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Nudging intensive care unit personnel towards sustainable behaviour

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Abstract

Background: The health care sector is among the most carbon-intensive sectors, contributing to societal problems like climate change. Previous research demonstrated that especially the use of personal protective equipment (e.g., aprons) in critical care contributes to this problem. To reduce personal protective equipment waste, new sustainable policies are needed.

Aims: Policies are only effective if people comply. Our aim is to examine whether compliance with sustainable policies in critical care can be increased through behavioural influencing. Specifically, we examined the effectiveness of two sets of nudges (i.e., a Prime + Visual prompt nudge and a Social norm nudge) on decreasing apron usage in an intensive care unit (ICU).

Study Design: We conducted a field experiment with a pre- and post-intervention measurement. Upon the introduction of the new sustainable policy, apron usage data were collected for 9 days before (132 observations) and 9 days after (114 observations) the nudge interventions were implemented.

Results: Neither the Prime + Visual prompt nudge, nor the Social norm nudge decreased apron usage.

Conclusions: While previous studies have found that primes, visual nudges and social norm nudges can increase sustainable behaviour, we did not find evidence for this in our ICU field experiment. Future research is needed to determine whether this null finding reflects reality, or whether it was due to methodological decisions and limitations of the presented experiment.

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Relevance to Clinical Practice: The presented study highlights the importance of studying behavioural interventions that were previously proven successful in the lab and in other field contexts, in the complex setting of critical care. Results previously found in other contexts may not generalize directly to a critical care context. The unique characteristics of the critical care context also pose methodological challenges that may have affected the outcomes of this experiment.

KEYWORDS
behavioural change, critical care, nudging, personal protective clothing, sustainability

1 | INTRODUCTION

The health care sector is among the most carbon-intensive sectors, contributing to 4.4% of global net greenhouse gas emissions and toxic air pollutants.[1] These levels are similar to those of the food sector.[2] Within Europe, 6% of all UK[1] and 7% of all Dutch CO_2 emissions are caused by the health care sector.[3] Within the health care sector, the intensive care unit (ICU) and operating room (OR) are among the most resource and waste intensive departments. Hence, they are promising targets for research into waste reduction.[4]

One of the most unsustainable practices within the health care system concerns the single use of disposable products like syringes and infusion bags, and personal protective equipment (PPE) such as gloves, gowns and aprons. Especially during the COVID-19 pandemic, use of single-use PPE increased dramatically,[5] and disposable medical clothing such as isolation gowns were among the largest contributors to CO_2 emissions of all PPE.[6] Medical consumables and their packaging are typically disposed of after a single use, some even without being used, which leads to waste generation. To move towards a circular hospital, single-use medical items need to be reduced and/or reused. Given the large negative impact of PPE in general and aprons in particular, a reduction in apron usage is an important first step.

Policies and information campaigns potentially encourage more sustainable behaviour. Public health policy is often based on the assumption that 'knowledge and information drive behavior'.[7] However, without compliance, policies do not have the desired effect. Even when knowing about (i.e., knowledge), agreeing with (i.e., attitude) and planning to act in line with a policy (i.e., intention), people may not act accordingly (i.e., behaviour). This structural deviation from rationality is termed the intention-behaviour gap.[8] Several factors may explain this gap, including lack of time,[9] lack of resources,[9] lack of responsibility,[10] lack of planning,[11] lack of self-control,[12] low self-efficacy,[11] habits[13,14] and negative perception of effectiveness.[15] Specifically in a health care context, the focus on infection prevention and patient safety may also hinder the adoption of more sustainable practices.[16]

One way to bridge the intention-behaviour gap is to nudge people towards the desired behaviour. Nudging refers to interventions whereby individuals are steered in the desired direction without limiting their choices.[17] This steering is done by implementing modest changes within the choice environment and thereby increasing the salience or convenience of the desired option.[18] Nudges are especially effective when people make automated decisions.[19] Activating automatic responses can even be more effective than directly asking people to adopt the desired behaviour.[20] There are different types of nudges.

Visual prompts are signs, often in the form of posters or stickers, that provide information in a direct and simplified way. Hence, a visual prompt is an informational intervention that functions as a reminder, catching an individual's attention and triggering them to act according to the desired behaviour.[21–23] Visual prompt nudges have been found effective when the desired behaviour is effortless and repetitive.[24,25] They have been used to increase sustainable behaviour, such as recycling food waste[25] and switching off the lights.[26]

Visual prompts may be accompanied with other forms of nudges to increase the salience of the desired behaviour.[27,28] Priming is a type of nudge that informs people before the decision-making moment.[29] It refers to the exposure of cues that can unconsciously alter an individual's behaviour.[30] Priming can increase sustainable behaviour, for example, by increasing people's preference for sustainable fashion.[31]

A third type of nudge that can be applied in a critical care context are social norms nudges. Such nudges are based on social comparison theory, which postulates that individuals tend to compare their

What is known about the topic

- The health care sector is among the most carbon-intensive sectors worldwide and personal protective equipment substantially contributes to this problem.
- Nudging can be a powerful tool to steer individuals towards more sustainable behaviour.

What this paper adds

- We examined the effectiveness of nudging to decrease apron usage in a critical care context.
- Context-specific characteristics of a critical care environment may limit the effectiveness of nudging.

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beliefs, abilities and behaviours to those of their peers.[32] Especially under new, uncertain or stressful circumstances, such as the introduction of a new policy, people are easily influenced by others.[33,34] People do not want to be the odd one, so they look at others to seek out what fits in with the norms of the group.[35,36] One way to make use of this social influence is to actively provide information about others' beliefs and behaviours (i.e., a social norm nudge). Social norms that refer to more similar contexts or reference groups tend to have stronger effects.[37] Social norm nudges have been shown to increase sustainable behaviour, for example, by reducing energy consumption,[38] reducing towel usage[39] and increasing recycling.[40]

2 | AIM

This study aimed to reduce the environmental impact of PPE by encouraging behavioural change among critical care personnel. We conducted a field experiment at the Erasmus University Medical Centre's (Erasmus MC) ICU. First, Erasmus MC introduced a new policy to reduce the number of health care tasks during which an apron had to be worn. Second, we examined the effectiveness of two nudges to encourage compliance with this new apron policy. Specifically, we tested the following hypotheses:

H1. Exposure to a prime and visual prompt nudge significantly decreases apron usage.

H2. Exposure to a social norm nudge significantly decreases apron usage.

3 | DESIGN AND METHODS

We conducted a field experiment between 5 and 25 July 2022 at the ICU of the Erasmus MC, the Netherlands. The Erasmus School of Economics' Internal Review Board-Experimental (IRB-E) granted ethical approval for this field experiment under reference code ETH2122-0751.

3.1 | New personal protective equipment policy

When dealing with non-isolation patients (for non-isolation patients, a different PPE protocol applies (i.e., yellow gowns at all times). Therefore, isolation patients are excluded from this study), medical staff at the Erasmus MC ICU wear white aprons (see Figure 1). Initially, critical care workers were obliged to wear the aprons during any health care tasks that brought them in direct contact with a patient (i.e., old policy). With approval of the Infection Prevention Center, Erasmus MC introduced a new PPE policy to reduce health care waste. In this new policy, aprons are only required when a health care worker encounters body fluids (e.g., blood or excreta). Aprons no longer need to be worn when delivering care like moving the patient (see Table 1). The new policy was communicated through newsletters and posters.

FIGURE 1 Personal protective equipment. Medical staff wear aprons when in contact with body fluids of non-isolation patients.

TABLE 1 Policy overview apron usage with non-isolation patients.

Policy	Instruction
Old (pre-baseline)	Apron to be worn at all patient contacts (e.g., turning patients over, feeding, washing)
New (baseline onwards)	Apron only to be worn when in contact with body fluids (e.g., blood, faeces, mucus)

3.2 | Experimental design

We conducted a field experiment to examine whether nudge interventions encourage sustainable behaviour among ICU personnel. The ICU at Erasmus MC has four units: A, B, C and D, with 10 beds per unit. We combined Units A and B and Units C and D because each set of two units share a coffee room, which enabled interactions between these units. We tested the effectiveness of two nudge interventions: a Prime + Visual prompt nudge (Intervention 1: Units A and B) and a Social norm nudge (Intervention 2: Units C and D). No interaction was possible between the two groups of units. This enabled us to test the two interventions simultaneously without risking spillover effects. Patients were randomly assigned to one of four units.

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To measure the effectiveness of each intervention, we counted how many aprons were used *per day shift per room*, both *before* (i.e., pre-intervention period) and *after* (i.e., post-intervention period) the nudge interventions were introduced. To determine how many aprons were used, we calculated the difference of the number of aprons counted at the start and end of the day shift. During the day shift, each patient is taken care of by one nurse and each unit is covered by three doctors. Given multiple people access a room, we make observations on room-level rather than individualized level. Gathering data per room (as opposed to the unit in its entirety) allowed us to exclude three types of rooms: One, rooms of isolation patients given the different PPE requirements. Two, empty rooms given that no aprons were used. Three, rooms with an occupation change during the day, given that not a full day shift of care was provided.

3.3 | Sample

A power calculation with alpha set to 0.05, a power of 80% and a medium effect size of 0.50[41–43] revealed a minimum sample of 134 observations per intervention, 67 in the pre-intervention period and 67 in the post-intervention period. With an expected occupation rate of 10 patients per day shift per combined unit (50% occupancy), and leaving room for applying the data exclusion rules, we collected data for 9 days per measurement period. No observations were collected in isolation rooms. Across the two measurement periods in Units A and B, 146 observations were collected (see Table 2). Seventeen observations were removed because room occupation changed during the day shift and one observation was removed due to restocking aprons during the day shift, leaving a total of 128 observations. Across the two measurement periods in Units C and D, 144 observations were collected. Twenty-one observations were removed because room occupation changed during the day shift and five observations were removed due to restocking aprons during the day shift, leaving a total of 118 observations.

Because the minimal required sample size was not reached within 9 days of data collection in the post-intervention period, two additional days of data were collected. Descriptive information and results of the extended data collection (9 and 11 days) are presented in Supplementary Materials. In the remainder of the paper, descriptive information and results of the originally planned data collection are presented (9 and 9 days).

3.4 | Intervention 1: Prime and visual prompt nudge

Intervention 1 (Units A and B) comprised two parts: a prime and a visual prompt sticker. The prime contained a decision tree displaying the possible scenarios during which PPE needs to be worn, along with a visual depiction of the relevant items (i.e., gloves and either gowns or aprons) and a sustainability statement (see Figure 2). The goal of the decision tree prime was to inform health care workers about correct PPE usage and to strengthen the effect of the visual prompt. Several

TABLE 2 Number of (removed) observations per intervention and measurement period.

Intervention	Units	Collected	Removed	Final pre-measurement	Final post-measurement
1: Prime + Visual prompt	A&B	146	18	74	54
2: Social norm	C&D	144	26	58	60

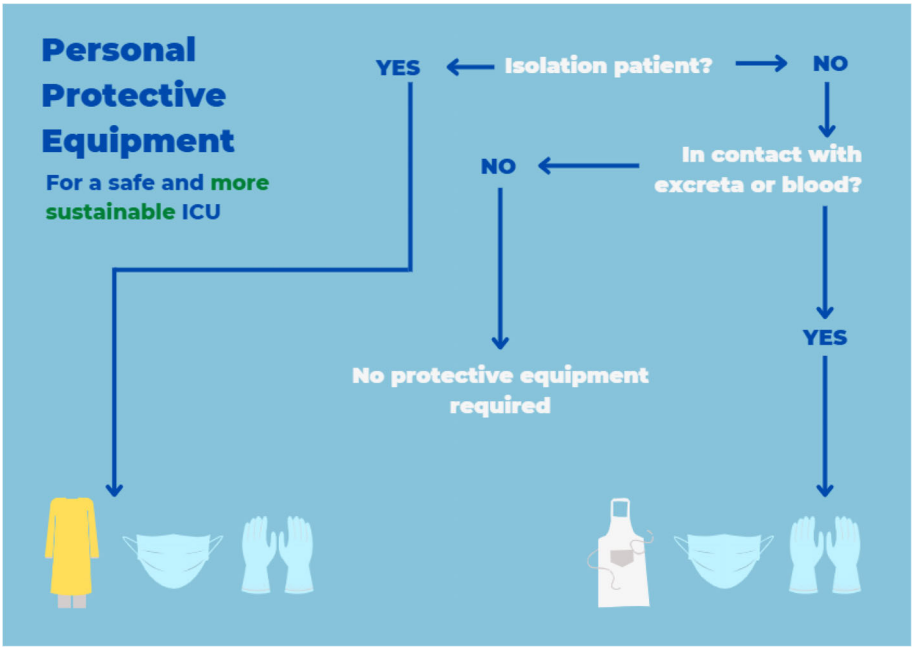

FIGURE 2 Priming nudge decision tree. Decision tree to nudge intensive care unit (ICU) employees to make the correct PPE decision.

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informed design decisions were made. First, a decision tree was chosen to provide workers with a visual guide that promotes a more sustainable use of PPE.[44] Second, an image aligned with the written message was used.[26] Third, the look and feel of the prime were similar to previous instructive stickers issued by the hospital, to facilitate the new instructions being perceived as more familiar and less intrusive.[45] Fourth, simple and clear language was used. Fifth, the word 'sustainable' was written in green since this colour is associated with environmental friendliness and signals sustainability.[18] And sixth, the sentence 'for a safe and more sustainable ICU' highlights the importance of both patient safety and sustainability, given worrying about patient safety may prevent critical care personnel from adopting more sustainable practices.[16,46] The prime was projected on electronic displays in the coffee room shared by critical care workers from Units A and B.

The visual prompt sticker contained an image of an apron, a reminder about when to wear an apron (i.e., 'aprons when in contact with excreta or blood'), and the sustainability statement from the priming nudge (Figure 3). The visual prompt was located near the entrance of each ICU patient room, on the towel dispenser next to the aprons. This location was specifically chosen so critical care workers would see the visual prompt upon entering the patient room, when deciding whether to use an apron for this contact moment with a patient. The design of the visual prompt was in line with the decision tree prime.

3.5 | Intervention 2: Social norm nudge

Intervention 2 (Units C and D) comprised a social norm sticker. The content of the sticker was determined in an online pilot study that took place among 32 critical care employees of another Dutch University Medical Center (Utrecht) between 30 May and 2 June 2022 (see Supplementary Materials). Results showed that 81% of respondents were in favour of using more sustainable protective clothing. Based on this information, we developed a social norm statement comprising both an injunctive and descriptive element (see Figure 4). We deliberately chose ICU workers from another Dutch UMC as a reference group, given social norm nudges are most effective when the target audience is similar to and identifies with the reference group.[47,48] Injunctive norms state what others approve or disapprove of while descriptive norms describe others' behaviour.[49,50] A combination of both tends to be more effective than either of the two norms separately.[51,52] The sticker also contained a congruent image of an apron to make immediately clear what the sticker was about.[26] We used the same look and feel as in Intervention 1 and located the sticker at the same location as the visual prompt nudge.

3.6 | Procedure

To start, baseline usage of aprons was determined during a pre-intervention period of 9 days (see Figure 5). At the start of day 10, the nudge materials were introduced. In Units A and B, the decision tree prime was shown on TV screens in the coffee room and the visual prompt stickers were added to the towel dispensers of each patient room. In Units C and D, the social norm stickers were added to the towel dispensers of each patient room. The nudge stickers were put in the patient rooms before the day shift personnel arrived to avoid any association between the experimenter and the stickers. To determine apron usage in the post-intervention period, observations were collected for another period of 9 days. At the end of this period, two

FIGURE 3 Visual prompt nudge. Left: Visual prompt nudge to encourage the use of aprons. Right: Visual prompt nudge located at the paper towel dispenser in a patient room at the intensive care unit (ICU).

FIGURE 4 Social norm nudge. Left: Social norm nudge sticker. Right: Social norm nudge located at the paper towel dispenser in a patient room at the intensive care unit.

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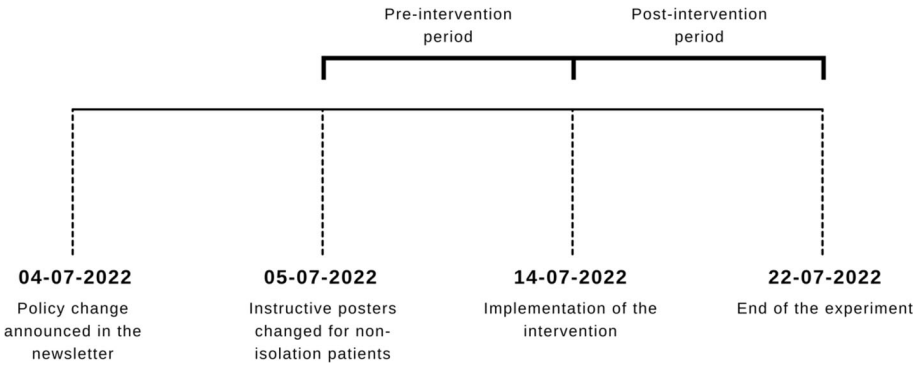

FIGURE 5 Experimental timeline. Both the pre-intervention and post-intervention period lasted 9 days.

TABLE 3 Average apron usage per intervention and measurement period.

Intervention	Measurement	Observations	Median	Mean	SD	Range
1: Prime + Visual prompt	Pre	74	5	5.973	4.068	1–20
	Post	54	5	5.889	3.580	0–17
2: Social norm	Pre	58	5	5.552	3.262	0–14
	Post	60	5.5	6.000	2.870	1–13

Note: Number of observations, medians, means, standard deviations (SD) and ranges per intervention and measurement period.

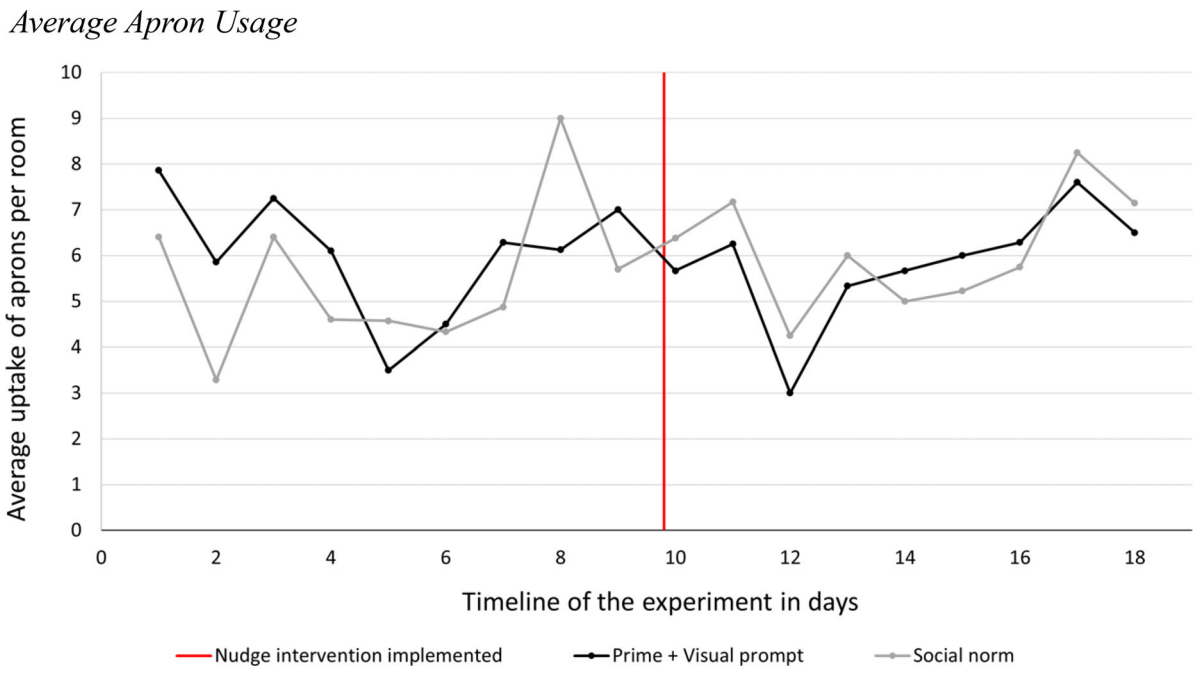

FIGURE 6 Average apron usage. Daily apron usage for Intervention 1 (Prime + Visual prompt, in black) and Intervention 2 (Social norm nudge, in grey).

additional days of observations were collected to avoid potential power problems (see Supplementary Materials). Upon completion of the extended intervention period, all nudge materials were removed.

The number of used aprons per room per day shift was determined by counting the number of available aprons twice a day: just before the start (7:30 AM) and at end (4:00 PM) of the day shift. Counting was intentionally made inconspicuous by simultaneously executing the task of replenishing the pile of aprons to not raise any suspicions from personnel, given awareness of being observed could alter the critical care workers' behaviour (i.e., Hawthorne effect[53,54];).

4 | RESULTS

In total, 246 observations were used for analysis. Each observation contained the number of aprons used during the day shift in a single ICU patient room (see Table 3). An overview of apron usage per day appears in Figure 6.

First, we examined whether the Prime + Visual prompt nudge (i.e., Intervention 1) led to a reduction of apron usage (H1). Because the data violated the assumptions for parametric testing, we conducted a Mann–Whitney *U* test. Results show that critical care

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personnel did not use fewer aprons after (Mdn = 5, $M = 5.889$, SD = 3.580), compared to before (Mdn = 5, $M = 5.973$, SD = 4.068) Intervention 1, $U = 1979$, $z = -0.092$, $p = 0.927$, Cohen's $d = 0.022$. These results indicate that the Prime + Visual prompt nudge did not elicit an increase in sustainable behaviour, rejecting H1.

Second, we examined whether the Social norm nudge (i.e., Intervention 2) led to a reduction of apron usage (H2). Since the data again violated the assumptions for parametric testing, we conducted a Mann–Whitney U test. Results reveal that critical care personnel did not use fewer aprons after (Mdn = 5.5, $M = 6.000$, SD = 2.870), compared to before (Mdn = 5, $M = 5.552$, SD = 3.261) Intervention 2, $U = 1566.5$, $z = -0.939$, $p = 0.348$, Cohen's $d = -0.146$. These results indicate that the Social norm nudge also did not elicit an increase in sustainable behaviour, rejecting H2.

5 | DISCUSSION

We examined whether nudging could be used to elicit sustainable behaviour among critical care workers. Specifically, we examined the effect of a Prime + Visual prompt nudge and a Social norm nudge on apron usage. Through these nudges, ICU employees were encouraged to choose PPE with the goal of reducing health care waste while adhering to patient safety standards. Unfortunately, although a small reduction in apron usage in response to the Prime + Visual prompt was observed, the effect was not statistically significant. The Social norm nudge also did not reduce apron usage. In previous literature, the primes examined in this paper all have been found to elicit more sustainable behaviour.[25,26,31,38–40,55] There are several possible reasons why our results do not align with these findings.

First, the use of PPE is likely influenced by perceptions of safety (both patient and personnel).[16,46] Possibly, these perceptions may have been too ingrained or strong to set aside after exposure to a nudge. This is particularly important as the intervention took place in a context in which memories about the lack of resources and safety measures during the peak of the COVID-19 pandemic had not faded. Indeed, interview findings with health care workers from Erasmus MC ICU revealed that they place high importance on quality of care and may therefore feel uncertain about sustainable alternatives and patient safety (Maanicus, 2022).[56] Although the new policy was approved by the Infection Prevention Center and the word 'safe' was included in the prime and visual prompt nudge, perhaps the interventions did not sufficiently play into these concerns. To examine the effect of safety concerns on nudge effectiveness in a critical care context, future research could compare nudge effectiveness between behaviours that are and are not related to (patient) safety.

Second, due to privacy constraints, it was not feasible to observe individual decision-making moments. Instead, we counted the number of aprons per day shift. While the interventions may have induced some health care workers to work more sustainably, it may have also made the situations during which aprons are supposed to be worn more salient to others. In other words, the intervention may have inadvertently induced some health care workers to wear (fresh) aprons more frequently than before. In turn, this could have offset any favourable results. Future research in which it is determined whether each decision was made correctly could examine whether this methodological limitation affected the study outcomes.

Third, apron usage before the introduction of the new policy was not measured. It is possible that the initial protocol modification itself led to a substantial alteration in apron uptake. The aim of this paper was not to estimate the effects of the new policy, but those of the additional interventions (nudges). However, a large change in the use of aprons after the policy change could potentially overshadow the impact of the subsequent intervention aimed at further reduction (Marsden & Torgerson, 2012),[57] and that no nudges were needed to further encourage policy compliance. This will not pose a threat to the internal validity of our results but may limit the external validity. When evaluating the effect of a new policy, we recommend also measuring behaviour before the introduction of the new policy as a baseline.

Fourth, incidental observations and experiences while making observations led to the belief that some health care workers in the ICU experienced a certain degree of psychological reactance to the intervention. Psychological reactance refers to negative reactions that arise when individuals perceive an attempt to alter their behaviour.[58] Previous research demonstrated that some people consciously act contrary to the encouraged action as a form of protest to being manipulated.[59] Examples of psychological reactance in this study are the repeated removal of social norm stickers and overheard discussions between ICU employees about the intervention unwelcomingly restricting their choices. Such interactions among staff members about the experiment violated the assumption of independence and may have fuelled other confounding factors like the Hawthorne effect.[53,54] Future research could examine whether this psychological reactance can be reduced by involving the target audience early in the process during the design stage[60] or by being transparent about the goal and implemented nudge.[61] Previous research has found that transparency can increase the acceptance of nudging while preserving[62–64] or even increase effectiveness.[65] In addition, future research should also focus on interventions aimed at behavioural change developed following a bottom-up approach.

6 | CONCLUSION

The Dutch health care sector strives to reduce the usage of single-use items to reduce material consumption and waste. Previous research demonstrated that within critical care, personal protective equipment such as apron is one of the largest contributors to CO_2 emissions. Previous research also demonstrated that nudging can be used to induce more sustainable behaviour. We examined whether a Priming + Visual nudge and a Social norm nudge could reduce apron usage among critical care workers, but neither affected apron usage. The question remains whether this null finding is a correct reflection of reality, or whether methodological choices and limitations affected the outcomes. Although the critical care context brings specific

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methodological challenges such as safety concerns[16] and a stressful work environment,[34] this study highlights the importance of testing behavioural interventions in a critical care context.

AUTHOR CONTRIBUTIONS

Sophie Van Der Zee: Conceptualization; research; methodology; data interpretation; writing. **Tamarah Verhoog**: Conceptualization; research; methodology; data analysis; data interpretation; writing; revision; review. **Theo Post**: Conceptualization; research; methodology; data analysis; data interpretation; writing; revision; review. **Pilar Garcia-Gomez**: Review; revision. **Erik M. van Raaij**: Review; revision. **Jan-Carel Diehl**: Research; review; revision. **Nicole Hunfeld**: Conceptualization; methodology; interpretation; review; revision. All authors contributed to the development of the manuscript and approved the final draft.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Aprons at https://github.com/sophievanderzee/Aprons.

ETHICS STATEMENT

The authors state no conflict of interest. The research was conducted without external funding. Approval for the conducted field experiment was received from the Erasmus School of Economics Internal Review Board-Experimental (IRB-E) under reference number ETH2122-0751. The conducted research adheres to the Netherlands Code of Conduct for Research Integrity. All data, code and materials are made publicly available through https://github.com/sophievanderzee/Aprons.

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