income above 50K Euro, self-employed, and civil servants are eligible for private health insurance. Due to Bonn's history as the former capital of West Germany, a large part of the privately health insured in our sample seem to be civil servants.

[10] To avoid confounds from parents arranging joint appointments for themselves and their children, our data analysis excludes children below the age of 15.

[11] The results presented below are robust to using alternative definitions of patient check-up history and painful treatments.

Treatment	*No-Rem*	*Neutral*	Pos^F	Pos^M	Neg^F	Neg^M	Total	F-test (p-value)	t-test (p-value)
Age	37.23	38.62	40.11	36.64	37.28	38.40	38.05	0.128	0.364
	(13.42)	(13.48)	(13.88)	(13.32)	(13.28)	(14.19)	(13.62)		
Female	0.542	0.594	0.612	0.579	0.570	0.624	0.588	0.592	0.159
	(0.500)	(0.492)	(0.488)	(0.495)	(0.496)	(0.485)	(0.492)		
Family	0.151	0.129	0.092	0.134	0.087	0.108	0.117	0.288	0.105
	(0.359)	(0.336)	(0.290)	(0.341)	(0.282)	(0.311)	(0.321)		
Private HI	0.219	0.138	0.204	0.193	0.193	0.174	0.186	0.369	0.202
	(0.414)	(0.346)	(0.404)	(0.396)	(0.396)	(0.380)	(0.389)		
At-Risk	0.182	0.138	0.209	0.257	0.159	0.094	0.172	<0.001	0.680
	(0.387)	(0.346)	(0.408)	(0.438)	(0.367)	(0.292)	(0.378)		
Patient retention	3.717	3.627	3.830	3.410	3.546	3.549	3.611	0.593	0.505
	(2.401)	(2.366)	(2.471)	(2.292)	(2.473)	(2.435)	(2.406)		
Regular	0.469	0.482	0.447	0.405	0.47	0.466	0.457	0.727	0.731
	(0.500)	(0.501)	(0.499)	(0.492)	(0.500)	(0.500)	(0.498)		
Pain	0.249	0.196	0.172	0.237	0.204	0.252	0.218	0.241	0.259
	(0.433)	(0.398)	(0.378)	(0.427)	(0.404)	(0.435)	(0.413)		
Distance	0.124	0.217	0.125	0.137	0.116	0.116	0.140	0.296	0.646
	(0.444)	(0.776)	(0.370)	(0.557)	(0.408)	(0.377)	(0.513)		
Rental price	7.194	7.131	7.168	7.147	7.318	7.087	7.173	0.494	0.793
	(1.181)	(1.183)	(1.224)	(1.182)	(1.225)	(1.264)	(1.210)		
N	192	217	202	196	213	207	1227		

Table 1: *Background characteristics. Mean values (standard deviations in parentheses).*
Notes: 'Family' is a dummy, indicating if several household members took part in the study. 'Private HI' is equal to 1 if a patient is covered by private health insurance (0 for public health insurance). 'At-Risk' indicates if a patient is recommended a 4 months check-up interval. 'Patient retention' is the number of years since a patient first visited the dentist. 'Distance' is the great-circle distance between a patient's home address and the dentist (scale: 1 = 100km). 'Rental price' is the average rent at the patient's home address (Euros per square meter, excluding utilities and dues). The dummy 'Regular' indicates whether a patient made at least two check-ups in the year prior to a given randomization wave. 'Pain' indicates if a patient was exposed to a painful dental treatment in the year prior to a given randomization wave. Time-variant patient characteristics (e.g., age, patient retention, etc.) are computed at each randomization wave. The final two columns report (i) p-values of F-tests from regressions of the respective characteristics on individual treatment dummies and (ii) p-values of t-tests comparing the characteristics in the *No-Reminder* treatment vs. all patients who received a reminder.

patients at the dentist for 3.6 years, and 17% are classified as 'at-risk' patients. 46% of patients have attended at least two check-ups in the previous year.

The final two columns of Table 1 report validation checks on the randomization. Comparing patients in the control treatment to those in the different reminder conditions (pooled sample) yields no significant differences in patients' background characteristics (see final column of Table 1). This indicates that randomization in patient characteristics was successful for our most important treatment comparison. F-tests for regressions of the individual patient characteristics on dummies for the six different treatments yield no significant difference except for the fraction of at-risk patients. In what follows, we provide evidence on the basic treatment effects as well as parametric analyses that control for differences in patient characteristics across treatments.

4 Results

This section presents the results of the experiment. We first focus on the short-run effect of reminders. We analyze how many people make a check-up appointment within one month after the treatment intervention, and how many actually keep their appointment. Section 4.2 examines whether these effects differ for different subgroups of the patient population. Thereafter, we study a considerably longer response period and assess the robustness of the short-run effects. In a final step, we exploit the panel nature of our data and analyze how people respond if they are 'repeatedly nudged'.

4.1 Do reminders influence behavior?

Our first main result is shown in Figure 2. The figure depicts the fraction of patients who contact the dentist within one month after the treatment intervention. We observe a strong effect of the reminders on patients' behavior: without receiving a reminder, only 8.9% of patients schedule a check-up. In the reminder treatments, the response rate is on average more than twice as high (19.3%). This difference is highly significant ($p < 0.001$).[12] Compared to the control treatment, response rates are significantly higher in each of the reminder treatments ($p < 0.001$ for *Neutral* and Pos^F, respectively, $p = 0.031$ for Pos^M, $p = 0.012$ for Neg^F, and $p = 0.009$ for Neg^M).

Figure 2 further illustrates that the reminders which include additional information do not yield higher response rates than the neutral reminder. The frequencies of responses for the different reminder treatments vary between 16.3% (Pos^M) and 23.0% (*Neutral*). All pairwise treatment differences turn out to be insignificant.[13] The comparison between negatively and positively framed reminders further indicates that gain/loss framing does not affect response rates in our setup. We also find no significant differences in responses to postcards with male vs. female covers.[14] Hence, the specific content of reminders does not seem to play a major role for patients' responses. The simple nudge in treatment *Neutral* has (statistically) the same impact on behavior as reminder messages that include additional information, independently of how this information is framed.

[12]The test statistics are based on two-sided t-tests that account for clustering at the household level.

[13]Except for the comparison of the *Neutral* and the Pos^M reminder ($p = 0.107$), all pairwise tests yield p-values that are well above conventional significance levels.

[14]$p = 0.593$ for treatments Pos^F and Pos^M versus Neg^F and Neg^M; $p = 0.382$ for treatments Pos^F and Neg^F versus Pos^M and Neg^M.

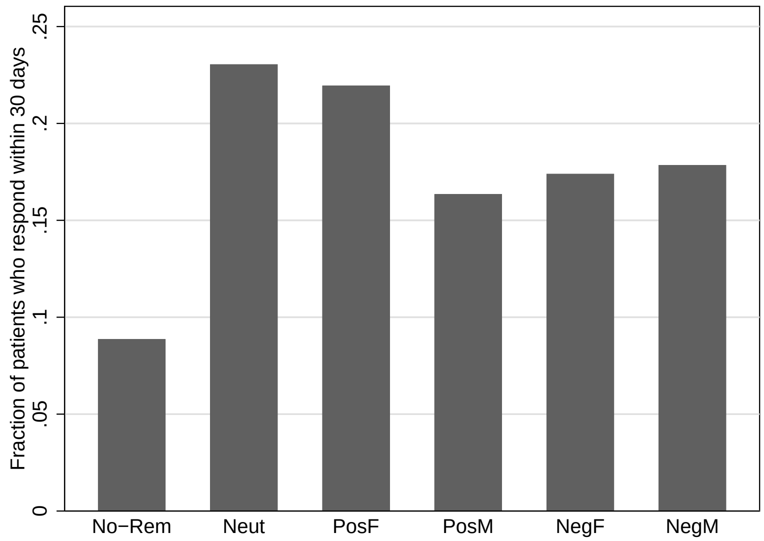

Figure 2: *Impact of reminders on response rates. Fraction of patients who contact dentist within 30 days after treatment intervention.*

The strong reminder effect persists once we control for patient characteristics and potential seasonal differences during our experiment. To demonstrate this point, we consider the model

$$\begin{aligned} Resp^{30} &= \alpha + \beta\, Rem + \gamma_1\, Rem \times Pos^F + \gamma_2\, Rem \times Pos^M \\ &\quad + \gamma_3\, Rem \times Neg^F + \gamma_4\, Rem \times Neg^M + X\delta + W\phi + \varepsilon, \end{aligned} \tag{1}$$

where X is a vector of patient characteristics and W includes dummies for the different randomization waves. The dependent variable, $Resp^{30}$, measures whether a person makes a check-up appointment within 30 days after the treatment intervention.[15] *Rem* indicates whether a person has received any reminder postcard. The coefficient β thus identifies the main reminder effect. In the full specification, β corresponds to the impact of the neutral reminder relative to the control group. The effect of the framed reminders is given by $\beta + \gamma_k$, for $k \in \{1, 2, 3, 4\}$, where the γ-coefficients capture the differences between a framed reminder and the neutral reminder.

Table 2 reports estimation results based on linear probability models.[16] Specification (1) estimates the average impact of reminders on patients' response rates. Specification

[15] Our results are robust when we consider shorter and longer response periods (see Figure 3 below). Note further that we start counting the response time at the same day for the treated and the control group (i.e., the first workday after we sent out reminder postcards in the respective randomization wave).

[16] To avoid complications with the interpretation of marginal effects from interaction terms in non-linear models (Ai and Norton 2003), we focus on LPM estimations. Results from probit estimations, which yield very similar results, are available from the authors.

Dependent variable: Response within 30 days					
	(1)	(2)	(3)	(4)	(5)
Reminder	0.105***	0.142***	0.133***	0.129***	0.145***
	[0.024]	[0.038]	[0.038]	[0.038]	[0.040]
Rem × Pos^F		-0.011	-0.010	-0.017	-0.031
		[0.044]	[0.043]	[0.042]	[0.044]
Rem × Pos^M		-0.067	-0.065	-0.059	-0.074*
		[0.041]	[0.041]	[0.041]	[0.042]
Rem × Neg^F		-0.057	-0.054	-0.051	-0.072*
		[0.040]	[0.040]	[0.040]	[0.043]
Rem × Neg^M		-0.052	-0.051	-0.054	-0.064
		[0.043]	[0.042]	[0.042]	[0.045]
Male				-0.021	-0.007
				[0.023]	[0.024]
Age				0.003***	0.001
				[0.001]	[0.001]
Family				0.004	0.008
				[0.037]	[0.038]
Private HI				-0.028	-0.023
				[0.029]	[0.028]
Distance				-0.041**	-0.046***
				[0.019]	[0.009]
Patient retention				0.007	0.007
				[0.005]	[0.005]
At-Risk				-0.001	-0.018
				[0.034]	[0.035]
Regular					0.148***
					[0.025]
Pain					-0.025
					[0.027]
Rental price					0.030***
					[0.009]
Constant	0.089***	0.089***	0.126***	0.024	-0.220**
	[0.020]	[0.020]	[0.039]	[0.050]	[0.089]
Wave dummies	no	no	yes	yes	yes
N	1,227	1,227	1,227	1,227	1,095

Table 2: *Response within 30 days*
Notes: All specifications are estimated with a linear probability model. Robust standard errors, clustered at the household-level, are reported in brackets. ***, ** and * indicates significance at a 1%-, 5%-, and 10%-level, respectively.

(2) includes treatment dummies for the reminders that contain additional information. As noted above, all these treatments display an insignificantly weaker increase in response rates compared to the neutral reminder. The results do not change when we include dummies for the randomization waves (Column 3) or a first set of background characteristics (Column 4). Specification (5) includes the full set of controls (which slightly reduces the sample size due to missing observations). The point estimate in this specification indicates that the neutral

reminder increases the response rate by 14.5 percentage points relative to the control group. For all reminders with additional information, the increase in response rates is somewhat less pronounced. The difference to the *Neutral* treatment is significant at the 10%-level for the Pos^M and the Neg^F treatment. However, relative to the untreated control group, all framed reminders still have a significantly positive effect on the response rate (F-tests for significance of $\beta+\gamma_k$: $p = 0.003$ for Pos^F, $p = 0.051$ for Pos^M, $p = 0.044$ for Neg^F, $p = 0.025$ for Neg^M).[17]

In sum, these results demonstrate that reminder messages lead to a sizeable and robust increase in the number of patients who schedule check-ups. Additional information about the benefits of dental prevention does not further increase the strength of the effect relative to the simple reminder in the *Neutral* treatment.

> **Result 1:** *Reminders significantly increase the likelihood of scheduling check-up appointments. The fraction of people who arrange a check-up within one month is more than twice as high as in the control group. The specific content and design of the reminder message has no significant influence on responses.*

A potential interpretation of these findings is that limited awareness about the importance of dental health prevention is not a major factor contributing to delayed check-ups. Rather, being reminded per se seems to be of first-order importance. This 'pure' reminder effect is likely to operate via increased attention and, potentially, via a reduction in the transaction cost of responding. Recall, however, that the main transaction cost of a check-up typically emerges with the actual visit at the dentist. In the next step, we thus consider the impact of reminders on patients' check-up attendance.

Who keeps an appointment?

One could imagine that patients who are 'nudged' into scheduling an appointment are more likely to miss the appointment. This could, for instance, be the case since reminders only reduce the costs of *arranging* an appointment, but not the costs of *attending* the check-up. (Naïve) Present-biased people might therefore schedule more check-ups in the reminder treatments, but then cancel or miss their appointments. A higher frequency of missed appointments in the reminder treatments could also occur if check-up appointments that are made in response to a nudge are less carefully planned. This could (at least partially) offset the impact of reminders on actual dental health prevention. Our data clearly reject this possibility.

[17] Consistent with earlier evidence on socio-demographic correlates of dental health prevention (e.g., Lang *et al.* 1994), specifications (4) and (5) of Table 2 also document that several patient characteristics influence response behavior.

Conditional on having made an appointment within a month, 9.7% of the patients in the reminder treatments miss their check-up date. This compares to 17.7% in the control group. While the difference is not statistically significant ($p = 0.402$), the observation indicates that the reminder effect summarized in Result 1 is not diluted by missed appointments. If anything, the impact of reminders is even stronger when we account for missed dates: the overall fraction of patients who contact the dentist within a month *and* actually show up at their check-up is 7.3% for the control and 17.6% for the treated group ($p < 0.001$).[18] The fact that we do not observe an increase in missed appointments for the treatment group suggests that reminders do not predominantly operate via the reduction in transaction costs for (naïve) present-biased individuals.

> **Result 2:** *The frequency of actual check-ups in the reminder treatments is significantly higher than in the control group.*

4.2 Does one reminder 'fit all'?

We now turn to the question whether particular types of reminders have stronger or weaker effects for specific subgroups. From a policy perspective, this analysis is interesting as it provides insights into whether targeting different groups of patients with type-specific reminders can increase their overall impact. To address this question, we estimate equation (1) for different subgroups of patients. We split our sample according to several important background characteristics: patients' gender, the type of health insurance, whether patients attended regular check-ups in the previous year, and whether they were exposed to a painful dental treatment in the past. In addition, we provide estimations for patients who are above and below median age, and for people living in neighborhoods with above- vs. below-median rental prices. Results are reported in Table 3.

The estimates reinforce our previous findings on the effectiveness of the neutral reminder. For almost all subgroups, this reminder triggers the highest response rate. Moreover, there is not a single subsample for which any of the reminders with additional information significantly increases response rates relative to the *Neutral* treatment. In fact, some of the framed reminders perform significantly worse than the neutral reminder in several subgroups. Among male patients, for instance, the negative male framing completely erodes the reminder effect, bringing down the response rate to the level of the untreated control group (see Column 2a). For patients with a painful dental treatment in the past, the neutral reminder has a very

[18] If we replace the dependent variable in Table 2 by an indicator for actual check-ups, we get nearly identical estimates. The results are available from the authors.

strong positive impact, whereas all other reminders yield no significant increase in responses relative to the control group (Column 8a). While an explanation for these patterns is beyond the scope of this paper, we can draw a clear-cut conclusion: the neutral reminder works best in that it is never dominated by any reminder with additional information.

Dependent variable: Response within 30 days							
				Panel A			
	(1)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
	Full	Male	Female	Younger	Older	Priv.HI	Publ.HI
Reminder	0.129***	0.138**	0.129***	0.144***	0.122**	-0.017	0.165***
	[0.038]	[0.058]	[0.049]	[0.047]	[0.059]	[0.093]	[0.040]
Rem × Pos^F	-0.017	-0.034	-0.014	-0.089*	0.017	-0.003	-0.014
	[0.042]	[0.064]	[0.054]	[0.051]	[0.062]	[0.091]	[0.048]
Rem × Pos^M	-0.059	-0.084	-0.046	-0.038	-0.089	0.002	-0.068
	[0.041]	[0.063]	[0.053]	[0.056]	[0.060]	[0.091]	[0.046]
Rem × Neg^F	-0.051	-0.051	-0.058	-0.034	-0.072	-0.044	-0.048
	[0.040]	[0.064]	[0.051]	[0.055]	[0.058]	[0.095]	[0.045]
Rem × Neg^M	-0.054	-0.130**	-0.018	-0.070	-0.037	0.016	-0.068
	[0.042]	[0.060]	[0.053]	[0.055]	[0.062]	[0.092]	[0.045]
N	1,227	506	721	613	614	228	999
				Panel B			
	(5)	(6a)	(6b)	(7a)	(7b)	(8a)	(8b)
	Full	High Rent	Low Rent	Regular	Non-Reg.	Pain	No-Pain
Reminder	0.145***	0.236***	0.034	0.177***	0.126***	0.264***	0.115**
	[0.040]	[0.057]	[0.057]	[0.066]	[0.048]	[0.087]	[0.046]
Rem × Pos^F	-0.031	-0.070	0.031	-0.013	-0.067	-0.231**	0.017
	[0.044]	[0.065]	[0.057]	[0.072]	[0.052]	[0.102]	[0.049]
Rem × Pos^M	-0.074*	-0.115*	-0.019	-0.072	-0.102**	-0.146	-0.059
	[0.042]	[0.061]	[0.055]	[0.075]	[0.048]	[0.101]	[0.047]
Rem × Neg^F	-0.072*	-0.082	-0.037	-0.068	-0.077	-0.237**	-0.047
	[0.043]	[0.064]	[0.056]	[0.072]	[0.050]	[0.102]	[0.049]
Rem × Neg^M	-0.064	-0.077	-0.003	-0.024	-0.117**	-0.253***	-0.018
	[0.045]	[0.070]	[0.056]	[0.075]	[0.050]	[0.094]	[0.052]
N	1,095	577	518	502	593	246	849

Table 3: *Response within 30 days for different subsamples*
Notes: Estimation (1) and (5) replicate specification (4) and (5) from Table 2. The estimates in panel A [B] include a full set of wave dummies and the restricted [full] set of controls, as reported in Column (4) [(5)] of Table 2. Specifications (3a–b) and (6a–b) split the sample according to the median age and rental price, respectively. Estimated coefficients for control variables and the constant are suppressed. Robust standard errors, clustered at the household-level, are reported in brackets. ***, ** and * indicates significance at a 1%-, 5%-, and 10%-level, respectively.

The estimates in Table 3 further reveal two groups of patients who do not react to reminders. Among patients covered by private health insurance (Column 4a) and patients living in low-rent neighborhoods (Column 6b), none of the reminders induces a significant increase in check-ups. The absence of a reminder effect for privately insured patients might be attributable to the differences in insurance conditions (e.g., the higher costs to regularly attend check-ups, see Fn. 2), which in turn could lead to more deliberate planning of check-up frequencies. For people from low-rent neighborhoods (Column 6b), neither the neutral reminder nor providing information about the potential benefits from check-ups significantly increases response rates. Follow-up research indicates, however, that providing additional economic incentives can help to encourage prevention in this group (see Altmann *et al.* 2012). We summarize our findings in

> **Result 3:** *The neutral nudge works best, in the sense that there is no group of patients for which a framed reminder increases responses significantly relative to the neutral reminder. There is a positive reminder effect in all subgroups, except for patients with private health insurance and patients living in cheaper neighborhoods.*

Our analysis of patient subgroups corroborates the positive impact of the simple, neutral reminder message. For a wide range of the patient population, the neutral reminder leads to a strong and significant increase in check-up arrangements. In fact, our results suggest that a neutral and uniform reminder might be preferable to targeting specific groups with different reminder nudges. This point is further reinforced if one accounts for higher costs of implementing group-specific nudges.

4.3 The long-run impact of reminders

So far, we have focused on the short-run response to our treatments. In what follows, we study whether the observed effects are driven by patients scheduling their check-ups just somewhat earlier than intended or whether there is indeed a persistent, positive reminder effect. Stated differently, we examine whether reminders activate patients that would otherwise not have scheduled check-up appointments.

To approach this question, we consider patients' responses up to 100 days after our treatment intervention.[19] Figure 3 depicts the cumulative frequency of responses over time for patients in the reminder treatments (black line) and the control treatment (grey line). Already a few days after receiving a reminder, the response rate is strictly higher in the reminder treatments. Over time, the gap between the two groups slightly declines. However, the treatment effect never vanishes. Patients in the reminder conditions exhibit a persistently higher

[19]Analyzing response rates for a longer time period is problematic, since high-risk patients will already receive their next reminders.

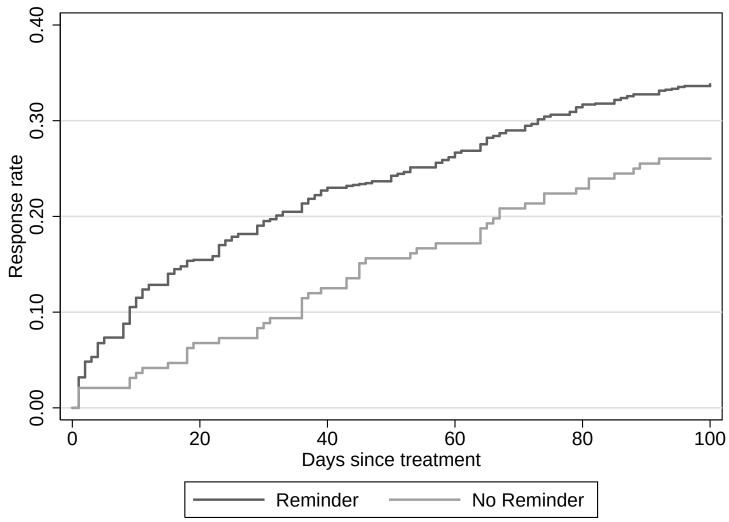

Figure 3: *Cumulated response of patients in the reminder treatments (black line) and the control treatment (grey line) over time.*

frequency of making check-up appointments. For days 51–100, the treatment difference is nearly constant at roughly 8 percentage points. This is also confirmed when we estimate equation (1) with a dummy indicating the response within 100-days as dependent variable.

To provide a parametric analysis of the incidence and timing of patients' responses in the different treatments, we conduct a duration analysis. Table 4 reports estimated hazard ratios based on Cox proportional hazard model. Specification (1) shows that patients who received a reminder exhibit on average a 40% higher hazard rate than the control group. Specification (2) estimates separate effects for the different reminder treatments. In line with the results for the short-run response, the results document that the neutral reminder has the strongest impact. The estimated hazard ratio for *Neutral* is roughly 1.5 relative to the control group. A similar effect is found for the Pos^F treatment. For the other treatments, the coefficients imply that the chance of contacting the dentist (conditional on not having done so before) is increased by a factor of 1.2–1.4 relative to the control treatment. Except for one treatment (Pos^M), these effects are significant at the 5% and 10% level. When we include wave dummies and further control variables (specifications 3–5), the underlying standard errors slightly increase but the estimated hazard rations remain almost unchanged.

We also replicated the different steps of analysis using an indicator for the actual show-up at the check-up. As in the short-run analysis, the frequency of missed appointments is relatively small (10.12% on average). Missed appointments occur again more frequently in the *No-Reminder* condition than in the reminder treatments (14.00% versus 9.58%). Thus, we obtain qualitatively similar results for the impact of reminders on the rate of actual check-

Dependent variable: Response duration					
	(1)	(2)	(3)	(4)	(5)
Reminder	1.418**				
	(0.019)				
Neutral		1.581**	1.506**	1.488**	1.542**
		(0.014)	(0.031)	(0.032)	(0.027)
Pos^F		1.563**	1.479**	1.401*	1.486**
		(0.014)	(0.035)	(0.068)	(0.041)
Pos^M		1.161	1.111	1.116	1.135
		(0.449)	(0.597)	(0.577)	(0.537)
Neg^F		1.428**	1.365*	1.351*	1.360
		(0.048)	(0.092)	(0.098)	(0.105)
Neg^M		1.371*	1.315	1.261	1.269
		(0.086)	(0.141)	(0.208)	(0.208)
Wave dummies	no	no	yes	yes	yes
Controls	no	no	no	yes^i	yes^{ii}
N	1,227	1,227	1,227	1,227	1,095

Table 4: *Duration analysis (Cox proportional hazard model)*
Notes: The table reports hazard ratios from estimations based on Cox proportional hazards model. *P*-values based on robust standard errors, clustered at the household-level, are reported in parentheses. Specification (4) and (5) include the (i) restricted and (ii) the full set of control variables, respectively. ***, ** and * indicates significance at a 1%-, 5%-, and 10%-level, respectively.

ups: in the treated group, the frequency of actual check-ups is 8 percentage points higher than in the control group (30.53% versus 22.39%).

> **Result 4:** *The reminder effect is persistent. In response to the reminders, check-up appointments increase by 8 percentage points after 100 days. The neutral reminder continues to have the strongest impact, increasing the conditional likelihood to call the dentist by 50% relative to the control group.*

The analysis of patients' long-run behavior demonstrates that the reminder effect is long lasting. While the absolute treatment effect is somewhat smaller than in the short run, the effect is still sizable and statistically significant. Our findings indicate that reminders – and in particular the neutral reminder message – bring significantly more patients to check-ups who would otherwise not have made an appointment (or would have delayed their next check-up for a long time).

4.4 Being 'nudged' more than once

Over the course of our experiment, several patients were treated twice. For these patients, random treatment assignment generates different sequences of treatments. This allows us to study whether the reminder effects depend on a patient's past exposure to the nudge. Among the group of patients who are up for a check-up at two points in time during our experiment, at T1 and at T2, we compare the following four treatment sequences: (1) Patients that neither received a reminder in T1 nor in T2 (i.e., patients that are in the control group twice), (2) patients that received a reminder in T1 and in T2 ($Rem_{\mathrm{T1}} \times Rem_{\mathrm{T2}}$), (3) patients that were untreated in T1, but were reminded in T2 ($NoRem_{\mathrm{T1}} \times Rem_{\mathrm{T2}}$), and finally (4) patients that received a reminder in T1, but not in T2 ($Rem_{\mathrm{T1}} \times NoRem_{\mathrm{T2}}$).

To analyze whether these different sequences generate differential response patterns after the *second* treatment intervention, we estimate the model

$$Resp^{30}_{\mathrm{T2}} = \lambda_0 + \lambda_1 Rem_{\mathrm{T1}} \times Rem_{\mathrm{T2}} + \lambda_2 NoRem_{\mathrm{T1}} \times Rem_{\mathrm{T2}} + \lambda_3 Rem_{\mathrm{T1}} \times NoRem_{\mathrm{T2}} + \nu, \quad (2)$$

where $Resp^{30}_{\mathrm{T2}}$ is an indicator for a response within 30 days after the second intervention (at T2). The coefficients λ_1 and λ_2 measure the reminder effects at T2 relative to the group which remains untreated twice, for patients who did (λ_1) or did not (λ_2) receive a reminder in T1. Comparing these coefficients allows us to assess whether reminders have a stronger effect when they are applied twice (which would imply $\lambda_1 > \lambda_2$) or whether repeatedly nudging people has a weaker impact ($\lambda_1 < \lambda_2$). By comparing λ_1 and λ_2, we can therefore assess wether reminders work mostly through a 'surprise' or a 'habituation' effect, or whether the effect of reminders is not affected by a patient's history of receiving reminders.

The coefficient λ_3 captures the behavior in the group that does not receive a reminder in T2, after having received a reminder in T1. An estimate of $\lambda_3 < 0$ would indicate that 'taking away' the reminder has detrimental effects, in the sense that patients' response rate falls below the one of the reference group who was neither reminded in T1 nor in T2. This could be the case, for instance, if people get used to being nudged and rely too heavily on receiving the next nudge. We thus explicitly address the concern that nudges can not easily be taken away and therefore might provide a slippery slope towards more heavy-handed interventions – a point that has been raised by critics of libertarian paternalism (e.g., Rizzo and Whitman 2009).

Dependent variable: 30day-response at second treatment (T2)				
	(1)	(2)	(3)	(4)
$\text{Rem}_{\text{T1}} \times \text{Rem}_{\text{T2}}$ (λ_1)	0.159***	0.144***	0.182***	0.227**
	[0.043]	[0.041]	[0.054]	[0.097]
$\text{NoRem}_{\text{T1}} \times \text{Rem}_{\text{T2}}$ (λ_2)	0.208**	0.198**	0.229***	0.276**
	[0.081]	[0.083]	[0.087]	[0.127]
$\text{Rem}_{\text{T1}} \times \text{NoRem}_{\text{T2}}$ (λ_3)	0.026	0.007	0.049	0.082
	[0.048]	[0.046]	[0.059]	[0.099]
$\text{Response}_{\text{T1}}$		0.127**	0.129**	0.014
		[0.059]	[0.058]	[0.062]
Constant	-0.017	-0.019	-0.197	-0.680***
	[0.141]	[0.124]	[0.142]	[0.165]
Wave dummies	yes	yes	yes	yes
Controls	no	no	yes^{i}	yes^{ii}
N	392	392	392	375

Table 5: *The effect of repeated treatment.*

Notes: All specifications are estimated with a linear probability model and include a full set of wave dummies. The dependent variable is an indicator for a response within 30 days after the second treatment. The sample is composed of patients that experienced a sequence of two treatments. Specification (3) and (4) include the (i) restricted and (ii) the full set of control variables, respectively. Robust standard errors, clustered at the household-level, are in parentheses. ***, ** and * indicates significance at a 1%-, 5%-, and 10%-level, respectively.

The results from estimating equation (2) are reported in Table 5.[20] The estimates document again highly significant reminder effects. Column (1) shows that the reminders have a slightly weaker effect when applied repeatedly. Relative to the group that is untreated in both T1 and T2, reminders increase the response by 16 percentage points for those who are treated for the second time, while the increase is 21 percentage points for the group who receives their first reminder in T2. While this difference is not statistically significant ($p = 0.573$), the direction of the effect indicates that the importance of habituation seems limited – the impact of receiving a second nudge in a row is slightly weaker than the impact of a first nudge after an untreated period.

The positive but insignificant coefficient for λ_3 reinforces this impression. It indicates that taking away reminders does *not* lead to a drop in the likelihood of making a check-up, relative to the group of people who had not been exposed to reminders in T1. Rather, patients who do not receive a reminder in T2 have virtually identical response rates, irrespective of whether they had or had not received a nudge in T1. On the one hand, this observation suggests that the increase in check-ups triggered by the reminders does not come at the potential cost of

[20] Note that it would be misleading to directly compare the point estimates with those from Table 2, as the results from Table 5 are based on a subset of the full sample.

a decline in active patient responses, once the nudge is taken away. On the other hand, the insignificant coefficient also indicates that having received a reminder in T1 does not increase the likelihood of calling the dentist once a subsequent check-up is due in T2.

One might be concerned that the estimates are influenced by whether or not a patient made a check-up in T1 – which is clearly affected by the treatment in T1. To account for this concern, Column (2) includes an indicator for patients' behavior in T1 ($Response_{\text{T1}}$). The point estimate for $Response_{\text{T1}}$, however, should be treated with caution, as the dummy is likely correlated with the error term in equation (2). The coefficients for λ_1, λ_2, and λ_3 are hardly affected when we include this new variable. Qualitatively, this also holds when we add further control variables in Columns (3) and (4). The point estimates for λ_1 and λ_2 increase, but the difference between both coefficients remains insignificant. Similarly, response rates in the treated-untreated sequence are always higher than for patients who are neither treated in T1 nor in T2 ($\lambda_3 > 0$), but the difference is statistically insignificant.

Result 5: *Patients who receive the second reminder in a row exhibit similar response rates as patients who receive the first reminder. Taking away a reminder has no detrimental effect on patients' response rates.*

Extending the analysis from above, we also studied whether differences in the sequences of receiving (i) neutral or framed reminders, (ii) positively or negatively framed reminders, and (iii) male or female framings matter for the observed treatment effects. In addition, we tested whether there are 'alternation effects', in the sense that receiving different reminders in repeated treatment sequences strengthens or weakens the reminder effect. Our analysis did neither reveal any further sequence effects nor any evidence on an effect from alternating the nudges.

5 Conclusions

Using random treatment assignment, we analyzed whether reminder nudges influence patients' likelihood of making dental check-ups. Our results document a strong and persistent effect of reminders on patient behavior. The effect of reminders does not come at the cost of a decline in active patient responses, once the nudge is taken away. Our data further indicate that simple nudges seem to work best: including additional information and framing does not increase responses relative to a simple, neutral reminder message. This observation, which corroborates evidence from other decision environments, suggests that limited awareness about the benefits of prevention does not play a major role in our context. Given that the observation seems to generalize to other domains, it also casts some doubt on the effectiveness of negatively framed information – such as warning messages on tobacco packages – in the regulation of (un)healthy behaviors.

From a more general policy perspective, our results show that reminders can be used as an unobtrusive, and low-cost instrument for encouraging health prevention. Preventive activities involve cognitive and economic costs in the short run, but yield benefits only in the long run. This makes prevention vulnerable to procrastination due to present-biased preferences or limitations in memory and attention. Since reminders play on both of these biases, our study does not provide a 'mechanism experiment' in the sense of Ludwig *et al.* (2011). While we cannot precisely pin down the channel which renders the reminders successful, some of our results suggest that the effects are not predominantly driven by present biases. A full-fledged structural approach – as suggested in Card *et al.* (2011) – appears to be a particularly promising avenue for quantifying the relative importance of limited memory and present-biased preferences in future research.

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A. Appendix

Framing	Text cover	Message text back
Neutral	time for dental prevention	Please make an appointment for your next check-up.
Positive	...keep your nice smile tomorrow	Investing some time on dental health prevention today decreases your risk of a painful dental disease in the future. In addition, you may avoid considerable costs of involved treatments. Please make an appointment for your next check-up.
Negative	...don't lose your nice smile tomorrow	Not investing some time on a dental health prevention today increases your risk of a painful dental disease in the future. In addition, you may incur considerable costs of involved treatments. Please make an appointment for your next check-up.

Table A.1: *Text of reminder messages.*

Figure A.1: *Covers of reminder postcards. Top row (left to right):* Neutral, Pos^F*, and* Pos^M *treatment. Bottom row (left to right):* Neg^M *and* Neg^F *treatment.*