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The effect of persuasive messages on hospital visitors' hand hygiene behavior

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Abstract

Objective: Hospital visitors pose a risk for transmitting pathogens that can cause healthcare-associated infections. The present study aimed to test an evidence-based intervention to improve visitors' hand hygiene behavior through persuasive messages. **Methods:** For the 14-week-long field experiment, seven signs were designed according to the principles of persuasion proposed by Cialdini: *reciprocity*, *consistency*, *social-proof*, *unity*, *liking*, *authority*, and *scarcity*. Each sign was displayed on a screen for one week directly above the hand-rub dispenser in a hospital lobby. Between each posting, the screen was blank for one week. **Results:** An electronic monitoring system counted 246,098 people entering and leaving the hospital's lobby and 17,308 dispenser usages. The signs based on the *authority* and the *social-proof* principles significantly increased the hand-rub dispenser usage rate in comparison to the average baseline usage rate. **Conclusions:** These results indicate that simple and cost-efficient interventions can initiate expedient behavior change in hospitals. However, the findings also highlight the importance of careful planning and rigorous pre-testing of material for an intervention to be effective. Theoretical and practical implications of these findings are discussed.

Keywords: behavioral change, hospital visitors, persuasion, hand hygiene, health and safety interventions, field experiment

The effect of persuasive messages on hospital visitors' hand hygiene behavior

Healthcare-associated infections pose a threat to patient safety. Infections impair the patient's health, can lead to long-term physical and mental problems, and, in the worst case, result in the patient's death. The World Health Organisation (WHO) estimates that hundreds of millions of patients are affected by healthcare-associated infections annually (WHO, 2011). According to the WHO, up to 7% of patients in industrialized countries and up to 10% of patients in developing countries will acquire at least one healthcare-associated infection (WHO, 2016). In Germany, where the present study was conducted, the prevalence of patients with healthcare-associated infections was 4.6% across 218 hospitals in 2016 (Behnke et al., 2017). In healthcare facilities, hygienic hand disinfection is one of the main elements of infection prevention. Appropriate hand hygiene inhibits the transmission of pathogens and reduces the risk of patients acquiring an infection (Allegranzi & Pittet, 2009; Pires, Soule, Bellissimo-Rodrigues, Gayet-Ageron, & Pittet, 2017).

Healthcare workers' hand hygiene behavior has been a focus of behavior change researchers for years. Contaminated healthcare workers' hands are the most common vehicle for patient-to-patient pathogen transmission (Allegranzi & Pittet, 2009). However, studies have shown that hospital visitors carry dangerous pathogens on their hands as well (e.g., Birnbach, Rosen, Fitzpatrick, Arheart, & Munoz-Price, 2015). These findings suggest that hospital visitors might be a relevant but largely neglected vector for pathogen transmission. Visitors of a healthcare facility should clean their hands at least before and after contact with a patient (Munoz-Price et al., 2015). Accordingly, the German Commission for Hospital Hygiene and Infection Prevention (KRINKO) recommended including visitors in hospitals' hand hygiene campaigns (KRINKO, 2016).

Little is known about how often and in what situations visitors clean their hands in hospitals. Visitors' hand hygiene rates vary among published reports. Several studies looked at how frequently visitors used hand-rub dispensers in hospital lobbies. Pittz (2009) observed 71 facilities and found that less than one percent of visitors used the dispenser. Very low usage rates were also found in three other studies (Birnbach et al., 2012; Hobbs, Robinson, Neyens, & Steed, 2016; Vaidotas et al., 2015). The location of the hand-rub dispenser seems to be one important factor for

increasing usage by visitors. Studies found considerable higher usage rates when the dispenser was free-standing and centrally located (Birnbach et al., 2012; Hobbs et al., 2016). Hobbs et al. (2016) also identified three visitor characteristics that were associated with dispenser usage in the hospital lobby: younger visitors, groups of visitors and visitors in the afternoon were more likely to clean their hands at the dispenser than older visitors, individual visitors and morning visitors, respectively. Still, all studies show that there is extensive room for improvement that might help to enhance patient safety.

Using signs to convey messages about health and safety is a popular intervention strategy to remind healthcare workers and laypeople to clean their hands (Jenner, Jones, Fletcher, Miller, & Scott, 2005) and also recommended by the KRINKO (2016). However, the reported effectiveness of sign-based interventions is mixed. For instance, Grant and Hofmann (2011) found that signs emphasizing patient safety improved professionals' hand hygiene practice, while signs addressing personal safety had no effect. Signs stressing the fact that hand hygiene saves lives did not significantly improve hand hygiene behavior (Birnbach, Rosen, Fitzpatrick, Everett-Thomas, & Arheart, 2017), nor did a sign claiming that hand sanitation was mandatory for all visitors (Birnbach et al., 2012).

In general, purely informative messages explaining risk also often fail to provoke change. The effectiveness of behavior change campaigns depends not only on the message's content but also on its tone (Joffe, 2008). Health campaigns often use threatening materials like shocking images or disgust-evoking pictures (Gaube, Lerner, & Fischer, 2019; Joffe, 2008; Leshner, Bolls, & Thomas, 2009). However, it is important for patients' wellness and health outcomes to feel safe in hospitals (Mollon, 2014) and trust in healthcare professionals (Birkhäuser et al., 2017). Targeting emotions like *fear* and *disgust* might evoke unintended negative feelings towards the hospital environment and could result in defensive responses (Leshner et al., 2009). Therefore, we abstained from using threatening material in the present study.

The intervention should be grounded in theory, as evidence-based interventions are considered to be more effective (Abraham, Kelly, West, & Michie, 2009; Albarracín, Johnson, Fishbein, & Muellerleile, 2001). Therefore, the nature of the target behavior was analyzed first. For

many people, cleaning the hands is an automatized behavior that does not involve much deliberate thinking (Aunger et al., 2010; Diefenbacher, Pfattheicher, & Keller, 2019; Diefenbacher, Sassenrath, Siegel, Grünewald, & Keller, 2012). Consequently, relying on cognitively demanding messages explaining the risk of pathogen transmission might be suboptimal. Persuading hospital visitors to clean their hands by using messages that trigger an automatic response might be a promising approach. Cialdini (2007, 2016) summarized seven fundamental principles of persuasion through which people are often involuntarily influenced:

1. *Reciprocity*: People feel obliged to repay acts of generosity such as favors.
2. *Consistency*: People have an internal desire to be and be seen as consistent in attitudes and actions and behave consistently with existing commitments.
3. *Unity*: People are more easily influenced by people they perceive as part of their in-group.
4. *Social-proof*: People look to other peoples' opinions and behaviors to decide what is appropriate.
5. *Liking*: People are more easily persuaded by someone they like or perceive as likable.
6. *Authority*: People often obey authorities and defer to experts.
7. *Scarcity*: People are motivated to avoid losses, and therefore tend to perceive scarce resources as being more valuable than readily available resources.

The effectiveness of these principles in nudging people has been confirmed for a variety of behaviors like restaurant tipping (Strohmetz, Rind, Fisher, & Lynn, 2002), environmental conservation (Goldstein, Cialdini, & Griskevicius, 2008), helping behavior (Bushman, 1988), and many more (see Cialdini, 2007, 2016). Cialdini describes the principles as triggering automatic behavioral reactions through processes that are often subtle and indirect (Cialdini, 2007). Targeting influence processes that prompt automatic behavioral reactions has been shown to be effective in persuading people to clean their hands. For example, Birnbach, King, Vlaev, Rosen, and Harvey (2013) and King et al. (2016) used olfactoric priming with a fresh scent to help improve compliance among hospital workers. Two other studies made social norms salient by displaying text-based messages at highway service station restrooms (Judah et al., 2009) and emojis in patient rooms (Gaube, Tsivrikos, Dollinger, & Lerner, 2018) which helped to increase hand hygiene rates. The

present study's goal was to see if signs based on the seven principles of persuasion help to improve visitors' hand hygiene behavior at a hospitals' lobby. To the best of our knowledge, it has never been systematically tested if the principles facilitate behavior change in this specific context, nor has the effectiveness of each of the seven principles been directly compared with each other. Therefore, we did not formulate an a-priori hypothesis on which of the principles might be most persuasive in motivating hospital visitors to clean their hands.

Method

We designed seven signs according to the principles of persuasion and compared their effect on visitors' hand hygiene behavior to the baseline situation in which no sign was present at a lobby in a German hospital. The reason for observing the behavior at the hospital's entrance was twofold: First, several previous studies have used that location to observe visitors' hand hygiene behavior. Therefore, the results of the present study can be compared with previous research. Second, at the chosen facility, all visitors must enter through the main lobby, which makes it easy to observe the hand hygiene behavior of a large volume of people. The study took place between August and November 2018 and lasted 14 weeks in total. Collecting data over this extended period allowed us to observe 246,098 people entering and leaving the hospital's lobby. This sample even exceeds a comparable previous study in which text-based messages were displayed at highway service station restrooms to improve handwashing behavior (Judah et al., 2009). The hospital was chosen because it is an acute care hospital with a variety of medical specialties and diverse patient clientele, which should translate into its visitors being a good representation of the general public in that area.

Material Development

All signs consisted of a photo on the left that filled about two-thirds of the space and a message in German on the right in capital letters. Additionally, every sign included the phrase "Please disinfect your hands!" at the lower-right corner to make sure the desired behavior was made clear to every visitor. An expert team of five social psychologists familiar with the seven principles of persuasion conducted a workshop to design messages that put each principle into

practice to prompt hospital visitors to clean their hands. In total, 34 messages (four for the authority principle and five for the other six principles) were finally agreed on to use for a subsequent online pre-test. Additionally, the workgroup developed ideas for pictures that could convey the messages optimally. For each principle, two picture ideas were chosen during the workshop. It was decided to pair text with images because using pictures is an effective way to convey a message (Joffe, 2008). According to Joffe (2008), visuals have three advantages over purely text-based messages: a) pictures are easier to remember; b) visuals are considered a credible source of information, and c) visual material conveys emotions. To increase their authenticity, the 14 (two for each principle) picture ideas were captured in a photoshoot at the hospital in which the study took place. The staff members were employees at the hospital at the time of the study. The visitors and the patient are local residents and familiar with the hospital. The group of people was chosen in regard to age, gender, and ethnicity to be a rough representation of the district's population and the hospital's usual visitor demographic.

Material Pre-Test

Subsequently, an online survey was conducted to identify the best message and picture for each principle. In the survey ($N = 35$), participants, which were recruited through personal address, first received a short explanation for each principle of persuasion. Each explanation was followed by four or five messages developed by our expert team to be in accordance with the respective principle. Participants had to rate how well each message expressed the principle on a seven-point Likert scale, from 1 (*completely inconsistent*) to 7 (*completely consistent*). After rating the messages, the participants saw four pictures, two that were designed by our expert team to fit the principle and two randomly selected distractors from the other principles. Participants were asked to rate how well the pictures reflected the messages on a seven-point Likert scale, from 1 (*completely inconsistent*) to 7 (*completely consistent*). Finally, for each principle, the message with the highest rating and the picture reflecting the messages the best were matched. Table 1 contains the pre-test ratings of the seven messages and pictures with the highest ratings selected for the field experiment. A professional graphic designer finalized all signs. Images, messages with

translations, and the pre-test rating results of all seven signs tested in the field experiment can be found in the online supplement.

TABLE 1: Pre-Test Ratings of the Messages and Pictures Selected for the Signs

	Message Rating		Image Rating	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Principle</i>				
Reciprocity	4.7	1.5	5.8	1.4
Consistency	5.3	1.2	4.3	1.9
Unity	5.3	1.7	5.7	1.3
Social-proof	5.4	1.1	6.0	1.0
Liking	5.9	1.1	5.7	1.3
Authority	5.7	0.9	5.4	1.4
Scarcity	5.7	1.3	4.9	1.6

Note. Item for the message rating: “How consistent is the message with the proposed principle?”; Item for the image rating: “How consistent is the picture with the messages above?” Both were rated on a seven-point Likert scale from 1 = *completely inconsistent* to 7 = *completely consistent*.

To aid discoverability and facilitate the integration of the results with other interventions of health-related behavior studies, the behavior change techniques used in the seven signs are coded according to the Behaviour Change Technique Taxonomy v1 (BCT-T-v1; Michie et al., 2013). All signs are *prompts/cues* [7.1] displayed to facilitate hand hygiene behavior. Placing a TV screen above the hand-rub dispenser can be coded as *adding objects to the environment* [12.5]. The individual signs can be coded with behavior change techniques as follows. Reciprocity: *information about others’ approval* [6.3] and *credible source* [9.1]. Consistency: *commitment* [1.9] and *information about health consequences* [5.1]. Unity: *information about health consequences* [5.1], *demonstration of the behavior* [6.1], *social comparison* [6.2], and *information about others’ approval* [6.3]. Social-proof: *demonstration of the behavior* [6.1], *social comparison* [6.2], and *information about others’ approval* [6.3]. Liking: *information about health consequences* [5.1], *information about others’ approval* [6.3], *credible source* [9.1]. Authority: *information about others’ approval* [6.3] and *credible source* [9.1]. Scarcity: *information about health consequences* [5.1] and *salience of consequences* [5.2].

Study Design

From previous observations, it was known that visitor rates vary over the course of the day (Hobbs et al., 2016) and between days of the week. Therefore, each sign was displayed for an entire week to account for those variations. Before the first presentation of a sign and between any two signs, there was also one week without any display, which acted as baseline assessments. Having control weeks between experimental weeks fulfilled two purposes: First, again, all time-connected differences in the baseline hand hygiene behavior of hospital visitors would be covered. Second, the mean patient hospitalization time at the facility was $M = 4.6$ days ($SD = 4.8$; range: 1.0 - 61.3). The majority of their visitors would only see one of the seven signs even if a patient stayed twice the average hospitalization time. The latter is necessary to minimize the probability of the effect of one sign influencing the effect of another one. The signs were displayed on a 32-inch full HD TV screen which was placed directly on top of the single alcohol-based hand-rub dispenser in the lobby. During the control phases, the TV was turned off. Pictures of the intervention setup can be found in the online supplement.

Procedure

Data were collected unobtrusive and anonymously with an electronic traffic monitoring system with two sensors (XOVIS PC2/PC2 UL – 3D, which are in compliance with the EU-DSGVO data protection regulation) installed at the lobby's ceiling. These types of sensors are often deployed in retail stores, airports, and train stations to reliably monitor people traffic. The electronic monitoring system yields two types of anonymous metadata: First, the event stream, which counts how many people pass over a predetermined line in a room, and second, the object stream, which determines peoples' direction of movement at the count line. In the present study, the sensors measured the traffic in the lobby and people approaching the hand-rub dispenser in the lobby. To measure the traffic in the lobby, the first count line stretched across the lobby about two meters (6.5 ft) in front of the dispenser. Everyone who entered the hospital lobby through the main entrance to go to reception or directly to the wards needed to cross this line. The same was true for everyone who left the hospital through the main entrance. It should be noted that the electronic monitoring system could not distinguish between visitors and other groups of people. Most patients

also enter the hospital through the main entrance. The hospital staff usually use the employee entrance; however, some staff members might occasionally walk through the lobby.

To measure the dispenser usage, a set of count lines was arranged in an approximately 30 cm-radius (11.8 inch) semicircle in front of the dispenser (see online supplements for a floorplan with count lines). The sensors recorded how often people entered or left the immediate dispenser area. The average of both counts (approaching and leaving the dispenser area) was used for further analysis, as there was a slight measurement error of 4.3% between the approach- and leave-count throughout the experiment. Measurement errors can sometimes occur when an object considerably bigger than the target area (e.g., a wheelchair) is recorded. Henceforth, this average will be called *dispenser usage* as it can be assumed people who stand directly in front of the dispenser actually use it. The 30 cm radius is too close to the TV set to provide a good view at the sign; therefore, it is highly unlikely that people would come so close only to have a better look at the picture. The two sensors were installed, and the accuracy of the recordings validated by specialists.

Originally, it was planned to additionally verify the chosen measure of dispenser usage with a dispenser-integrated mechanism counting how often the lever was pressed. However, after observing the behavior of visitors, it became clear that people considerably varied in how often and how strongly they pressed the dispenser lever when cleaning their hands (the mechanism only counts an action when the lever is pressed almost fully down). The same was also true for the amount of hand-rub (in ml) used, which is also often applied as a proxy measure for hand hygiene behavior. With mechanical dispensers, the amount of hand-rub in ml used by a person to clean their hands depends on how often and how strongly the lever is pressed. Therefore, both the dispenser-integrated count and the hand-rub amount in ml could not be used as reliable validation measurements for the number of people using the dispenser. It should be noted that the present study did not take the quality of people's hand hygiene behavior (i.e., whether they were using enough hand-rub or if the hand-rubbing duration was adequate) into consideration.

Employing an electronic sensor system had two main benefits over direct observation: First, the Hawthorne effect—i.e., the change in behavior that arises from the mere awareness of being

under investigation—can be reduced to a minimum. Second, it was the most cost-efficient method to have 24/7 observation throughout the 14-week field experiment. The sensor system provided accumulated dispenser usage and count data of people entering and leaving the hospital's lobby every 15 minutes, which represents the unit of analysis. Therefore, the dependent variable in the study was the dispenser usage rate in percent for every 15-minute interval recorded by the system. The usage rate per 15-minute interval was calculated by dividing the number of dispenser usages by the number of people entering and leaving the hospital's lobby and multiplied by 100 to gain a percentage. There had already been video surveillance in the lobby before the start of the experiment, therefore, no additional signs to point out surveillance were needed. The University of Regensburg's Research Ethics Committee waived the requirement for a full ethical review of the study as no personally identifiable data was collected. Additionally, both the University's Research Ethics Committee and the management team of the Rottal Inn Hospital dispensed with the requirement for informed consent as the experiment was of a passive nature.

Results

Over the entire study period, 246,098 people entering and leaving the hospital's lobby and 17,308 dispenser usages were recorded. In total, the electronic monitoring system provided sensor data from 9,259 intervals of 15 minutes (units of analysis). This accumulates to 13.8 weeks. Data were discarded for one hour around the time the display was changed in the lobby every week to avoid data recordings from the experimenter and data from visitors who might have been influenced by the experimenter's presence. This exclusion explains about 0.1 weeks missing from the 14 weeks in total. There was one technical issue on the first day of the first baseline week at which the sensor did not record data, which accounts for another 0.1 missing weeks. Only in three out of the 9,259 cases did the system erroneously record more people approaching the dispenser than entering and leaving the lobby (error rate: 0.03%). These cases were excluded from the analysis. There were no technical problems besides. Only 15-minute intervals in which movement in the lobby was recorded were included in the analysis, leaving us with a sample size of 6,551 intervals. Often during the night no people entered or left the hospital, accounting for the intervals

in which no movement was recorded. The average usage rate (arithmetic mean) during the entire study period was $M = 6.4\%$ ($SD = 7.3$).

The dependent variable in the study was the dispenser usage rate. For count and rate variables, the Poisson distribution rather than the normal distribution is the appropriate model for fitting data, especially if the data is heavily skewed to the right, which is often the case for count and rate data (Hilbe, 2014; Walters, 2007). The dispenser usage rate in the present study was indeed heavily skewed to the right (see online supplement for a histogram of the usage rate data over the entire study period). One crucial feature of Poisson models is the equality of the mean and variance functions, also known as the assumption of equidispersion (Cameron & Trivedi, 1990; Hilbe, 2014). Testing the assumption of equidispersion showed a sign of overdispersion in our data, which means that the variance of the Poisson model exceeds its mean (Cameron & Trivedi, 1990). To adjust for the overdispersion, a negative binomial regression model was chosen, which is recommended in the literature (e.g., Hilbe, 2014). The dispenser usage rate measure was neither truncated nor censored, which would violate the distribution assumption of the negative binomial regression model (Hilbe, 2014). Overall, a negative binomial regression model seems to fit the distribution of the dispenser usage rate data well.

First, it was tested whether there were any differences in the dispenser usage rate between the seven baseline weeks. Over the seven baseline weeks, 3,248 15-minute intervals with movements were recorded with 119,423 people entering and leaving the hospital's lobby, and 7,932 dispenser usages. The recorded numbers for each baseline week are displayed in the online supplement. Table 2 displays the results of the regression. To compare the mean usage rates from each baseline week against each other, a Tukey post-hoc test was performed on the regression model. None of the contrasts showed significant differences. This indicates that the baseline dispenser usage rate did not vary significantly throughout the experiment. The average usage rate (arithmetic mean) during the control weeks was $M = 6.0\%$ ($SD = 7.4$). Figure 1 displays the mean dispenser usage rates of the seven baseline weeks.

TABLE 2: Predicting Dispenser Usage in the Baseline Weeks Against W1 Baseline

<i>Predictor</i>	<i>b</i>	<i>SE</i>	<i>z</i>	<i>p</i>	<i>e^b</i>	95% CI for <i>e^b</i>	
						LB	UB
Constant	1.83	0.06	29.77	<.001	6.24	5.55	7.06
W2 Baseline	-0.06	0.08	-0.67	.500	0.95	0.80	1.11
W3 Baseline	-0.12	0.08	-1.39	.166	0.89	0.76	1.05
W4 Baseline	-0.03	0.08	-0.32	.747	0.97	0.83	1.15
W5 Baseline	-0.07	0.09	-0.77	.440	0.94	0.79	1.11
W6 Baseline	0.03	0.08	0.34	.735	1.03	0.87	1.21
W7 Baseline	0.01	0.09	0.11	.914	1.01	0.86	1.19

Note. W = week; *b* = unstandardized coefficient; *SE* = standard error; *z* = *b*/*SE*; *p* = probability value; *e^b* = exponentiated regression coefficient; Log Likelihood = -9,290.62 (*df* = 8); AIC = 18,597; BIC = 18,645.92.

Fig. 1. Mean (and the 95% confidence interval) dispenser usage rate in percent during the seven baseline weeks (W). Means are the average usage rate of all 15-minute intervals within each week. Usage rate per 15-minute interval was calculated by multiplying the number of usages within these 15 minutes by 100 and dividing it by the number of people passing by. The blue (dotted) line represents the grand mean over all seven weeks (average baseline usage rate).

Next, the effects of the seven signs on the dispenser usage were compared to the average baseline level. Over the seven experimental weeks, 3,303 15-minute intervals with movements were recorded with 126,675 people entering and leaving the hospital's lobby and 9,376 dispenser

usages. The average usage rate (arithmetic mean) during the experimental weeks was $M = 6.7\%$ ($SD = 7.2$). Again, the recorded numbers for each baseline week are displayed in the online supplement. The regression model included the average baseline and the seven signs used in the intervention weeks. Table 3 displays the results of the regression. Two out of the seven messages showed a statistically significant increase in dispenser usage rate compared with the average baseline usage rate. Overall, the sign based on the *authority* principle ($M = 7.7$, $SD = 7.4$) was the most effective, with a 27.8% (95% CI [16.8%, 38.7%]) relative increase compared with the baseline usage rate. Additionally, a significant increase in the dispenser usage rate was found for the sign based on the principle of *social-proof* ($M = 6.9$, $SD = 7.3$). There was no significant increase in the dispenser usage in the weeks with the signs designed according to the principles of *reciprocity* ($M = 5.9$, $SD = 6.5$), *consistency* ($M = 6.4$, $SD = 6.4$), *unity* ($M = 6.6$, $SD = 7.2$), *liking* ($M = 6.6$, $SD = 6.7$), and *scarcity* ($M = 6.6$, $SD = 8.4$). To compare the mean usage rates from the seven signs against each other, a Tukey post-hoc test was performed on the regression model (only experimental weeks included). The usage rate in the week during which the *authority* sign was displayed significantly outperformed the usage rate during the week of the *reciprocity* sign ($p = .007$). None of the other contrasts showed significant differences. This post-hoc analysis is confirmed by the confidence intervals around the mean usage rates displayed in Figure 2.

TABLE 3: Predicting Dispenser Usage in the Experimental Weeks Against the Baseline

Predictor	<i>b</i>	<i>SE</i>	<i>z</i>	<i>p</i>	e^b	95% CI for e^b		Relative Increase (RI)	95% CI for RI	
						LB	UB		LB	UB
Constant	1.80	0.02	84.68	<.001	6.05	5.80	6.31	---		
W1 Reciprocity	-0.03	0.06	-0.51	.608	0.97	0.86	1.09	-2.3%	-12.0%	7.5%
W2 Consistency	0.05	0.06	0.84	.400	1.05	0.94	1.18	5.9%	-3.6%	15.3%
W3 Unity	0.09	0.06	1.56	.119	1.10	0.98	1.24	10.7%	-0.3%	21.6%
W4 Social-proof	0.13	0.06	2.14	.032	1.14	1.01	1.28	14.7%	3.4%	26.0%
W5 Liking	0.08	0.06	1.38	.168	1.09	0.97	1.22	9.5%	-0.7%	19.7%
W6 Authority	0.24	0.06	4.10	<.001	1.27	1.13	1.42	27.8%	16.8%	38.7%
W7 Scarcity	0.09	0.06	1.57	.117	1.10	0.98	1.24	10.7%	-2.0%	23.3%

Note. W = week; *b* = unstandardized coefficient; *SE* = standard error; $z = b/SE$; *p* = probability value; e^b = exponentiated regression coefficient; Relative Increase (RI) is the arithmetic mean of the difference between each, 15-minute interval's usage rate and the average baseline usage rate in %; Log Likelihood = -19,072.1 (*df* = 9), AIC = 38,162; BIC = 38,223.28.

Fig. 2. Mean (and the 95% confidence interval) dispenser usage rate in percent during the seven experimental weeks (W). Means are the average usage rate of all 15-minute intervals within each week. Usage rate per 15-minute interval was calculated by multiplying the number of usages within these 15 minutes by 100 and dividing it by the number of people passing by. The blue (dotted) line represents the average baseline usage rate.

The two signs (*authority* and *social-proof*) that significantly outperformed the average baseline were compared against the baseline weeks directly preceding each sign respectively (W6 Baseline for *authority* and W4 Baseline for *social-proof*). According to the Mann-Whitney U test, the dispenser usage rate of 7.7% in the week with the *authority*-sign displayed is significantly higher than the baseline usage rate in W6 Baseline of 6.4% ($p < .001$). Additionally, the dispenser usage rate of 6.9% in the week with the sign designed according to the principle of *social-proof* displayed is significantly higher than the W4 Baseline usage rate of 6.1% ($p = .019$). When averaging all experimental conditions, the dispenser usage rate increased by 11.0% (95% CI% [7.0%, 15.1%]) from the baseline usage rate.

To investigate whether there was a social effect on the dispenser usage rate caused by the number of people entering or leaving the hospital, a method used by Judah et al. (2009) was adopted. The correlation between the number of people entering and leaving the hospital lobby

with the dispenser usage rate for all episodes was calculated. There was a significant positive trend for the dispenser usage rate to increase during intervals with more people being recorded at the lobby ($r = .15$; $p < .001$; 95% CI [.12, .17]). This trend was slightly stronger during the experimental weeks ($r = .17$; $p < .001$; 95% CI [.13, .20]) than during the baseline weeks ($r = .12$; $p < .001$; 95% CI [.09, .16]). Table 4 depicts the correlations between the recorded number of people entering and leaving the lobby with the dispenser usage rate for each sign separately. We found significant positive correlations for all but one sign (*unity*). Additionally, the recorded number of people entering and leaving was split at the Median ($Mdn = 38$). Intervals below the median were classified as *low traffic* while intervals above the median were classified as *high traffic*. The dispenser usage rate was significantly higher in *high traffic* intervals than in *low traffic* intervals for all seven signs as well as the average baseline (see Table 4). Overall, there was a social effect in both the baseline and the experimental weeks. This means that in intervals with more people entering and leaving the hospital lobby, the hand-rub dispenser usage rate was generally higher.

TABLE 4: Results of the Social Effect Analyses

	Pearson's Correlation				Mann-Whitney U test				
	r	p	95% CI		M_{Low}	M_{High}	p	95% CI	
			LB	UP				LB	UP
Average Baseline	.12	< .001	.09	.16	5.3	6.9	< .001	-3.64	-3.05
W1 Reciprocity	.20	< .001	.12	.29	5.1	6.9	< .001	-3.92	-2.11
W2 Consistency	.25	< .001	.17	.33	4.8	7.8	< .001	-4.84	-3.24
W3 Unity	.07	.126	-.02	.16	6.0	7.2	< .001	-3.92	-2.34
W4 Social-proof	.12	.013	.02	.21	6.1	7.4	< .001	-4.75	-2.62
W5 Liking	.18	< .001	.09	.27	5.4	7.7	< .001	-4.93	-3.49
W6 Authority	.19	< .001	.10	.27	6.4	8.8	< .001	-5.45	-3.48
W7 Scarcity	.13	.005	.04	.22	5.9	7.4	< .001	-4.37	-3.06

Note: r = Pearson's correlation coefficient; p = probability value; M_{Low} = Arithmetic mean of the usage rates of all 15-minute intervals with low traffic (below median); M_{High} = Arithmetic mean of the usage rates of all 15-minute intervals with high traffic (above median).

Discussion

In the present study, it was explored whether signs designed according to Cialdini's principles of persuasion could improve visitors' hand hygiene behavior at a hospital's entrance. The 6.0% baseline usage rate of the dispenser was higher compared to previous observations

(Birnbach et al., 2012; Pittz, 2009), but showed considerable room for improvement. The baseline usage did not significantly vary over time, indicating that no confounding variables (e.g., weather) seemed to influence visitor behavior. The consistency in baseline usage affirms our claim that the seven signs' effects are independent. Two of the seven signs significantly increased the dispenser usage rate compared to the average baseline level. The sign based on the *authority* principle led to the highest dispenser usage rate of 7.7%. This constitutes a relative increase of 27.8% (95% CI [16.8%, 38.7%]) from the average baseline level of 6.0% and a relative increase of 19.8% (95% CI [9.5%, 30.1%]) from the baseline usage rate of 6.4% directly preceding the sign at baseline week six (W6 Baseline). The second sign that significantly outperformed the baseline dispenser usage rate was based on the principle of *social-proof* with a dispenser usage rate of 6.9%. It showed a relative increase of 14.7% (95% CI [3.4%, 26.0%]) from the average baseline level of 6.0% and a relative increase of 12.8% (95% CI [1.7%, 23.9%]) from the baseline usage rate of 6.1% directly preceding the sign at baseline week four (W4 Baseline). The dispenser usage rate at the weeks with the other signs being presented did not differ statistically significant from the baseline level. The relative increases in dispenser usage ranged between -2.3% and 10.7% for these five signs. As in Judah et al.'s (2009) experiment, the data showed a social effect for people's hand hygiene behavior at the hospital lobby, i.e., a significant positive trend for the dispenser usage rate during intervals with more people being recorded in the vicinity. It can be assumed that people are more likely to clean their hands when they see other people using the dispenser (i.e., social-proof). This trend was even slightly stronger during the experimental weeks than during the baseline weeks. However, the social effect in the present study was considerably smaller than in Judah et al.'s work. One speculation for this difference could be that people might expect to get more negative judgment when being observed to abstain from washing their hands at a public restroom in comparison to not using the hand-rub dispenser at a hospital lobby. Finally, the social effect was not stronger for more effective signs, as was the case in the study conducted by Judah and colleagues.

The relative increases in hand-rub dispenser usage found in the present study are slightly higher compared to a similar previous study, in which text-based persuasive messages were

displayed at highway service station restrooms to improve handwashing (Judah et al., 2009). Judah and colleagues reported relative increases in soap usage rates between -4.8% and 12.1%. In their study, the four most assimilable messages to the signs tested in the present experiment were based on two theoretical domains—*norms/affiliations* and *status/identity*—and resulted in relative increases between 2.9% and 12.1%. The most straightforward reason for the overall higher relative increases in hand hygiene behavior in the present study is that the baseline level usage rates in Judah et al.'s experiment were considerably higher, ranging at 31.7% (male restrooms) and 65.1% (female restrooms) compared to the 6.0% in our field experiment. The present study's results can also be compared with the outcomes of Grant and Hofmann's (2011) work, which tested the effect of norm-based signs emphasizing either patient safety or personal safety on hand hygiene product use and adherence to hand hygiene guidelines among hospital workers. For the patient safety sign, they found a 45.4% relative increase in product use and a 10.5% relative increase in observed adherence. In the wards with the personal safety signs being displayed, both measures slightly decreased (-4.3% and -0.4% respectively). Again, their baseline usage/adherence levels were higher than in the present study. The most similar set-up compared the effect of a freestanding hand-rub dispenser with and without a sign claiming that hand hygiene was mandatory for visitors (Birnbach et al., 2012). The dispenser usage rate increased by 25.1% from 9.3% to 11.7% when the sign was present. However, this increase was not statistically significant, which might have been caused by low statistical power. Overall, the relative increases found in the present study are within the range of other comparable research results. These findings are further evidence that signs can lead to significant improvements in hand hygiene behavior. However, it also shows that sign-based interventions seem to be limited in their effectiveness.

The findings of the present field experiment also underline important implications for designing health and safety interventions. Signs *per se* do not change behavior by merely attracting attention (see Joffe, 2008). The signs' capability to trigger the intended principle and in turn produce an automatic reaction might rely on several factors like the relevance and trustworthiness of the conveyed message, its framing, tone, and context-fit (Fishbein & Cappella,

2006; Joffe, 2008). These factors could help to explain why the *authority* sign showed the most substantial improvement in the usage rate compared to the baseline level. Historically, the default in medical situations has been to comply with physicians' recommendations because of their higher level of expertise (Frosch, May, Rendle, Tietbohl, & Elwyn, 2012; Haug & Lavin, 1981). Therefore, when the hospital's medical director advises visitors to clean their hands, the automatic reaction should be to follow the doctors' advice. However, the paternalistic physician-patient perspective, which puts the patient in a passive position towards the doctor, is transforming. The role model for the physician-patient relationship is trending towards a more equal partnership and a shared decision-making-process (Schäfer, 2017; Thielscher & Schulte-Sutrum, 2016). Still, a recently published paper found that among German patients with elevated heartrate, the recommendation of a physician is the critical mediator for treatment selection (Schmieder et al., 2019). Patients reported doctors to be their main source of information regarding medical issues and their key influencers on therapy related decisions. Therefore, it can be assumed that the principle of *authority* was effectively activated in the present study by a good fit between the message and the context.

A similar set of assumptions might be applied to the *social-proof* sign. Other hospital visitors might act as valid and trustworthy peers against whom to compare one's own behavior. People often involuntarily use the behavior of peers as a reference and usually do not want to deviate from this norm (Cialdini & Goldstein, 2004; Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). Again, it can be assumed that the *social-proof* principle was effectively activated through the sign signaling that other hospital visitors clean their hands. This might have led to an increased level of compliance with the normative behavior of using the dispenser. Additionally, the evidence for the social effect found in the present study is a further example for the *social-proof* influence on people's behavior.

The factors mentioned above could also help to explain why some signs were less persuasive. For example, depicting people in traditional local outfits which should activate a sense of unity might fail to convey meaningful information because it does not fit into the hospital context and some people might not identify with the local group. Therefore, the *unity*-sign might have been

less potent in triggering the intended principle of persuasion and in turn did not produce a strong automatic reaction. More research is needed to better understand how the fit between target behavior, message, and situation interact to activate the intended principles effectively. Also, future research should focus on testing experimentally if the principles of persuasion indeed activate an automatic response or trigger deliberate thinking in this specific context. A further implication of this study is that even when an intervention is grounded in theory, putting considerable effort into planning and piloting the intervention material in the field before a large roll-out is necessary to understand the casuistic factors at play (Fishbein, Hall-Jamieson, Zimmer, Von Haeften, & Nabi, 2002). Additionally, health and safety interventions using signs can also be categorized as *nudging*, i.e., a slight push to encourage desired behavior (Caris et al., 2018). When an intervention is designed to nudge people towards a certain behavior, potential risks and unintended consequences should always be assessed *a-priori*. For the present study, the potential risk for hospital visitors being encouraged to sanitize their hands was evaluated to be no more than minimal. No meaningful unintended negative consequences were anticipated. Triggering automatic reactions through nudging has been criticized for being manipulative and undermining personal autonomy (see Schubert (2015) for a discussion on the ethics of nudging). However, the present intervention's intention in improving hand hygiene behavior in hospitals was not concealed, and as the overall low usage-rate indicates, people's personal decision whether to use the dispenser or not was uncompromised.

The present study had several limitations. First, due to the monitoring system, it was impossible to control if the signs only affected visitors. While employees use another entrance, some hospital staff still pass by every day. Additionally, most of the patients enter the hospital through the main entrance. This is not a problem, as patients should also clean their hands at the entrance, but some of the messages explicitly mentioned visitors, so patients might not have felt targeted. Also, there is a cafeteria next to the hospital's entrance. Part of the traffic recorded was not from people entering or leaving the hospital but from people going to the cafeteria. As this was true for both the baseline weeks and experimental weeks, it does not affect the interpretation of our results. The additional traffic might make the effect of the intervention on visitor hand hygiene

behavior look smaller than it was. Second, with the monitoring system, it was not possible to test whether people who entered the hospital with the signs in direct view used the hand-rub dispenser more often than people who left the hospital without the sign in direct view. This should be tested in a subsequent study. Third, it cannot be guaranteed that the sensor's recording whenever people entered or left the immediate dispenser area is a perfect representation of actual dispenser usage. However, sample observations have shown that people who approach the dispenser within the sensor's radius also use it. Fourth, no assertion about the quality of hand hygiene behavior (i.e., if enough hand-rub was used and if it was properly spread over the hands) can be made. As mentioned above, observed visitors considerably varied in how often and how strongly they pressed the dispenser lever when cleaning their hands. Future research should investigate if the quality of visitors' hand hygiene behavior affects infection prevention. Fifth, even though the majority of people entering and leaving the hospital lobby saw only one sign, giving the range of hospitalization time per patient, some visitor's might have seen more than one sign. Still, as the baseline usage rate did not increase over time, the potential carry-over effect is negligible. Sixth, we do not know if the signs were equally effective in activating the intended principle of persuasion. In the material pre-test, the participants were asked to rate whether the messages were consistent with the proposed principles and to rate whether the pictures were consistent with the above-stated messages. This approach was chosen to make sure that the message to be conveyed was complemented by the image to a high degree. However, the final signs were not tested on their effectiveness in activating the intended principle. In subsequent research, the intervention material should be more thoroughly validated (see Sassenrath, Diefenbacher, Siegel, & Keller (2016) for one of the few examples of a diligent intervention material pre-test in this context). Finally, the overall increase in dispenser usage rates was rather moderate. However, to put the figures in perspective, in an average week, about 17,580 people passed by the dispenser. A usage rate of 6.0% equals 1,055 dispenser usages, while 7.7% (in the *authority*-sign week) represents 1,354 usages. It is assumed that the effect does not substantially decline over time since the visitors are constantly changing. Extrapolated to one year, this would mean that placing a single sign based on the authority principle in the hospital lobby might result in the dispenser being used about 15,548

times more annually. Considering the scale of the negative consequences for every patient affected by a healthcare-associated infection, this easy-to-administer and cost-efficient intervention might have an impact on patient safety in healthcare facilities. However, though several studies have reported a decline in infection rates after hand hygiene interventions targeting visitors and patients (e.g., Cheng et al., 2007; Gagne, Bedard, & Maziade, 2010), it should be noted that there is no published evidence to indicate that improving visitors' hand hygiene behavior at a hospital lobby reduces healthcare-associated infection rates. It could be only speculated whether the intervention had an effect on visitors' hand hygiene behavior closer to the point-of-contact with the patients on the wards by raising awareness on the topic. Further research should be conducted to test whether there is a carry-over effect from the entrance to the on-ward behavior. It should also be explored if placing the signs at the wards' entrances or within the patient rooms could improve visitors' hand hygiene behavior in closer proximity to the actual point-of-contact with the patients.

To our knowledge, this is the first study to systematically test Cialdini's seven principles of persuasion on improving hand hygiene in hospitals among visitors. Signs based on the *authority* and *social-proof* principles substantially increased dispenser usage at the facility's entrance. The results indicate that a straightforward and cost-efficient intervention can initiate expedient behavior change in a natural setting. However, the results also showed that the intervention material needs to be carefully planned and pre-tested. More research is needed to find optimal ways to enhance this positive effect and to see whether the findings can be generalized in other healthcare environments.

Author Contributions

All authors developed the study concept. All authors contributed to the study design. Material testing and data collection were performed by S. Gaube and V. Windl. The data was analyzed by S. Gaube. S. Gaube and E. Lerner interpreted the results. S. Gaube drafted the manuscript, and E. Lerner provided critical revisions. All authors approved the final version of the manuscript for submission.

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