Nudge Interventions Promoting Hand Hygiene: A Large-Scale Field Experiment in an Industrial Plant

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Abstract

Aim: This study investigated the effectiveness of nudge interventions promoting hand hygiene in an industrial plant during the COVID-19 pandemic. **Subject and Methods:** A large field experiment was conducted with 861 participants and 14,645 observations. The interventions involved manipulating the placement of alcohol gel dispensers, the presence of social norm messages, and the placement of footstep stickers on the ground. **Results:** All interventions significantly increased the usage of alcohol gel dispensers, with the combination of placement and social norm message providing the greatest results, increasing usage by 47%. People passing by in groups had a higher probability of using the dispenser than individuals, and this effect appeared to be solely mediated by the leading example of the first person in the group using the dispenser. **Conclusion:** The findings provide guidance for promoting health and safety compliance within organizations to combat surging infection rates related to COVID-19 and other infectious diseases, such as the seasonal flu.

Keywords

Nudging; Hand hygiene; Infectious diseases; Field experiment; Process Industry

Highlights

- Nudges effectively increase hand hygiene in industrial plant during the COVID-19 pandemic.
- The study manipulates dispenser placement, social norm messages and footstep stickers.
- The interventions significantly increase alcohol gel usage, with best results arising from the combination of placement and social norm messages.
- Social influence plays a role, with groups more likely to use the dispensers when led by first person using it.

Hand hygiene is a critical factor to prevent illness and counter the spread of infectious diseases (Aiello et al. 2008; Wong et al. 2014). Good hand hygiene practices have shown to, among others, reduce illness-related absenteeism, at work (Arbogast et al. 2016) or schools (Wang et al. 2017), mitigate food poisoning (Lee et al. 2017) and prevent detrimental or even fatal hospital-acquired-infections (HAIs) (Boyce & Pittet 2002; Jefferson et al. 2009). More recently, it also appeared as one of the important safety guidelines to prevent the spread of the coronavirus (SARS-CoV-2), in public and in the work place, during the pandemic (Brauner et al. 2021; Ingram et al. 2021). To date, multiple vaccines have proven effective against this coronavirus reducing hospitalization, severe illness and excess mortality drastically (McDonald et al. 2021). Yet, the higher risk for fatalities in developing countries (Levin et al. 2022) and the potential increasing chance of future pandemics, due to climate change (Mora et al. 2022), indicate that insights into pandemic control, and combatting the spread of infectious diseases in general, remains of primordial importance. Next to vaccination, it became evident that human behavior plays an important role in controlling such a pandemic and infection. Good hand hygiene, social distancing, the wearing of mouth masks, ventilation and a significant reduction in social contacts, appeared to be the core aspects to battle the spread of the virus (Brauner et al. 2021; Ingram et al. 2021; Talic et al. 2021). Preventive behavioral measures to stop the spread of viral infections, like disinfecting hands, have been more common and promoted in health environments because health risks are greater in these contexts (Allegranzi and Pittet 2009). However, the coronavirus and other viruses like the seasonal flu penetrate all levels of society, endangering also other vulnerable groups of people (Mirzadeh and Khedmat 2022; Liu et al. 2021), including the work force of organizations and their social networks. The present paper aims to assess whether

behavioral interventions can be used to promote good hand hygiene in a non-health private company context and hence to evaluate if these behavioral interventions could assist in controlling the spread of these viruses.

Especially in environments with many social interactions, effective safety measures against the coronavirus are critical. Not only in the context of Corona, but also for other diseases that may compromise employee health and absence. Previous studies have shown that influenza accounts for millions of lost days at work and substantial economic losses to employers (Akazawa et al. 2003). Here, we aim to investigate the social dynamics that influence compliance with hygienic safety measures. In order to do so, we carry out a field experiment at the sites of a Belgian steel plant, with a total of 5500 employees, to investigate the influence of several behavioral interventions on hand hygiene. We set up interventions such as varying the position of hand sanitizers, increasing their visibility and by placing messages to encourage hand hygiene. Because group influences are very important in large industrial plants, we also assess whether there is a difference in the usage of the hand sanitizer when entering in group compared to people who pass by individually. Those insights can prove useful to support policymakers in minimizing the infection rates in both health and non-health organizations, and society as a whole.

Revising safety measures from a boundedly rational behavioral perspective

Next to vaccines, interventions implemented to slow down the spread of the coronavirus include hand washing and disinfecting, wearing masks in public, physical distancing, ventilation and eventually a variety of lockdowns, covering curfew, quarantines and travelling restrictions (Lunn et al. 2020; Meyerowitz-Katz and Merone 2020). It became increasingly clear however that

the expected compliance with the proposed more rational measures is complicated by a variety of human factors. From a social perspective, the perseverance of people is put to the test on respecting the corona measures, by demanding a reduction of social interaction, self-isolation, curfew restrictions, limited physical affection and the lack of leisure activities. This derogation of the social tissue is detrimental for the mental health of the population (Xiong et al. 2020). Both economic and social challenges complicate fostering and enforcing compliance with the imposed safety measures (McKibbin and Fernando 2021). It is therefore important to take a closer look at the behavioral and cognitive barriers that hamper compliance with the safety measures in more depth. Some people might have the intention to comply with the safety measures, to the extent that they find it reasonable, but fail to act accordingly. Other people might be ignorant or reluctant to compliance. What determines whether people decide to disinfect their hands, when arriving at the workplace, or not? Do people apply rational calculations about the infection rate at work? We know that humans are not always rational agents that optimize behavior, especially not in such a complex and unseen pandemic. Human decision-making is bound in its rationality and often works with heuristics that are prone to cognitive biases (Kahneman 2011). Other influences such as the strong impact of human emotions result in decisions and actions that can differ strongly from our desired outcome; or the outcomes that governments consider desirable (Benartzi et al. 2017). According to the dual-process theory of decision-making (Kahneman 2011), a relevant distinction can be made between two systems of thinking.

System 1 thinking is a more automatic, fast and unconscious way of thinking that requires little effort and is associated with no feeling of control. This is seen as a more instinctive way of 'thinking' or decision-making, and includes subconscious values, drives and beliefs that influence

our ‘gut reactions’. Examples are the automatic actions when driving a car on an empty road, subconsciously linking a color to certain moods and mindlessly following the example of a group of people (e.g., looking up or suddenly starting to run). System 2 thinking is considered a more rational way of thinking and is associated with the subjective experience of power to act, choice and concentration. It includes conscious attention for the mental effort that is being done. Examples are trying to remember something, comparing the price-quality of products and focusing attention in a noisy room. Behavioral interventions that address System 1 assist in following through with the right intentions or that encourage the desired behavior by rearranging the social or physical environment. This approach, also referred to as ‘nudging’, acts upon various often overlooked aspects of human behavior, including its bounded rationality, in current safety measures and is a valuable complementary component of current behavioral change strategies.

The concept of nudging

The idea that humans are boundedly rational has given rise to a series of psychological studies investigating how behavior can be influenced through by modifying contextual, often subconscious, factors. Thaler and Sunstein (2008) put forward the concept of ‘nudging’, meaning literally ‘to give a little push’, to address this practice. They suggest that people can be guided and supported in making the right decisions to promote the more preferred behavior, by altering the choice architecture surrounding this behavior – i.e. the physical, social and psychological aspects of the context that influence our choices. A typical example of a nudge is a default opting-out procedure to promote organ donations (Davidai et al. 2012), which leverages the human tendency to minimize effort when indifferent to the outcome (de Ridder et al. 2022). Another example is

the use of colorful footprints towards the stairs to promote stair climbing (Van Hoecke et al. 2018). This salient intervention draws attention to a certain desired action (i.e., stair climbing) suggesting it is the better choice to make in the given situation. The goal of these nudges is to counter undesired flaws in modern day decision-making, targeting evolutionary heuristics and cognitive limitations, to achieve the desired behavioral outcomes (Tversky and Kahneman 1974). The application of nudges has been found successful in various domains, including health (Hanks et al. 2012), financial decision-making (Thaler and Benartzi 2004), climate preserving actions (Bergquist et al. 2023) and education (Weijers et al. 2021), and can be an aid to a good health and safety policy (Dolan et al. 2012; Goldenbeld et al. 2016).

Effectiveness, cost-effectiveness and ethical concerns

A recent meta-analysis by Mertens and colleagues (2022), including more than 200 studies, concludes that overall choice architecture interventions (or nudges) promote behavioral change with a small to medium effect size (Cohen's d = 0.45). Other studies, including data from governmental nudge units (DellaVigna and Linos 2022) and controlling for publication bias (Maier et al. 2022), call for caution and indicate that expected effect sizes are likely to be lower. Hallsworth (2022) adds that the goal should be to assess the effectivity of nudges in specific contexts, rather than to summarize the effectiveness of nudges in its entirety; which may lead to inaccurate and irrelevant conclusions. Context dependency is key for nudge interventions and should encourage research to define the crucial influencing environmental factors. In addition, the long-term effects of nudges have barely been studied and the few studies show mixed results (Brandon et al. 2017; Marchiori et al. 2017; Van Rookhuijzen et al. 2021). It appears to be dependent on both nudge

types and implementation context, which again highlights the importance of a fine-grained analysis of the contextual moderators.

One of the biggest advantages of using nudge interventions is their cost-effectiveness in comparison to typical intervention methods such as financial incentives. Indeed, Benartzi et al. (2017) report that government nudges often yield particularly high returns at a low cost when it comes to boosting retirement savings, college enrolment, energy conservation, and vaccination rates. For example, $1 spent on retirement saving interventions resulted in an increased contribution of $100 for nudges, compared to $14.58 for information campaigns and $1.24 for tax incentives. These findings suggest that nudging interventions could be of great value to improve the cost effectiveness of behavior change programs in public and private organizations, including public health policy.

Nudging has also sparked debates concerning ethical issues and whether it is legitimized to alter people's behavior in often covert ways without consent of the affected individuals (Lin, Osman and Ashcroft 2017). Sunstein (2015) concludes that when nudges fall within the periphery of the concept of manipulation (i.e., not the strongest forms such as lies), when they have legitimate purposes, when they would be effective, and when they do not diverge from the kinds of influences that are common and unobjectionable in ordinary life, that the burden of justification often can be met. Also, it is impossible not to have a choice architecture. For instance, regarding placement of alcohol gel dispensers, it has to be placed somewhere. Optimal placement boosting use may be a nudge, but placement discouraging use is also a nudge relative to the optimal position, be it in the wrong direction from a health optimization viewpoint.

Nudging hand hygiene

Prior to COVID-19, hand hygiene was already particularly important for hospitals, as HAIs can be detrimental or fatal for patients with a weakened immune system (Boyce and Pittet 2002). Hand hygiene is considered one of the primordial factors to combat HAIs (Jefferson et al. 2009). Aaerestrup and Moesgaard (2017) examined how hospital visitors can be nudged to comply with hand hygiene protocols. They found that nudge interventions focused on the placement of the hand sanitizers, colorful indications and social norm messages (i.e., informing about what people do or find important) were successful in promoting hand hygiene. These findings were replicated in more recent studies in hospitals with larger sample sizes (Mobekk and Stokke 2020; Hansen et al. 2021). A systematic review on nudge effectiveness promoting hand hygiene found that nudges were overall effective, but included mainly studies in hospitals and schools, and only one in a shopping street and a military base (Gof 2022). These results are encouraging in the light of a pandemic, and for controlling viral viruses in general, as they provide guidance of how we could successfully improve hand hygiene in a non-health private organization using nudge interventions. More closely to this topic, Van Dessel and colleagues (2022) found nudges (i.e., placement plus red sign 'Please disinfect hands', and posters with elderly 'Disinfecting hands saves lives. Will you disinfect your hands?') to be effective in promoting hand hygiene among visitors of a supermarket. A remaining question which we address in the current study is whether these interventions can be successful in contexts such as the daily workplace, especially contexts in which health and hygiene is not very apparent, like industrial plants. The clear distinction of the effect of hygiene nudges between environments where hygiene is less apparent (e.g., industrial plants), compared to environments where hygiene is more apparent (e.g., hospitals, schools, food stores), is hardly

investigated. In addition, most nudge studies focus on visitors, while more research among employee populations is needed (Gof 2022).

Friction and salience

Some choice architectural elements used in previous nudge studies, including those promoting hand hygiene, form a valuable basis for this study. Friction is one of those concepts often used for effective behavior change. This concept was first described in the 19th century by Guillaume Ferrero as 'the Principle of Least Effort' (1894), stating that if humans are presented with multiple paths for any decision, they will inevitably pick the easiest. Metcalfe et al. (2020) found that the mere placement of healthy food in school cafeterias affected the food selection and consumption of the pupils, and Van Houten et al. (1981) nudged participants to take the stairs by increasing the waiting time of the elevator by 16 sec. By strategically placing hand sanitizers and reducing friction, an increased usage of alcohol gel could be expected, as found in the hospital studies (Aaerestrup and Moesgaard 2017).

Another relevant aspect includes altering the salience of the alcohol gel dispensers. Salience is described as that property by which some things stand out compared with its surroundings. It captures the capacity of something in the environment to catch and retain one's attention (Taylor and Thompson 1982). A better placement of the hand sanitizer increases the visibility and might be more salient. As an example of the versatile ways in which salience can be increased, Hansen (2011) found that the use of green footstep prints towards trash cans reduces littering. He argues that increased salience is an important aspect of behavior change interventions and that the presence of stronger social norms could moderate the salience effect. This means

that the stronger a certain behavior is considered as 'desirable', the stronger the effect can be of salient interventions drawing more attention to these specific actions.

Group behavior and social norms

People are easily influenced by their social context. How others behave or what they value (i.e., social norms) has a strong impact on the individuals' belief and behavior. Research has shown that the behavior and attitudes of others can be contagious, either by the thought of missing information that the group must have (i.e., social proof; Cialdini 1993, 1999) or by the need to belong to a group, based on the fear of being expelled, which can lead to conformity[1] (Ash 1956). In the light of the COVID-19 pandemic, the apparent impact of social influences is shown in recent occurrences, such as global panic buying in retail (Prentice et al. 2022) and international stock market inefficiencies (Aslam et al. 2022). Both examples are generated by contagious behaviors and expectations, and stress the possible consequences of herd mentality and herd behavior[2] (Banerjee 1992). Studies in several domains, including health and finance, use insights in those social dynamics (i.e., herd behavior, conformity and social proof) to implement behaviorally informed social interventions (Allcott 2011; Bikhchandani and Sharma 2000; Lindhout and Reniers 2017). The same social dynamics should be considered when developing safety interventions to combat infectious diseases (e.g., promoting hand hygiene), especially during a pandemic.

During the pandemic clear expectations have been communicated by the government and employers regarding safety measures (Brauner et al. 2021; Talic et al. 2021), and relatives and

[1] Conformity is the act of matching attitudes, beliefs, and behaviors to group norms to avoid rejection (Ash 1956).
[2] Herd behavior refers to people acting in the same way as others are doing, instead of using their own information or by making independent decisions.

colleagues express their opinions and values to a certain degree. In this way, behavior such as hand hygiene compliance can become strongly subjected to social norm influences. Social norm nudges provide feedback on one's actions compared to a reference group[3] and have proven particularly effective in promoting pro-environmental behavior (Farrow et al. 2017; Bergquist et al. 2022). Social normative feedback can either be descriptive, representing what most people actually do to allow impactful comparisons (e.g., "the majority of guests reuse their towels" in Goldstein et al. 2008), or injunctive, communicating what behavior others approve or disapprove (e.g., "Please don't remove the petrified wood from the park" in Cialdini et al. 2006). According to Cialdini (2013), injunctive norms are often more effective when the undesirable behavior is more prevalent than the desirable behavior. In a health context, social norm messaging has proven effective in promoting hand hygiene among hospital visitors (Mobekk and Stokke 2020). The question remains whether the effect maintains in an environment, such as a steel industry plant, where social norms towards hand hygiene are less strong and explicit.

[3] Reference groups refer to any group that is used by an individual as a standard for evaluating themselves and their own behavior (Bicchieri 2017).

Current study

According to studies in hygiene-focused environments, including schools and hospitals (Jefferson et al. 2020), proper hand hygiene reduces acute respiratory infections (ARIs) and absenteeism by up to 16% and 36%, respectively. Hospital studies suggest health-promoting nudges can enhance hand hygiene compliance up to 40-60% (Aarestrup et al. 2016; Hansen et al. 2021; Mobekk et al. 2020), which in turn would lead to an approximate 8% ARI reduction and a 16% decrease in absenteeism according to the results of Jefferson et al. (2020). As COVID-19 and seasonal flus impact the broader population, more research, especially in under investigated less hygiene-centric organizational settings, is needed to assess the effectiveness of behavioral interventions in reducing workplace absenteeism and preventing hospitalizations (Mirzadeh and Khedmat 2022; Liu et al. 2021). For this end, a large-scale field experiment is carried out at the Belgian site of the multinational steel factory during the pandemic (June – August 2020). Here, we aim to examine if nudge effects hold in a context where health and hygiene is less apparent and that involves mainly employees instead of visitors (e.g., successful hand hygiene nudges in supermarkets, Van Dessel et al. (2022)), often overlooked in nudge studies (Kubera 2023) (RQ1). To address this issue, multiple nudge interventions are developed and implemented on the site of the steel company.

The first nudge intervention focuses on the placement of the hand sanitizers. By doing this we alter the required amount of effort to perform the action, which is often referred to as a reduction of friction (Popova and Popov 2015). By making the action easier to perform, even slightly, an increase of the desired behavior is likely to occur. In accordance with similar behavioral studies manipulating friction to promote healthy food, consumption and hand hygiene in hospitals,

we expect this intervention to have a moderate effect on hand hygiene compliance at the industrial plant (Hypothesis 1). In this study, with 'compliance' we refer to people disinfecting their hands or not every time one passes by hand sanitizers. Mainly, while entering or leaving a different area/room with potentially other people nearby, and thus risk of contagion. This should be interpreted in the context of periods of heightened risk of contagion through social contact, such as during a pandemic or seasonal flu. Further refinement of required handhygiene compliance (e.g., repetition over time, hand movement while rubbing or disinfectant details) lies beyond the scope of this study. A second intervention focuses on salience by placing green footstep prints towards the hand sanitizer. This should redirect the attention to the hand sanitizer more explicitly and increase its weight on the decision to comply or not. A small positive effect on hand hygiene compliance is expected (Hypothesis 2), as was found in previous studies with salient footstep prints in the context of littering (Hansen, 2011) and the use of stairs (Van Hoecke et al. 2018). A third intervention is a displayed message relating to the elaborated concept of social norms (Bicchieri 2017). By providing information about what others do (i.e., descriptive norms) and approve (i.e., injunctive norms) regarding the use of the hand sanitizer, we aim to highlight good examples and values, and to evoke social influences promoting hand hygiene. The use of social norm messages proved successful in improving hand hygiene in hospitals (Mobekk et al. 2020). Here we expect a positive effect of social norm messaging, but smaller than in the hospital environment, as compliance with hand hygiene and its potential consequences carries a lower weight in the current industrial context (Hypothesis 3).

In addition, we aim to study if the appearance in group influences the usage of the hand sanitizer (RQ2), taking in consideration the relevant insights of herd behavior (Le Bonn 1899;

Economou et al. 2018; Lin 2018). Here, we expect that people in group become more aware of potential moral condemnations and therefore become more sensitive for guiding social cues (i.e., social norm messages and behavior of group members) and tend to conformity (Banerjee 1992), increasing the usage of the hand sanitizer (Hypothesis 4).

Method

Participants

In this study, carried out in a natural industrial setting, we observed all employees passing by the main entrances in the Administrative Building (AB) of the steel plant. During the two months of our research, 861 separate employees worked at the AB, excluding those who worked remotely. Of this group, 74% identified themselves as male (N= 639) and 26% as female (N=222). The male group had an average age of 48 years old (*M*= 48.2, *SD*= 10.6), compared to an average age of 46 years in the female group (*M*= 46.3, *SD*= 8.7). The members of both groups had a predominantly Belgian nationality, respectively 98% and 95% for the male and female group. Most of the employees working at the AB are white-collar workers, with a small share of blue-collar workers (<5%). Before starting this study, approval was obtained from the labor unions representing all employees, informing them about the content of the study, interventions and privacy implications. Summaries of the results are free accessible for the employees on the intranet website of the steel plant. Ethical clearance for this study was provided by the safety department of the industrial plant.

Research design

In this field experiment, we use a mixed design incorporating within-subjects evaluations per location and between-subjects comparisons between locations, including multiple control groups (see overview Table 1). Five locations at the AB were selected with the highest number of passersby. This included three main entrances to the building (*Gate 1-3*), the sandwich bar (*Gate*

4) and one entrance to the restaurant (*Gate 5*). A variety of interventions was assigned to each location, including pre- and post-tests. Except for the control location, each location contained a varying combination of the interventions but in a different order to partially counterbalance sequence effects. The experiment lasted 7 weeks in total. *Gate 5* functioned as a control measurement. No interventions were implemented here. Because of worsening corona conditions and governmental measures, reasons unrelated to the experiment, this location had to close in week 6. Therefore, several control measurements were done at other locations, removing active interventions for a week, to see if the effects would decrease or persist. In the other gates (*Gates 1-4*), the control condition and Intervention 1 lasted for two weeks, while other interventions lasted at least 1 week.

Table 1. The sequence of the nudge interventions per location

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Gate 1 (camera footage)	Control	Control	Placement	Placement	Placement Social norm	Placement Social norm Footsteps	Control
Gate 2 (camera footage)	Control	Control	Placement	Placement	Placement Footsteps	Placement Social norm Footsteps	Placement Social norm Footsteps
Gate 3	Control	Control	Placement	Placement	Placement Footsteps	Control	Placement Footsteps
Gate 4	Control	Control	Placement	Placement	Placement Social Norm	Placement Social Norm	Placement Social Norm
Gate 5	Control	Control	Control	Control	Control	/	/

Note: Gate 1 = 'Main entrance Wing 5'; Gate 2 = 'Main entrance 2; Gate 3 = 'Main exit; Gate 4 = 'Sandwich bar'; Gate 5= 'Restaurant'; Control = 'Original position of hand sanitizer'

Materials and procedure

We test the effect of the mere placement of the dispensers (see Figure 1), removing them from the wall and placing them on a pillar in the middle of the entrance (see Figure 2), making it more visible and less effortful to use the dispenser. The same manual dispensers are chosen that hung up already, requiring a horizontal push to use it. Every location has the same type of dispenser. Using a new, hands free, dispenser could have influenced the behavior of interest and thus the results of the experiment. For this reason, four stable stands are crafted at the central workshop of the industrial plant with weighted bases to resist the impact of horizontal pushes. For the second intervention, we add a sign with a social norms message ("Here we use ALCOHOL GEL to protect each other", in Dutch) on a green background (see Figure 3). A potential unintended effect of social norms messaging occurs when the message emphasizes the majority of people performing the undesired behavior. A message displaying that 30% of the people comply with the rules, triggers thoughts of 70% doing the opposite (Cialdini et al. 2006; Goldstein et al. 2008). As we estimate the initial compliance rate to be rather low, we decide to keep the message more abstract by not providing any percentages. Mentioning the 5% baseline level of compliance at the administrative building of the steel plant could have been detrimental for the effectiveness of this intervention. A third intervention is the use of salient green footstep prints on the floor heading towards the alcohol gel dispenser (see Figure 4). For this purpose, we used ground stickers that can be placed easily on the ground and were robust. At last, we test a combination of all three nudges, including placement, salient footsteps and a social norms message (Figure 5).

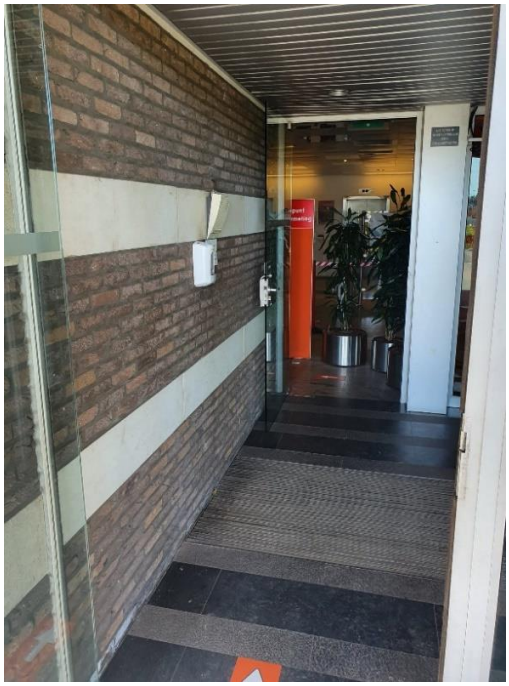

Figure 1. Original placement of the hand sanitizer (Control condition)

Figure 2. The mere placement of the hand sanitizer on a pillar (Intervention 1)

Figure 3. The placement of the hand sanitizer on a pillar with a social norms message (Intervention 2)

Figure 4. The placement of the hand sanitizer with salient footprints (intervention 3)

Figure 5. The placement of the hand sanitizer on a pillar with a social norms message along with salient footprints (Intervention 4)

Observation method

Two observations methods were selected: alcohol gel consumption (in ml) and camera footage.

Alcohol gel consumption

At all locations, changes in the volume of the dispensers were measured. This provided us with information how much alcohol gel had been used exactly at each of the five location. From this we could deduce and estimate how many of the passersby disinfected their hands. To make an accurate estimate two things needed to be assessed, namely the amount of pushes per individual while using the dispenser and how much milliliter of alcohol gel one push contains. A preliminary observation has been carried out to check the amount of pushes. From the 100 people

observed, 97 pushed the dispenser one time, the other 3 two times. Based on this observations, the assumption was made that one person would push the dispenser one time in most cases during the experiment. Camera footage was used to double check as will be discussed later. To assess the volume of one push, the average was taken of 50 pushes. The average volume of one push was 1 ml. The consumption of the alcohol gel was measured at each location twice a week, at Wednesday and Friday evening at 19h. To determine the amount of passersby data was collected from the electric gates, which people need to pass to enter, together with camera footage.

Camera footage

At specific locations, including *Gate 1* and *Gate 2,* camera footage was used. This allows us to make observations that are more accurate and to double-check the reliability of the alcohol consumption method. Specifically, we used this data to investigate social effects, usage in group or individually, and the difference between different time slots (07h00 – 11h00; 11h00 – 15h00; 15h00 – 19h00). In this way, data from more than 14 000 observations is collected during the experiment across all locations. In-person observations were not appropriate because of the time-consuming nature, the impossibility to observe multiple places simultaneously because of lack of additional observers, and the potential impact on the participants' behavior. The approval for using cameras is obtained from employee unions and the management of the industrial plant on condition that the privacy of the employees would be strictly protected.

Data analysis

We use the ordinal least squares (OLS) method to investigate the effect of the nudge interventions on the alcohol gel consumption, along with the mere effect of the time periods (i.e., 'Monday-Tuesday-Wednesday' and 'Thursday-Friday') and locations on the consumption of the alcohol gel. The usage (in ml) per passerby is the dependent variable, while the interventions, time periods and locations served as predictors.

To attain a deeper insight into the usage of the alcohol gel dispenser a logistic regression (LR) was conducted to analyze the dichotomous data of dispenser use (1= used, 0= not used) collected using the camera footage. These results do not only provide us a more detailed insight in the effectiveness of the nudges, but also allow us to investigate the effect of social dynamics in influencing the usage of the alcohol gel dispenser. More specifically, we measure the effect on usage by the participants being in a group or not and whether or not the first person used the dispenser. In addition, the effect of individual weekdays (i.e., Monday, Tuesday, Wednesday, Thursday and Friday) and specific time intervals per day (i.e., 'Morning' = 07h00-11h00, 'Noon' = 11h00-15h00, and 'Afternoon' = 15h00-19h00) are assessed. The Odds-ratio (OR) is used to facilitate the interpretation of the probabilities of the dichotomous outcome variable. The OR is a measure of association between exposure and outcome. It represents the odds that an outcome will occur given a particular exposure, compared to the odds that the outcome will occur without that exposure. All analyses were performed in IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, N.Y., USA).

Results

Ordinary Least Squares (OLS) regression – Alcohol gel consumption

Table 2 displays the results of the first part of the OLS regression analysis, including the effect of the nudge interventions, time periods (i.e., 'Monday-Tuesday-Wednesday' and 'Thursday-Friday') and locations, for the alcohol consumption method. The results of the OLS regression show us that all the intervention conditions have a statistically significant result on a 0.01 level ($p < .01$). In the control condition, the dispenser was used in 7% (N=993)[4] of the opportunities observed (N=13820). In the placement and placement-footsteps condition, the dispenser was used in 27% (N=2434) and in 47% (N=1125) of the 2393 and 3075 observed opportunities respectively. For the placement-message condition, the dispenser was used in 45% (N= 1384) of the observed opportunities (N=3075), and in the placement-message-footsteps condition the dispenser was used in 57% (N= 1613) of the observed opportunities (N=2830). See Table A1 in appendix for a more detailed overview of the amount of passersby and the alcohol gel consumption (in ml) per condition. Passersby in the placement condition are 21% more likely to use the alcohol gel dispenser when compared to the baseline. Passersby in the placement-message condition, in the placement-footsteps condition and the placement-footsteps-message condition respectively have a 46%, 38% and 54% higher probability of using the alcohol gel. The regression model additionally incorporates the second time period (i.e., 'Thursday-Friday'). The results reveal that the passersby in the have a small lower chance of 3% using the dispenser when compared to the baseline (i.e.,

[4] Note that this number represent the usage in ml. Given that pre-observations determined that 97% of the participants pushes one time and that one push equals 1ml, we use the usage in ml as an estimate of the amount of individuals who used the dispensers.

'Monday-Tuesday-Wednesday'), but these results are not significant. Next to nudging interventions and days-of-the-week effects, the model also controls for the locations of dispensers. Estimation results indicate that passersby at the locations *Main entrance Wing 5* ('Gate 1') and *Main entrance 2* ('Gate 2') are respectively 8% and 15% more likely to use the alcohol gel, when compared to the baseline measure, here *Main exit* ('Gate3'). People that passed by at the locations *Sandwich bar* ('Gate 4') and *Restaurant* ('Gate 5') were respectively 17% and 14% more likely to use the alcohol gel. Figure 6 provides an overview of the usage of the hand sanitizers (in ml/passerby) per condition.

Table 2. Results of the OLS regression analysis

VARIABLES	USAGE HAND SANITIZER	
	B	95% CI
Placement	0.213*** (-7.758)	0.16 - 0.27
Placement-message	0.417*** (-10.904)	0.34 - 0.50
Placement-footsteps	0.431*** (-10.715)	0.35 - 0.51
Placement-footsteps-message	0.516*** (-12.729)	0.43 - 0.60
Thursday-Friday	-0.025 (-1.230)	-0.07 - 0.02
Gate 1	0.078** (-2.329)	0.01 - 0.15
Gate 2	0.149*** (-4.514)	0.08 - 0.22
Gate 4	0.166*** (-4.571)	0.09 - 0.24
Gate 5	0.142*** (-3.612)	0.06 - 0.22
Observations	64	

R-squared	0.885

Note. t-statistics in parentheses; *** $p < .01$, ** $p < .05$, * $p < .1$; reference level for interventions 'Control', days of the week 'Monday-Tuesday-Wednesday' and for gates 'Gate 3'.

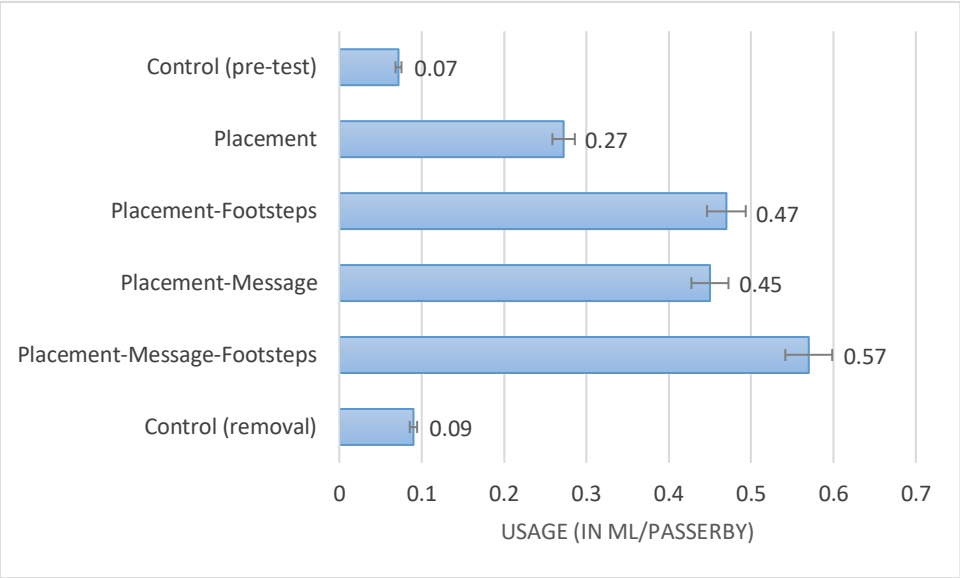

Figure 6. The usage of the hand sanitizers (alcohol gel consumption). The error bars represent 95% CI.

Logistic Regression (LR) analysis – Camera footage

The results of the LR provide us a more detailed insight into the effects of the nudge interventions, including differences on daily basis (i.e., Monday, Tuesday, Wednesday, Thursday and Friday) or certain time period during the day ('Morning', 'Noon' and 'Afternoon'). The data collected based on the camera footage has a higher accuracy and can thus be used as a double check of the effects found using the alcohol consumption method. The cameras were only present

at location *Main entrance Wing 5* ('Gate1') and *Main entrance 2* ('Gate2'), so the following findings only refer to these locations.

Nudge interventions

A summary of the results can be found in Table 3. The results of the LR analysis show that all intervention conditions have a statistically significant effect on a 0.01 level ($p < .01$). In the control condition, the dispenser was used in 4% (N=7274) of the opportunities observed (N=326). In the placement and placement-footsteps condition, the dispenser was used in 28% (N=1141) and in 41% (N=321) of the 4142 and 789 observed opportunities respectively. For the placement-message condition, the dispenser was used in 45% (N=226) of the observed opportunities (N=502), and in the placement-message-footsteps condition the dispenser was used in 51% (N=987) of the observed opportunities (N=1938). See Table A2 in appendix for a detailed overview of the amount of passersby and hand sanitizer usage per condition. The OR of the placement condition indicates that passersby in this condition were 7.7 times more likely to use the alcohol gel than in the baseline condition ('Control'). The OR ratio of the placement-footsteps condition, the placement-message condition and the placement-footsteps-message condition indicates that passersby were respectively 17.9, 19.8 and 20.4 times more likely to utilize the dispenser compared to the baseline condition. Figure 7 provides an overview of the usage of the hand sanitizers (in %) for all conditions.

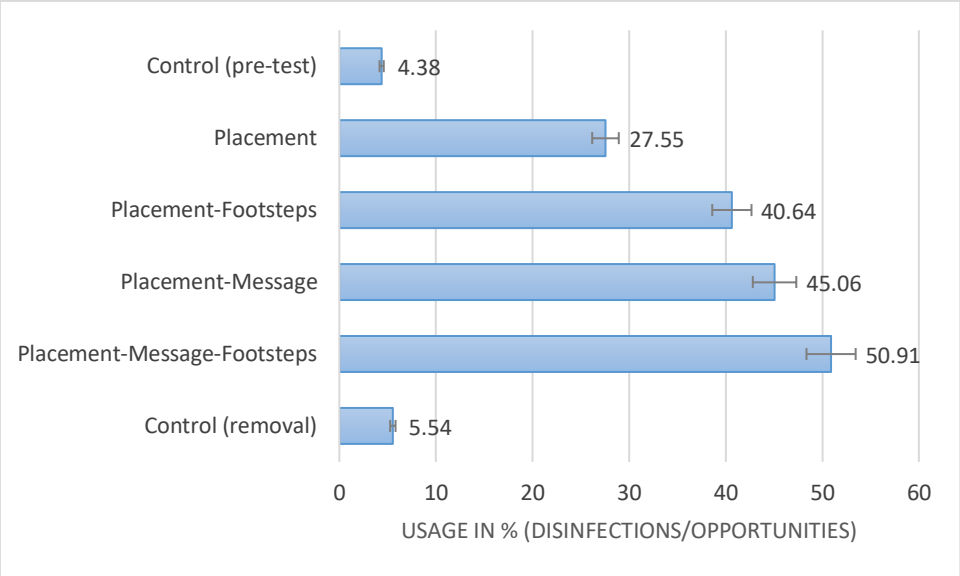

Figure 7. The usage of the hand sanitizers (camera footage).
The error bars represent 95% CI.

Weekday and time of the day

When checking for the effects of the before mentioned days of the week in Table 3, we see that each day presents a statistically significant effect. When taking Monday as the baseline condition, we see that the passersby at the other days are 12-19% less likely to use the alcohol gel dispenser. For Tuesday, Wednesday, Thursday and Friday, this is 12% ($p < .1$), 13% ($p < .1$), 15% ($p < .05$) and 19% ($p < .01$) respectively. The results also show us that the passersby in the morning, between 07h00-11h00, ('Morning') are 15% less likely ($p < .01$) to use the alcohol gel compared to the baseline, in this case the time period between 11h00 and 15h00 ('Noon'). People passing by

between 15h00-19h00 ('Afternoon') were 41% less likely ($p < .01$) to disinfect their hands compared to the baseline.

Social group effects

The LR analysis also allows us to investigate how social influences impact the usage of the alcohol gel (Table 3). The results of the first model indicate that passersby in group ('Group') are 8.4 times more likely ($p < .01$) to use the dispenser than when they are not in group; controlling for the weekdays and daily time periods. The second model adds the variable 'Group 1st', which captures if the first person in the group did or did not use the dispenser. When we look at the results we see that passersby in group were 27.3 times more likely ($p < .01$) to use the alcohol gel when the first person used the alcohol gel, compared to when this person did not. In addition, we see that the group effect, observed in the first model, is no longer significant after controlling for the 'Group 1st'. This indicates that not the mere fact of being in group impacts the use of the alcohol gel, but that the group effect is likely to be mediated by the leading example of the first person using or not using the dispenser. This finding remain stable after controlling for weekdays and time of the day effects. Across both models, we observe that the intervention effects remain relatively stable and significant at a 0.01 level ($p < .01$). In a subsequent analysis, we found that people who are in a group with the first person using ('Group 1st') were 2.5 times more likely ($p < .01$) to use the hand sanitizer compared to people who are in a group in general. Additionally, we found that people in a group with the first person using were 16.8 times more likely ($p < .01$) to sanitize their hands compared to individuals in a groups where the first person did not use the hand sanitizer.

Table 3. Results of the Logistic Regression (LR) analysis

VARIABLES	USAGE HAND SANITIZER			
	Exp (B)	Exp (B)	95% CI	Cohen's D
Placement	7.728***	7.724***	6.76 - 8.83	0.69
	(-30.05)	(-30.045)		
Placement-footsteps	17.896***	17.891***	16.02 - 24.36	1.08
	(-31.05)	(-31.052)		
Placement-message	19.781***	19.755***	14.91 - 21.46	1.13
	(-27.93)	(-27.924)		
Placement-footsteps-message	20.456***	20.438***	17.71 - 23.59	1.15
	(-41.204)	(-41.198)		
Tuesday	0.896	0.9	0.78 - 1.04	-0.07
	(-1.494)	(-1.430)		
Wednesday	0.859**	0.862**	0.75 - 0.99	-0.02
	(-2.182)	(-2.120)		
Thursday	0.832***	0.835**	0.73 - 0.96	-0.02
	(-2.605)	(-2.549)		
Friday	0.763***	0.773***	0.66 - 0.90	-0.05
	(-3.486)	(-3.303)		
Morning	0.851***	0.852***	0.77 - 0.94	-0.05
	(-3.314)	(-3.262)		
Afternoon	0.592***	0.601***	0.51 - 0.71	-0.15
	(-6.285)	(-6.111)		
Group	8.363***	0.543	0.16 - 1.85	1.29
	(-12.192)	(-0.977)		
Group (first person)		24.012***	16.62 - 37.15	1.58
		(-4.833)		
Observations	14,645	14,645		

Note. Z-statistics in parentheses; *** p < .01, ** p < .05, * p < .1; reference level for interventions 'Control', days of the week 'Monday' and time of the day 'Noon'.

Discussion

Next to the medical approach, it became clear that human behavior is a vital factor to temper a pandemic by an infectious virus like COVID-19 (Bavel et al. 2020). Yet, successfully attaining desired changes in behavior is proving difficult. Therefore, evaluating the effectiveness of behavioral interventions in controlling the spread of the coronavirus, and in extension for other viruses, such as the season flu, in both health and non-health environments, is undeniably necessary (Jefferson et al. 2020).

Nudges promoting hand hygiene: Friction, salience and social norms

Reducing friction is one of the most straightforward, yet also one of the most underutilized behavioral change techniques. Sunstein (2022b) also refers to the term 'sludge' to name excessive frictions that needlessly prevent people from doing what they want or should do. Thaler (2021) adds that removing or reducing barriers could be more productive than trying to overcome them. This can be seen as the urge of humans to follow the path of least resistance and convenience, driven by System 1, that is only deviated from for good reasons by the intervention of System 2 (Kahneman 2011). Our findings fall in line and reveal that the mere placement of the dispenser, clearly in sight and directly at the entrance, influences the hand sanitizing behavior of the passers-by. These results validate previous studies showing that by simply altering the required effort, people can be nudged to consume healthier (Metcalfe et al. 2020), take the stairs more instead of the elevator (Houten et al. 1981) and to complete otherwise complex registration forms (Sunstein 2022b).

By implementing salient green footsteps, we were able to draw the attention of the passersby and attain a small, but positive effect on compliance on top of the mere placement. Similar to the footsteps being used to reduce littering (Hansen 2011), this study shows that these visual cues can be used to elicit the desired action, by increasing visibility. Together with the successful alterations in friction, these salient changes show how much the direct environment influences people at the specific moment they have to make a choice (Ischen et al. 2022). Kahnemann (2011) captures this in his acronym WYSIATI ('What You See Is All There Is'), referring to the fact that people make judgements or impressions according to the information that is available (i.e., availability heuristic), mainly driven by the automatic processing of System 1.

Through displaying a short social norm message, we implemented an additional environmental cue, providing information about the customs and values of the social environment (Bicchieri 2017). The message contained both descriptive ('Here we use alcohol gel') and injunctive aspects ('to protect each other') and had a clear significant positive effect on hand sanitizing behavior. Being part of a group has always been important to humans, giving System 1 great weight to avoid potential social norm violations in our decision-making; an argument supported by brain response studies to social norms (Zinchenko and Arsalidou 2018). Our findings show, together with a vast amount of studies in the literature (see Allcott 2011; Bicchieri 2017; Cialdini et al. 2006), that conveying social norm information in concise timely messages can successfully influence behavior.

The successful implementation of the hand hygiene nudges indicates the potential of behavioral interventions that respond to the underlying system 1. Large informational health campaigns, regulation and well-developed hygiene procedures are essential, but rely mainly on

infallible logical processing of information (i.e., System 2). This study proves that a complementary approach, focused on designing good choice architecture using behavioral insights (including nudges), should be considered to overcome and assist psychological shortcomings in safety and health compliance.

Nudging hand hygiene in a non-health organizational environment

Previous studies found that nudge interventions can significantly promote hand hygiene compliance in hospitals (Mobekk et al. 2020). As the effectiveness of nudge interventions is heavily depending on the implementation context (Hauser et al. 2018; Sunstein 2022a), the question remained whether the nudge interventions would also work in organizational environments where hygiene is less prevalent, unlike hospitals, schools and food stores (Gof 2022; Hansen et al. 2021; Van Dessel et al. 2022). This study is among the first to investigate the effectiveness of nudges promoting hand hygiene in a non-health organizational environment and the findings confirm the effectiveness of hygiene promoting nudges in such contexts. This ties in with a debate regarding the practice of nudging. Recent studies found that the effectiveness of nudges can be smaller than expected when controlling for publication bias (DellaVigna and Linos 2022; Maier et al. 2022). An important consideration here is that the expected effectiveness of nudge techniques in general can be very different from observed effects if the context is insufficiently taken into account (Hallsworth 2022). For example, a recent study on the effect of salience on hand sanitizing in a shopping street found no effect of the intervention (Weijers and de Koning 2021), whereas the current results in a factory and previous results in hospitals do show the effectiveness of this type of nudge. This shows that specific locations and contexts could act as a mediating factor. By testing

the effectiveness of nudge interventions in heterogeneous domains, we can increase our understanding of the applicability of nudge techniques to promote specific behaviors like the disinfection of hands. Sunstein (2022) argues that the most important implication involves shifting to more targeted and personalized nudge interventions, which can produce higher welfare benefits than blind 'mass' approaches.

The additivity and cost-effectiveness of nudge interventions

In our study, the combination of the nudge interventions lead to a higher increase in people disinfecting their hands in comparison to the isolated interventions. It appears that the effect of the nudges added up to a great degree, instead of cancelling each other out. This shows that both saliency and social factors may influence System 1 simultaneously and independently. In a study with much smaller effects, Brandon et al. (2019) also reported a smaller reduced peak load electricity consumption with isolated interventions (2%-4%) compared to a combination of interventions (7% reduction). They equally found additivity of the nudge interventions in subsequent applications and limited evidence of crowd out effects. Ayal and colleagues (2021) concur with this idea of additivity and found that combining visibility cues and social norms was more effective to orient people toward more moral behavior then separate interventions. The additivity of effects is of course even more important for nudging that yields smaller effect sizes (DellaVigna 2022). If multiple nudge techniques can be combined to attain a cumulative greater effect, this would be of great value for policy makers and behavioral change practitioners trying to promote certain behaviors, including compliance with the hygienic safety measures.

Associated with the effectiveness of nudge interventions are the costs incurred for implementation. Benartzi and colleagues (2017) showed that simple nudge interventions were able to achieve significant results in a very cost-effective way, when compared to more classic policy instruments including information campaigns and tax incentives. In this study the implementation cost were equally kept to a minimum. The total amount of the intervention costs added up to no more than 200 euros in total, excluding the organization cost of a limited amount of necessary meetings. This allows us to make a rough estimation of the cost-effectiveness of our interventions regarding absenteeism. The absence rate during the winter period due to the seasonal flu at the steel plant is on average around 10%. We already mentioned that good hand hygiene can reduce absenteeism up to 36% (Jefferson et al. 2020) and that our combined nudge condition resulted in a 50% compliance rate among the 861 employees at the AB (i.e., 15.5 avoided cases). The median cost of a lost day at work for the industrial organization adds up to 300euros/day for white-collar workers and the lost days per case of illness is considered to be three on average (Akazawa et al. 2003). This then results in an avoided cost of 13950 euro and a return on investment (ROI) ratio of 68 for every euro invested in implementing the nudges. This high ROI ratio aligns with findings of Benartzi and colleagues (2017) where ROI ratios added up to 100 for every dollar spent for nudges increasing retirement savings, while information campaigns and tax incentives attained a ratio of 14.58 and 1.24 respectively. A future careful analysis should be done to compare different hygiene promoting interventions (including nudges), regarding their cost-effectiveness, to further substantiate these findings.

Group effects and herd behavior

Another important aspect of this research is the influence of the social dynamics on the usage of the alcohol gel dispenser. The findings provides interesting results concerning this matter, showing that people who pass by in group are significantly more likely to disinfect their hands, than people who pass by individually. However, this effect is mediated by the leading example of the first person in the group. It appears that the behavior of the first person in the group largely determines whether the other will use the dispenser or not. This is a clear example of herd behavior where passersby assume that the example of the person in the front of them is the way to go (Banerjee 1992). They might believe that the person or people in front of them know(s) something that they are not aware of, concerning the necessity to comply with the safety measure or not. It could also be possible that the passersby following the example fear the possibility to be rejected by the group and conform to avoid this threat, leaning towards conformity (Ash 1956). In addition, the dimension of social proof could be at play and is strongly related to the concept of herd behavior. This is defined as an informative social influence that can lead to herd behavior. Seeing how others behave in ambiguous situations where we are uncertain might provide information or cues in guiding actions (Cialdini 1993). In this case, individuals who are not familiar with the new situation might take the behavior of the first person as a guidance for appropriate action. For the reason that the effect remains stable over the weekdays, it might be more plausible to assume that people follow the example because they want to avoid accusations from the group, than that they do not know how to act in the specific situation.

Time and day of the week effects

Interestingly, we see that passersby are more likely to use the alcohol gel on Monday, than on the other days of the week. An explanation might be that people start their week with fresh energy and good intentions, but that this diminishes as the days go by. This idea is further supported, as the odds of using the alcohol gel lowers when days of the week pass by; with the lowest probability at Friday. This is in line with the concept of ego depletion. The ego depletion theory indicates that self-control draws from a finite pool of cognitive resources. When the pool of cognitive resources declines, so does self-control (Kahneman 2011), and therefore also the reliance on System 2, in favor of System 1 thinking. Another finding is that people are more likely to use the dispenser at noon, between 11h00 – 15h00, which might be an anticipation of people getting their lunch. If the virus possibly finds their way to the hands of the people, they might have the reflection to disinfect their hands before bringing them to their mouth to eat. Another explanation might be that people are less subjected to time pressure during the lunch break to comply with the safety measures, while during the morning (7h00-11h00) or afternoon (15h00-19h00) they might be more in a rush. Although nudge interventions influence the odds of people performing a certain behavior, certain factors remain likely to moderate its effectiveness including cognitive load (Carroll et al. 2018; Sweller 1988). In this case, time pressure could reduce the effectiveness of the nudge interventions, but still invoke a relative smaller reduction then in a situation with more System 2 interventions (e.g., training or campaigns). Referring back to the concept of ego depletion, we actually would expect here that nudge interventions experience a relatively smaller reduction in effectiveness because it draws on less cognitive resources then typical System 2 interventions (Kahneman 2011).

Long-term effectiveness

An important and insufficiently investigated aspect of nudging is the long-term effect of the interventions (Marchiori et al. 2017). Our findings show that the effectiveness of the nudges maintained for several weeks and that the effect almost completely disappeared after removing the nudges (i.e., drop to pre-test level). This entails two things. First, it shows that the within-subjects design (sequence of interventions) is not the driving force behind the large effect sizes in the consecutive conditions. Secondly, it show that the hygiene nudges in this study have no long-term effects on behavior after the nudges are removed, and thus most likely not on attitudes (related to health and hygiene). Previous studies have shown that some interventions can have a long-lasting effect on behavior even after removing the nudges, such as the continued climbing of stairs after the closing time of the elevator was lowered to the pre-test level (Van Houten et al. 1981). More research is needed to identify which factors, related to the nudge approach, could lead to effective habit formation; including the necessary amount of repetitive actions (not equal to intervention duration), the role of the implementation context and the features of the desired action (Wood 2019).

Limitations and further research

For this research, a large field experiment was conducted at the steel plant. An advantage of field studies is that the findings have a high ecological validity (Meyer 1995). Because of the high ecological validity, the chances are higher that our e can be replicated at different, but similar, real life settings. Field experiments, on the other hand, tend to have a generally lower internal validity. For this reason, a well thought out experimental design was used, including pre- and posttest, control measures and high amount of participants (n= 861, 14 645 observations), to

control for these confounding influences to the greatest extent. Further research should integrate both controlled (e.g., laboratory or online) and more ecologically valid methods (e.g., field experiments and 'mega studies', which are massive field experiments, see Milkman et al. (2021)) to support each other's deficiencies and further substantiate our findings. This aligns with Beshears and Kosowsky (2020) highlighting the need for both approaches to advance the field of nudging.

Another limitation of this study is that it is unclear how peripheral characteristics of the nudging interventions, such as the color of the footsteps or message, could influence the result (note that Aaerestrup and Moesgaard 2017, had similar results with red messages). Likewise, given limited resources (i.e., available locations, time restrictions), we only tested one variation of the message being displayed right above the dispenser. Future exploration of different nudge formats (e.g., different colors and a variation of social norm messages) can bring additional value to the current findings.

Subsequently, our findings do not allow to draw conclusions on the long-term effects of the interventions (i.e., >3 months later). Some of the nudge interventions' effects, in general, have shown to decrease over time (Allcot and Rogers 2014). We were able to show that the effect of the interventions maintained for several weeks and that the effect disappeared completely after nudge removal. Yet, a follow-up after a couple of months was intended, but not possible due to the rapidly changing governmental policy and business environment (e.g., mandatory remote work) due to the pandemic.

Further research should aim to refine which types of nudges work for promoting hand hygiene in which settings and under which circumstances. The organizational context, for example, both present in this study and the hospital studies, but not in the shopping street where similar

interventions proved ineffective (Weijers and de Koning 2021), could play a role in the nudge effectiveness. Michael Hallsworth (2022) highlights that having an eye for different effects in different environments with different cultures and demographics, rather than merely generalizing conclusions across different contexts and populations, is necessary to advance the field of behavioral science (incl. nudging) and to overcome distorted interpretations regarding nudge effectivity.

Conclusion

This study investigates the effectiveness of nudge solutions for the rapid surging infection rates during the coronavirus pandemic. More specifically, nudge interventions were developed and tested for the first time to promote hand hygiene in a non-health private company context. A large field experiment was conducted at the sites of a multinational steel plant, investigating nudges that would increase the amount of people disinfecting their hands at the main entrances. The nudge interventions included the placement of the alcohol gel dispenser, a social norms message and footsteps placed on the ground. All interventions contributed significantly to an increase in the usage of the alcohol gel dispensers by the passersby. In addition, our findings show that people passing by in group have a significantly higher probability of using the alcohol gel than when they passed by individually. This effect was largely determined by the first person in the group using the alcohol gel dispenser. The nudge approach proved successful to promote hand hygiene in heterogeneous environments, including a non-health private company context, and provides guidance to combat contagious viruses, such as the coronavirus and the seasonal flu.

Appendix

Table A1. A detailed overview of the amount of passersby and the alcohol gel consumption (in ml) per condition

Intervention	Passersby	Usage (in ml)	Usage (in ml/passerby)	Estimated compliance (in %)*
Control (pre-test)	12520	876	0.07	7%
Placement	9014	2434	0.27	27%
Placement-Footsteps	2393	1125	0.47	47%
Placement-Message	3075	1384	0.45	45%
Placement-Message-Footsteps	2830	1613	0.57	57%
Control (removal)	1300	117	0.09	9%
Total	31132			

Note. *Average user performing one push, which equals 1ml (see details in 'Observation method' section). Therefore, 'usage in ml' equals the expected amount of users, and the 'usage in ml/passerby' equals the estimated compliance rate in %.

Table A2. A detailed overview of the amount of passersby and hand sanitizer usage per condition (camera footage)

Intervention	Passersby	Usage	Usage (in %)
Control (pre-test)	6624	290	4.38%
Placement	4142	1141	27.55%
Placement-Footsteps	789	321	40.64%
Placement-Message	502	226	45.06%
Placement-Message-Footsteps	1938	987	50.91%
Control (removal)	650	36	5.54%
Total	14645		

Authors' contributions

Samuël F.A. Costa: Conceptualization, Methodology, Investigation, Writing- Original draft, Visualization, Data Curation, Validation **Mustafa Disli:** Formal analysis, Supervision, Writing- Reviewing and Editing **Wouter Duyck:** Methodology, Supervision, Writing- Reviewing and Editing, Funding Acquisition **Nicolas Dirix:** Supervision, Writing- Reviewing and Editing

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Availability of data and material

Data are available for researchers who meet the criteria for access to confidential data upon request.

Declarations

Ethics approval

APA ethical standards were followed in the conduct of the study and ethical approval was received from the ethical board of the Flemish Government and AMB (HBC.EC.2020.2242).

Consent to participate and for publication

Consent to participate and publish was obtained from all participants included in the study, directly (written or verbal) and indirectly (through labor unions).

Conflicts of interest

The position of all researchers at independent academic institutions minimizes the conflict of interest. The funding source had limited to no involvement in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication.

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