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Keep the status quo: randomization-based security checks might reduce crime deterrence at airports

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ABSTRACT

Due to the increasing number of passengers at airports, regular security checks reached their capacity limits. Thus, alternative security checks are being discussed to increase their efficiency. For example, instead of screening all passengers briefly, a randomly selected sample of passengers could be screened thoroughly. However, such randomization-based security checks could be perceived as less secure based on the assumption that fewer illegal objects would be uncovered than through regular security checks. To analyze whether this is the case, we conducted an online experiment that investigated people's perceptions of and preference for traditional and randomization-based security checks from both the passenger and the criminal perspectives. The findings suggest that within security checks with explicitly stated equal probabilities of detecting illegal objects, passengers do not exhibit strong preferences for either the traditional or the randomization-based security checks. However, randomization-based security checks would be preferred by criminals. Thus, with regard to security, the status quo, namely traditional security checks, is still the best way to keep airports secure.

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Airport security; risk perception; decision-making; uncertainty

1. Introduction

Security measures at airports have been intensified and tightened in recent decades (Jackson et al. 2012; Bureau of Transportation Statistic 2020). Before the Lockerbie incident in 1988,[1] not every piece of luggage or every passenger was checked. Since then, additional regulations have been introduced, including the restriction of liquids in hand luggage (LaTourrette et al. 2012; Bennetts and Charles 2016). However, this has increased not only the cost of security measures but also the wait time for security checks. At the same time, air and passenger traffic has increased (except for 2020 due to Covid-19). Regular security checks have reached their capacity limits (International Air Transport Association 2018). Alternatives to keep airports secure are discussed considering cost–benefit analyses (LaTourrette et al. 2012; Stewart and Mueller 2014). Instead of screening all passengers with even more extensive methods, an alternative is that only a limited number of people is checked (Nguyen, Rosoff, and John 2017; Nguyen and John 2018; Ridinger et al. 2016; Scurich and John 2014; Viscusi and Zeckhauser 2003). In this case,

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travelers are selected for security screening based on various mechanisms, such as randomization, behavior, or demographics criteria. While randomization-based security checks are a standard in road traffic (WHO. Global Health Observatory (GHO) data; Lee and McGovern 2016), they have not yet been implemented in an airport setting.

It, therefore, remains unclear how such randomization-based security checks are perceived and whether the screening of fewer passengers at airports would lead to a lower security perception than the status quo of screening all passengers. Therefore, the present study examines how secure people perceive traditional and randomization-based security checks at the airport. Overall, the findings of the study provide insights into the perception and preference for different security checks not only from the passenger's perspective but also from the criminal's perspective and uncover additional factors other than effectiveness that seem to be important.

1.1. Theoretical background

Despite airports being relatively secure, meaning that the risk of a terrorist incident occurring in such a location is low, studies have shown that people feel insecure at airports and fear flying due to the high level of media coverage of prior terror-related incidents (Elvy 2011; Gigerenzer 2004; Overbye 2017; Viscusi and Zeckhauser 2003). Indeed, the likelihood of so-called 'dread risks,' namely events associated with low probabilities yet severe consequences, is often overestimated by the public (Gigerenzer 2004; Kahneman and Tversky 1979; Slovic 2006; Tversky and Kahneman 1974). With regard to airport security, this phenomenon could result in people's demand for security measures being high, suggesting that the introduction of risk-based security checks would likely be perceived as a highly insecure approach, which implies a low level of acceptance among passengers.

Up to now, only a limited number of studies have examined how passengers perceive different security checks. The few studies that had been conducted found that traditional security checks were generally perceived as more secure when compared with selection-based security checks, and airports implementing them are preferred as departure airport (Nguyen, Rosoff, and John 2017; Nguyen and John 2018; Ridinger et al. 2016; Scurich and John 2014; Stotz et al. 2020). Passengers seem to prefer traditional security checks regardless of the alternative screening methods described in these studies. One such alternative is a randomization-based screening, where only a certain number of people are randomly selected for screening. In a prior study, a lower screening rate was associated with lower detection rates and thus, a lower security perception, irrespective of whether 30% or 90% of passengers were screened (Stotz et al. 2020). This finding implies that security perception does not only depend on the number of people selected for screening. It rather seems that people fundamentally differentiate between 'screening all passengers' and 'screening a sample of passengers' and thus, ignore the presented numerical information.

However, other studies have shown that even when the alternative comprises a two-stage screening, the traditional security check was still perceived as more secure (Nguyen, Rosoff, and John 2017; Nguyen and John 2018). This two-stage screening requires all people to walk through a metal detector or body scanner, and every luggage is x-rayed. In addition, some people are checked more closely using either the same or additional methods, such as detection dogs or manual explosive devices.

In all three studies presented above (Nguyen, Rosoff, and John 2017; Nguyen and John 2018; Stotz et al. 2020), the participants were not informed about the detection rate of the two security checks. Thus, traditional security checks could have been perceived as more effective in detecting illegal objects than the presented alternatives, which would explain the observed higher security perception of traditional security checks. Besides, from a criminals' perspective, a higher perceived effectiveness would indicate a higher certainty of getting caught.

Consequently, and in accordance with the deterrence theory, a higher certainty of getting caught results in a higher deterrence (Scheider 2001; Paternoster 2010; Geerken and Gove 1977; Chalfin and McCrary 2017; Braga and Weisburd 2012). Scurich and John (2014) conducted an experimental study that included a traditional and a randomization-based security check with equal detection probabilities of illegal objects. Despite their explicit statement of equal detection probability, they found that traditional security checks are perceived as more secure compared to randomization-based security checks. Despite the differences in security perception, about half of the participants preferred the airport with traditional security checks and the other half the airport with randomization-based security checks as departure choice. In contrast, both security options were perceived as equal deterrent. In line with other researchers (Bennetts and Charles 2016), Scurich and John concluded that airport preference is not only based on security perception but is influenced by additional factors, such as the perceived fairness, convenience or effectiveness of the security checks (e.g. security and convenience are particularly described as tradeoff factors).

There are three important limitations in the study by Scurich and John (2014) that need to be discussed. Firstly, even though the study included a question about the perceived effectiveness, it cannot be ruled out that participants correctly understood that the detection probability of illegal objects was equal. The ability to understand and process mathematical concepts has previously been shown to depend on an individual's numeracy (Peters et al. 2006; Peters 2008, 2012). Risk communication literature points out that in particular, people with low levels of numeracy show more difficulty in understanding percentages and likelihoods and are less likely to take numerical information into account (e.g. extracting and integrating graphical information) in their decision-making (Hess et al. 2011; Keller, Siegrist, and Visschers 2009). Thus, people, and particularly low numerates, might face greater difficulty in understanding that the probability of detecting illegal objects is equal in both security checks. In turn, simply providing numerical information might not be enough as a communication strategy.

Secondly, some participants may have no preference regarding security checks but were nevertheless compelled to make a choice. As a result, they either randomly selected one of the two security checks or chose the default option of the more familiar one, namely the traditional security check. Thus, the reasons for people's security check preference remain largely unclear.

Thirdly, the perspective of a passenger (e.g. feeling secure) is not the only important aspect of security checks. The deterrent and protective effects against criminal activity are others. Scurich and John (2014) used a hypothetical scenario from a passenger's perspective ('fly to a business meeting') and then asked how deterred people were by these security checks, which might be difficult to judge from a passenger's perspective. In fact, operationalizing and measuring deterrence is challenging since most people would not engage in illegal activities (e.g. smuggling a bomb through airport security). A potential solution to this issue is to present a hypothetical scenario from a criminal perspective ('smuggle illegal objects') and measure the perceived likelihood of success.

1.2. Overall study aims

The overall aim of this study was to assess how people judge the security of traditional and randomization-based security checks at airports. Namely, we investigated whether different assumptions regarding detection probabilities can explain people's perception of and preference for different security checks. To achieve this goal, we adapted the study from Scurich and John (2014) and addressed some of the study's previously mentioned limitations. Furthermore, we focused both on the passenger's perspective (i.e. flying from an airport) and the criminal's perspective (i.e. smuggling illegal objects) to investigate airport security perceptions.

2. Methods

2.1. Adaptation of scenario from a previous study

Based on Scurich and John (2014), a hypothetical choice scenario was presented, which contained two variations of airport security checks. The probability of detecting illegal objects was indicated to be equal in both variations. In the option with the traditional security check, all passengers were searched, but not all illegal objects were detected. In the randomization-based security check, a fixed number of randomly chosen passengers was searched. In this security check, due to the more intensive check, all illegal objects were found within the checked group. Given that many people have difficulties in dealing with numbers and percentages (Peters et al. 2006; Peters 2008, 2012), we wanted to know whether the scenario from Scurich and John (2014) could be simplified and become more understandable. First, we added a sentence to both security check options that made it explicit that the probability of detecting illegal objects was equal instead of just indicating this with numbers (see verbatim scenario description below). Second, we added the information that the security checks were more extensive in the randomization-based security check than in the traditional security check to explain why the randomized security checks resulted in equal detection probabilities even though not everyone is checked (i.e. to reach equal detection probabilities). Based on these two adjustments, we expected the new scenario to be more understandable than Scurich and John's (2014) version.

Original scenario

'**Airport A** has a procedure that searches all passengers. It will detect one in three passengers who carry illegal objects (traditional approach).'	'Airport **B** has a procedure that randomly searches one in three passengers. Of the passengers selected to be searched, it will detect all who are carrying illegal objects (randomized approach).'

New scenario

'At **airport A**, all passengers are checked, but the security personnel only detects illegal objects in one of three cases. All in all, every third passenger is identified who carries illegal objects.'	'At **airport B**, only every third passenger is checked. The selection of passengers is at random. As a result of the more intensive checks, the security personnel discover all illegal objects of the passengers selected to be searched. All in all, every third passenger is identified who carries illegal objects.'

A pre-test was conducted prior to the main study to check whether the adaptations in the new scenario improved the understandability of the equal detection probability.

2.2. Pre-study to check for understandability of scenario

In total, N = 273 members of the internet panel of the University of Zurich and students from the Swiss Federal Institute of Technology Zurich (ETH Zurich) completed the pre-study. Participants were randomly assigned to one of the two scenarios. The age ranged from 18 to 78 years (M = 30, SD = 12) with 69% (n = 189) being female participants. We examined whether participants correctly indicate that the probability of detecting illegal objects is equal in the two security checks with the following question: 'At which airport is it more likely that passengers carrying illegal objects will be detected?' (response options: airport A, airport B, both airports are equal).

More participants indicated that the equal probability of detecting illegal objects was equal in the new scenario (64.6%, n = 93) than in the original scenario from Scurich and John (2014)

(42.6%, n = 55). This difference in the understandability of the original scenario and our new scenario was statistically significant (x^2 ($_2$) = 13.20, $p < .01$). The remaining participants either perceived a higher detection probability of illegal objects at the security check at airport A (original scenario: 39.5%, n = 51, new scenario: 21.5%, n = 31) or at airport B (original scenario: 17.8%, n = 23, new scenario: 13.9%, n = 20).

2.3. Main study design and procedure

The study started with an instruction page and a request for informed consent to participate. After questions regarding sociodemographic variables, gender and age, participants were shown the scenario. In this between-subjects design, participants were randomly assigned to either the scenario by Scurich and John (2014) or our adapted version. As in the pre-study, we examined if participants correctly indicated that the two security checks had the same probability of detecting illegal objects. Based on this variable, participants were subsequently assigned into two groups: those who indicated that the probability of detecting illegal objects was equal at both airport and those who indicated a higher detection probability of illegal objects at either the security check at airport A or at airport B (for simplification we name this variable understandability).

Participants then had to judge the two security checks from a passenger's perspective and from a criminal's perspective. For this, they had to indicate which airport they would prefer to fly from and at which airport they would smuggle illegal objects through (response options: airport A, airport B, no preference). Additionally, they indicated the perceived likelihood of successfully smuggling illegal objects past the security checks using a 10-point rating scale ranging from 1 = very low to 10 = very high for airport A and B separately. Next, a semantic differential was presented, where participants had to rate whether the security checks at airport A or B were better, considering the following variables: wait time, personnel costs, strictness, fairness, airport security and deterrence of crime (5-point rating scale ranging from 1 = airport A is better, 3 = both are equal, 5 = airport B is better). Then, they had to indicate the personal importance of these variables (5-point rating scale ranging from 1 = not important at all to 5 = very important).

Lastly, we added the subjective numeracy scale with eight items by Fagerlin et al. (2007) (translation from Keller and Siegrist (2009)) to assess if high numerates were more likely to understand that the detection probability of illegal objects was equal at both airports (Cronbach's alpha $\alpha = .81$).

The experiment ended with a debriefing concerning the fictitious scenarios for all participants.

2.4. Sample

A market institute recruited participants from the German-speaking part of Switzerland in January 2020. Quotas for gender and age were applied to obtain a heterogenous sample of the German-speaking Swiss population. Participants received no information regarding the aim of the study to avoid selection bias. A small monetary incentive was given for participation. A total of N = 678 participants completed the survey. Since we wanted to ensure that participants read the scenarios carefully, we excluded the participants who finished in less than half the median duration (n = 54, median = 6.7 minutes). Finally, data from N = 624 participants (50% female, n = 314) aged between 18 and 69 (M = 45, SD = 15) were analyzed. All analyses were conducted using SPSS 25 (IBM Corp. Released 2017).

3. Results

3.1. Evaluation of the scenarios' understandability

A chi-square test suggests that understandability differed significantly between the presented scenarios (x^2 $(_2)$ = 12.22, $p < .001$). People reading the new version of the scenario were more likely to correctly indicate that the probability of detecting illegal objects was equal (47.7%, n = 145) than people reading the original scenario from Scurich and John (2014) (33.6%, n = 107). The remaining participants either perceived a higher detection probability of illegal objects at the security check at airport A (original scenario: 47.2%, n = 150, new scenario: 30.4%, n = 93) or at airport B (original scenario: 19.2%, n = 61, new scenario: 22.2%, n = 68). Numeracy might explain why some participants correctly indicated that the detection probability of illegal objects was equal at both airports while others did not. The mean of numeracy in the present study was M = 4.06, SD = 0.90. Thus, a point-biserial correlation was calculated between numeracy and understandability. However, the results ruled out that the understandability of the equal probability of detecting illegal objects is related to numeracy ($r_{pb} = .04$, $p = .31$).

3.2. Passengers' preference of departure airport

We hypothesized that a given passenger's preference with regard to a departure airport depends on whether that passenger perceives the probability of illegal objects being detected to be equal at both potential airports. Thus, we assumed that those people who indicated the detection probability of illegal objects to be equal at both airports would not show a preference for either potential departure airport. In an effort to confirm this hypothesis, we first grouped the participants into (1) those, who indicated that the probability of illegal objects being detected was equal at both airports and (2) those, who indicated that the probability of detecting illegal objects was higher at either airport A or B[2]. Furthermore, we had to rule out that the relationship between understandability and preference is dependent on whether the participants had seen the original or the new scenario. Therefore, we conducted a log-linear analysis (final model fit - likelihood ratio: x^2 $(_4)$ = 2.21, $p = .70$), which ruled out a three-way interaction of preference, scenario and understandability (x^2 $(_2)$ = 1.27, $p = .53$). Moreover, no significant two-way interaction of scenario and preference of departure airport was found (x^2 $(_2)$ = 0.95, $p = .62$). There was a significant interaction of scenario and understandability (x^2 $(_1)$ = 8.14, $p < .01$) as well as understandability and departure airport (x^2 $(_2)$ = 101.95, $p < .001$). The non-significant three-way interaction allowed us to pool data from the original and new scenarios to further examine our main assumption of the relationship between preference of departure airport and understandability of the equal probability of detecting illegal objects.

Over both scenarios, 40.1% (n = 250) of all participants preferred airport A implementing a traditional security check, 25.5% (n = 159) preferred airport B implementing a randomization-based security check and 34.5% (n = 215) showed no preference of departure airport. Results of a chi-square test revealed differences in the preference of departure airport depending on the understandability of the scenario (x^2 $(_2)$ = 103.44, $p < .001$). Figure 1 shows that of the participants who correctly indicated that the detection probability of illegal objects to be equal, more than half (56.7%, n = 143) had no preference regarding a departure airport. About 20% each preferred either the traditional security check or the randomization-based security check (airport A: 20.2%, n = 51, airport B: 23.0%, n = 58). In contrast, the majority of people who did not indicate that the detection probability are equal, preferred an airport implementing a traditional security check as departure airport (53.5%, n = 199), while fewer participants showed a preference for a randomization-based security check (27.2%, n = 101) or had no preference of departure airport (19.4%, n = 72). For a detailed overview of the preference of departure airport depending on the scenario and understandability, see Table A1 in the appendix.

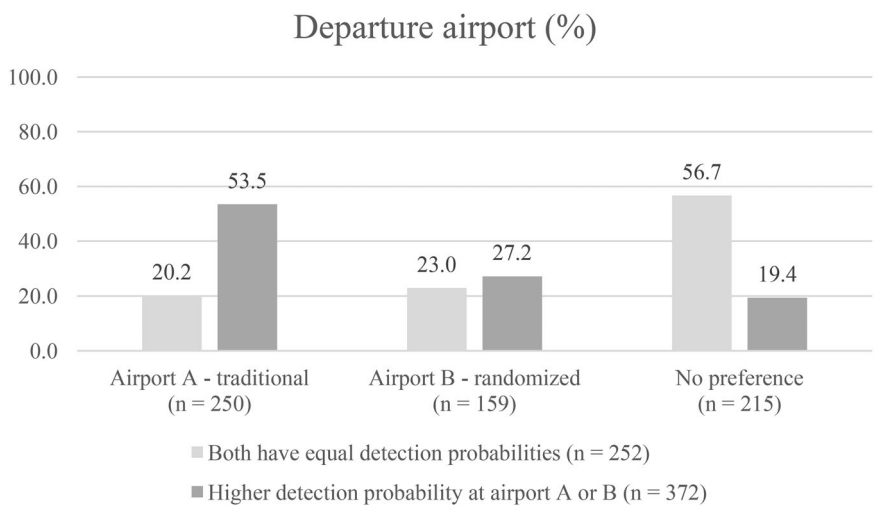

Figure 1. Preference of departure airport across understandability (percentages of participants).

3.3. Criminals' preference for an airport to smuggle illegal objects through

As a next step, we examined people's preference for a particular airport from the perspective of someone seeking to engage in criminal activity. Again, we assumed that people's preference for an airport to smuggle illegal objects through depends on their understanding of the equal probability of illegal objects being detected at the two airports rather than on the presented scenario. Theoretically, those participants who correctly indicate that the detection probability to be equal in relation to both types of security checks should have exhibited no preference in terms of which airport to smuggle illegal objects through. To test this assumption, we grouped the participants into (1) those who indicated that the probability of detecting illegal objects was equal at both airports, and (2) those who indicated that the probability of detecting illegal objects was higher at either airport A or B[3]. We then conducted a loglinear analysis (final model fit - likelihood ratio: x^2 $(_2)$ = 1.75, p = .42), which ruled out the possibility of a three-way interaction among preference, scenario, and understandability (x^2 $(_2)$ = 1.75, p = .42).[4] Moreover, this analysis allowed us to pool data from both the original and new scenarios in order to examine whether differences in terms of the preferred airport to smuggle illegal objects through are dependent on the understandability of the scenario.

Across the two scenarios, 14.9% (n = 93) of the participants reported that they would try to smuggle illegal objects past the traditional security check, 58.8% (n = 367) would try it past the randomization-based security check, while 26.3% (n = 164) showed no preference with regard to which airport to smuggle illegal objects through. The results of the chi-square test revealed differences in relation to the preference for a particular airport to smuggle illegal objects through, depending on the understandability of the scenario (x^2 $(_2)$ = 59.99, $p < .001$). Figure 2 reveals how correctly indicating the equal probability illegal objects being detected at both airports led to participants increasingly reporting 'no preference[(42.9%, n = 108) when compared with indicating a higher detection probability at either airport (15.1%, n = 56). Further, the reported preference for a randomization-based security check was lower when the participants correctly indicated that the probability of detecting illegal objects was equal (45.2%, n = 114) when compared with when they did not (68.0%, n = 253). Overall, fewer participants opted to smuggle illegal objects through a traditional security check (both airports have equal detection probabilities: 11.9%, n = 30; higher detection probability at airport A or B: 16.9%, n = 63) than to smuggle such objects through a randomization-based security check (both airports have equal detection probabilities: 45.2%, n = 114; higher detection probability at airport A or B: 68.0%, n = 253). A

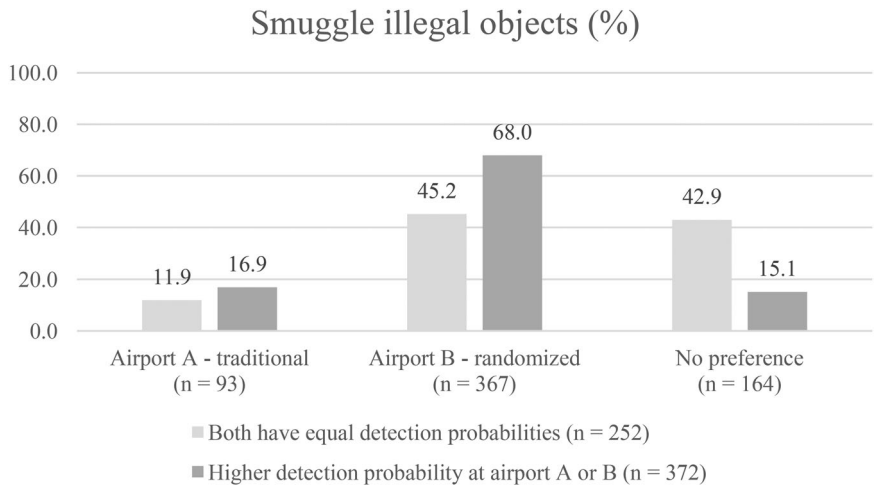

Figure 2. Preference of airport to smuggle illegal objects across understandability (percentages of participants).

detailed overview of the participants' preference for an airport to smuggle illegal objects through depending on the scenario and the level of understandability can be found in

3.4. Criminals' perception of security

Arguably, a criminal will choose to smuggle illegal objects past the security check that is associated with a higher probability of being successful. We wanted to determine whether the perceived likelihood of successfully smuggling illegal objects past the security checks differs between the two security checks and whether it depends on the understandability of the equal probability of detecting illegal objects and finally, on the scenario. It is possible that those participants who correctly indicated the detection probability at both airports to be equal perceived the likelihood of smuggling illegal objects through both airports to also be equal. To investigate this matter, we performed a $2 \times 2 \times 3$ mixed analysis of variance (ANOVA) concerning the security perceptions of airports A and B, the scenario, and the level of understandability. For this analysis, we differentiated between those participants who indicated that the detection probability was higher at airport A and those participants who indicated that the detection probability was higher at airport B when measuring the likelihood of smuggling illegal objects through airport A and airport B.

The results showed that the perceived likelihood of successfully smuggling illegal objects was higher in relation to an airport that implemented a randomization-based security check ($M = 5.27$, $SD = 2.35$) than an airport that implemented a traditional security check ($M = 4.48$, $SD = 2.82$) ($F(1, 620) = 21.11$, $p < .001$, $\eta_p^2 = .03$). However, the results also suggested that the differences in security perceptions depended on the perceived probability of detecting illegal objects. In fact, the differences in security perceptions were larger in those participants who perceived a higher detection probability at airport A (traditional security check at airport A: $M = 3.91$, $SD = 3.02$; randomization-based security check at airport B: $M = 5.59$, $SD = 2.33$) than in those participants who correctly indicated the probability of detecting illegal objects to be the same at both airports (traditional security check at airport A: $M = 4.70$, $SD = 2.59$; randomization-based security check at airport B: $M = 5.10$, $SD = 2.39$). Those participants who perceived a higher detection probability at airport B perceived it to be equally feasible to successfully smuggle illegal objects through both types of security checks (traditional security check at airport A: $M = 5.10$, $SD = 2.72$; randomization-based security check at airport B: $M = 5.02$, $SD = 2.60$) ($F(2, 618) = 13.63$, $p < .001$, $\eta_p^2 = .04$) (see Figure 3).

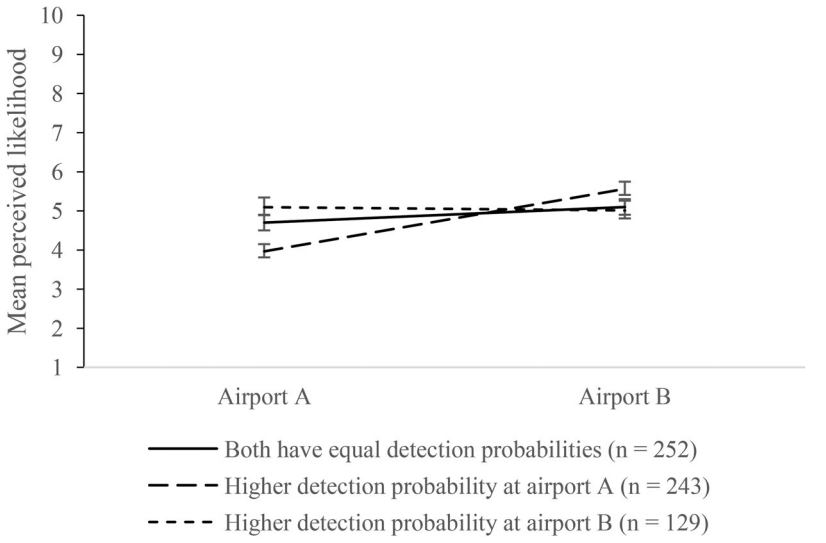

Figure 3. Mean values of the perceived likelihood of successfully smuggling illegal objects at airports A (traditional security check) and B (randomization-based security check) across understandability. The error bars represent standard errors.

No significant effect could be found for the remaining interactions and main effects (interactions: airport x understandability x scenario ($F(2, 618) = 1.29$, $p = .28$, $\eta_p^2 = .00$), scenario x airport ($F(1, 618) = 0.35$, $p = .55$, $\eta_p^2 = .00$), understandability x scenario ($F(2, 618) = 0.01$, $p = .99$, $\eta_p^2 = .00$); main effect: understandability ($F(2, 618) = 0.88$, $p = .42$, $\eta_p^2 = .00$), scenario ($F(1, 618) = 0.70$, $p = .40$, $\eta_p^2 = .00$)).

3.5. Additional relevant factors of security checks

Finally, the results presented in the sections 3.2 and 3.3 suggest that other factors than perceived security might be relevant for passengers and criminals. This possibility was examined with a semantic differential. Furthermore, we wanted to assess how important those factors are perceived. Figure 4 shows the semantic differential of wait time, personnel costs, strictness, fairness, airport security and crime deterrence according to the perceived importance of these factors (for a detailed overview see Table A3 in the appendix). Since the analyses of preference for a security check in section 3.2 and 3.3 indicate that the understandability (yes/no) of the scenario seemed to be important in the previous analyses, results from the semantic differential are presented separately for people who correctly indicated that the detection probability of illegal objects was equal and people who did not. Figure 4 reveals that an airport with a traditional security check is overall perceived to be more secure, better at crime deterrence and fairer compared to an airport implementing a randomization-based security check. In contrast, participants evaluated a randomization-based security check more positively on economic aspects (wait time, personnel costs) compared to a traditional security check.

Furthermore, as shown in Figure 4, airport security is perceived to be the most important factor, followed by crime deterrence, fairness, wait time and personnel costs.

4. Discussion

The present study resulted in two key findings, which are both of relevance in relation to security practice at airports. First, based on the assumption that both traditional and randomization-based security checks prove equally effective at uncovering attempts to smuggle illegal objects,

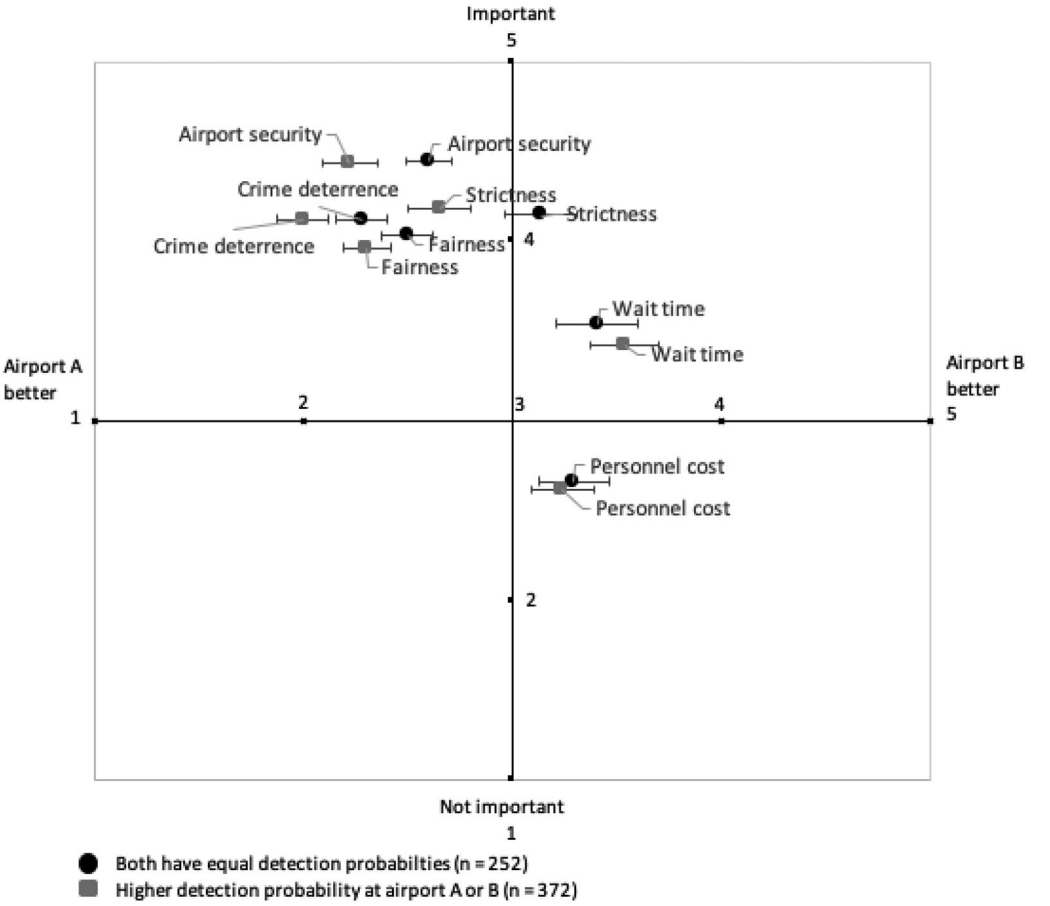

Figure 4. Mean values of the factors wait time, personnel costs, strictness, fairness, airport security and crime deterrence. X-axis represents the question "Which airport is better regarding … ?", 5-point rating scale; y-axis represents the question "How important are these factors?", 5-point rating scale. The error bars represent confidence intervals.

the majority of passengers do not have a preference regarding the type of security check they must undergo. The remaining passengers either favor traditional security checks due to the higher feeling of security, deterrence, or fairness associated with them, or favor randomization-based security checks due to lower wait times and costs associated with such checks. However, it is crucial to note that criminals might feel less deterred by a randomization-based security check than by a traditional security check. While the general public's preference for a particular departure airport involves a tradeoff between security-related and economic factors, criminals tend to ignore economic factors and so might favor a randomization-based security check (Bennetts and Charles 2016; Scurich and John 2014).

The findings of the present study contrast with those of the study by Scurich and John (2014), who identified equal preference with regard to the departure airport choices and found no difference in terms of deterrence. The most likely explanation for this difference concerns the choice of methods used in the studies (e.g. the option to choose 'no preference' and the different operationalization methods regarding deterrence). However, the possibility cannot be excluded that other explanations, for instance, cultural differences (e.g. it might be that the concept of risk-based screening is more familiar to Americans (Transportation Security Administration 2020) than to Swiss people), might influence the preference and perception of risk-based security checks.

Second, communicating about security checks at airports is challenging because even if the detection probability of illegal objects of security checks is directly stated, participants might

misunderstand this information or do not take it into account when making decision. In fact, it is suggested that some people prefer the security check they perceive as more effective, irrespective of the objective detection probability. When misunderstandings arise about the likelihood of detecting illegal objects, traditional security checks are perceived as more deterrent and airports implementing them are preferred as departure airport. One explanation could be that traditional security checks are more familiar to the public and tend to be perceived as the status quo, whereas any deviation from this status quo is perceived as less secure. The study from Stotz et al. (2020) showed that switching from 100% screening to less than 100% leads to a lower security perception, independent of the actual percentage of screened passengers. Another explanation could be that people hold subjective beliefs with regard to how a security check works as well as how good it is at detecting illegal objects. According to the prior risk research, people do not always act as rational agents who weigh up the probabilities and severities of different outcomes; instead, they sometimes rely on gut feelings to guide their perceptions (Slovic 2006; Kasperson et al. 1988). Thus, it might be the case that people underestimate the likelihood of being selected for security screening and so perceive themselves to have a higher chance of successfully smuggling illegal objects through a randomization-based security check. Even though it was explicitly mentioned in the present study that people are randomly selected for security screening, this situation may not have been perceived as truly random (Lum et al. 2015; Viscusi and Zeckhauser 2003). It could be that the participants assumed selection for screening to be based on specific criteria (e.g. suspicious behavior, sociodemographic profile) and, on the basis that they do not fulfill those criteria, considered themselves to be able to evade being selected for security screening. This notion is supported by the lower perceived fairness of randomization-based security checks, as noted by Scurich and John (2014). Although inequality could be perceived in the fact that some people can bypass security checks whereas others are screened, the probability of being selected for security screening is, due to the randomization-based approach, equal for all passengers and so should be equally fair.

4.1. Practical implications

For an airport, the optimal use of limited security resources is not only key but also challenging due to the differing demands of the stakeholders involved. On the one hand, the objective of the security sector is to implement as many security measures as necessary to ensure security at the airport. On the other hand, the airport's financial sector wants to keep the costs for security as low as possible within the regulatory framework. While the traditional security checks better match the aims of the security stakeholders, a randomization-based screening is a promising alternative to keep costs low. The latter argument gains importance with regard to the economic loss of passengers due to Covid-19 and the associated future uncertainty.

From the perspective of the security sector, screening everyone but less rigorously is perceived as more secure and deterrent than screening a random sample thoroughly. The chance of not being selected for screening is perceived to be higher than the chance of not being detected while being screened, regardless of the detection probability of illegal objects. Consequently, it is plausible that lower security perception reduces crime deterrence and attracts potential offenders. What this could mean for existing security measures at airports is illustrated by one example. Members of the TSA pre-check program (Transportation Security Administration 2020) need to pass a one-time background check and are then only checked at random (Jackson, Chan, and LaTourrette 2012). Thus, if a potential offender manages to pass this background check, they would find airports with TSA pre-check programs attractive for criminal activities.

Lastly, the findings are discussed from the perspective of the airport's financial sector. Fortunately, there have been only very few attacks on Western airports. Thus, individuals may, in

general, feel very secure at airports. Consequently, from an airport operator's point of view and in terms of cost–benefit analyses, a reduction of perceived security and deterrence due to the introduction of randomization-based security checks could be managed (LaTourrette 2012; Stewart and Mueller 2014). An airport could promote the benefits of a randomization-based security check, such as reduced wait time in security control and a more convenient security check (i.e. due to the lower probability of being screened).

All in all, it will remain a challenge to satisfy the demands of the various stakeholders and find a balance between security and economic aspects.

4.2. Limitations and implications for future studies

As with any study, our study faced certain limitations. First, at the airport, a distinction is made between illegal and prohibited objects. Depending on the classification as illegal or prohibited, the consequences of getting caught vary. For example, carrying a Swiss Army knife on the airplane is prohibited, but its possession is not illegal. In this case, the only consequences would be a withdrawal of the knife, which can be seen as a mild punishment. As a result, the deterrence effect would be low. However, the severity of punishment is one important aspect of the deterrence theory (Scheider 2001; Beccaria 1976; Killias, Scheidegger, and Nordenson 2009). Further studies should examine if security perception is dependent on the severity of punishment.

A second limitation concerns the addition of the sentence that references the equal detection probability in the new scenario. The inclusion of a sentence that explicitly mentions how the detection probability is equal should simplify the probability description. However, such a statement might have caused the participants to believe that the 'correct' answer to the question is that the two screening procedures are equally likely to detect illegal objects, even if they do not believe or understand the probabilities presented. Consequently, the participants' answer would not be what they actually think but rather what they assume to be the perfect answer in the eyes of the researchers. Therefore, it cannot be entirely ruled out that the participants gave a socially desirable answer rather than stating what they truly believed. Yet, given that no differences were found between the two scenarios, this seems rather implausible.

Some participants failed to correctly indicate the stated equal detection probability, which cannot be explained by lower numeracy levels (Peters et al. 2006; Peters 2008, 2012). While we assessed the participants' numeracy via a self-assessment approach, another study found similar effects (i.e. no effect of numeracy) on risk communication when using objective numeracy measures (Jenkins, Harris and Lark 2019). Another explanation could concern the detection rate. The traditional security check did not detect everything, while the randomization-based security check did detect everything. Even though we tried to simplify the scenario and make it more plausible by adding information about the 'more intensive checks' related to the randomized approach, the participants may still have perceived it to be unreliable. This finding reflects the difficulty associated with risk communication strategies, whereas the presentation of objective numerical information does not necessarily result in adequate perceptions. Nevertheless, we were able to show that from the perspective of a criminal, understanding the probability of illegal objects being detected has little influence on preferences and perceptions concerning security checks. Regarding the use of online scenarios, there are two important issues to note. First, the use of a manipulation check helps to determine the understandability of a scenario. However, it does not capture participants' subjective beliefs as to whether the descriptions of the detection probabilities associated with the two types of security checks are realistic and identical. Future studies should operationalize the perceived credibility in order to help better understand people's preferences. This could be achieved by further differentiating between those participants who found it credible that the likelihoods of detecting illegal objects were the same for both security checks and those participants who did not. Second, the 'no preference' option

also captures those participants who were satisfied with either type of security check. Despite the fact that, as suggested by Scurich and John (2014), a forced choice better matches daily decisions, those people without a preference would have been forced to make a choice either way. The findings of the present study revealed that participants who correctly indicated the probability of detecting illegal objects to be equal in relation to both security checks made use of the 'no preference' option more often than participants who did not.

4.3. Conclusion

In summary, the findings from this study suggest that passengers do not exhibit strong preferences for either the traditional or the randomization-based security checks, while from a criminal perspective, there exists a preference for randomization-based security checks. In fact, other factors than the detection probability of illegal objects seem to be of importance. While traditional security checks are associated with a stronger feeling of security and fairness, randomization-based security checks are rated more favorably on economic aspects, such as wait time or costs. Thus, with regard to security at airports, the status quo, namely traditional security checks, is still the best way to keep airports secure. However, in terms of cost–benefit analyses, randomization-based security checks seem to be a promising alternative. Increasing the familiarity of randomization-based alternatives may reduce deviations from the status quo and help to improve security perceptions. Further research is required to better understand how communication about (alternative) security checks need to be designed to influence the perception of safety and criminal deterrence.

Notes

1. An aircraft was destroyed by a bomb, killing all 243 passengers and 16 crew, as well as 11 people, who were hit by sections of the aircraft. It is known as the deadliest terror attack in the history of the United Kingdom (Ushynskyi 2009).
2. Additional analyses were performed in relation to three groups of participants: (1) those who indicated that the detection probability was the equal, (2) those who perceived the detection probability to be higher at airport A, and (3) those who perceived the detection probability to be higher at airport B. The results showed similar effects. As the focus of this analysis was on those participants who correctly indicated that the detection probability was equal, we combined groups 2 and 3 for most analyses.
3. Further analyses were conducted with three groups of participants: (1) those who indicated that the detection probability was equal, (2) those who perceived the detection probability to be higher at airport A, and (3) those who perceived the detection probability to be higher at airport B. The results showed similar effects. As the focus of this analysis was on those participants who correctly indicated that the detection probability was equal, we combined groups 2 and 3 for most analyses.
4. All two-way interactions were significant: scenario and understandability (x^2 $(_1) = 9.31$, $p < .001$), scenario and preference to smuggle (x^2 $(_2) = 6.76$, $p < .05$), understandability and preference to smuggle (x^2 $(_2) = 56.55$, $p < .001$)

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References

Beccaria, Cesare. 1976. *On Crimes and Punishments*. New York: Macmillan.

Bennetts, Christopher 'Kit', and Michael B. Charles. 2016. "Between Protection and Pragmatism: Passenger Transport Security and Public Value Trade-Offs." *International Journal of Public Administration* 39 (1): 26–39. doi:10.1080/01900692.2015.1028638.

Braga, Anthony A., and David L. Weisburd. 2012. "The Effects of Focused Deterrence Strategies on Crime: A Systematic Review and Meta-Analysis of the Empirical Evidence." *Journal of Research in Crime and Delinquency* 49 (3): 323–358. doi:10.1177/0022427811419368.

Bureau of Transportation Statistic 2020. *Air Carrier Traffic Statistics*. Washington, DC: Green Book.

Chalfin, Aaron, and Justin McCrary. 2017. "Criminal Deterrence: A Review of the Literature." *Journal of Economic Literature* 55 (1): 5–48. doi:10.1257/jel.20141147.

Elvy, D. 2011. "Terrorism, Threat and Time: The Mediating Effect of Terrorist Threat on Public Willingness to Forego Civil Liberties." 2011 European Intelligence and Security Informatics Conference, 12–14 Sept. 2011.

Fagerlin, Angela, Brian J. Zikmund-Fisher, Peter A. Ubel, Aleksandra Jankovic, Holly A. Derry, and Dylan M. Smith. 2007. "Measuring Numeracy without a Math Test: Development of the Subjective Numeracy Scale." *Medical Decision Making* 27 (5): 672–680. doi:10.1177/0272989X07304449.

Geerken, Michel, and Walter R. Gove. 1977. "Deterrence, Overload, and Incapacitation: An Empirical Evaluation." *Social Forces* 56 (2): 424–447. doi:10.2307/2577734.

Gigerenzer, Gerd. 2004. "Dread Risk, September 11, and Fatal Traffic Accidents." *Psychological Science* 15 (4): 286–287. doi:10.1111/j.0956-7976.2004.00668.x.

Hess, Rebecca, Vivianne H. M. Visschers, Michael Siegrist, and Carmen Keller. 2011. ""How Do People Perceive Graphical Risk Communication? The Role of Subjective Numeracy." *Journal of Risk Research* 14 (1): 47–61. doi:10.1080/13669877.2010.488745.

IBM Corp. 2017. IBM SPSS Statistics for Windows 25.0. IBM Corp., Armonk, NY.

International Air Transport Association. 2018. In *Annual Review*.

Jackson, Brian A., E. W. Chan, and T. LaTourrette. 2012. "Assessing the Security Benefits of a Trusted Traveler Program in the Presence of Attempted Attacker Exploitation and Compromise." *Journal of Transportation Security* 5 (1): 1–34. doi:10.1007/s12198-011-0077-0.

Jackson, Brian A., LaTourrette Tom, Edward W. Chan, Lundberg Russell, Andrew R. Morral, and David R. Frelinger. 2012. *Efficient Aviation Security: Strengthening the Analytic Foundation for Making Air Transportation Security Decisions*. New York, NY: RAND Corporation.

Jenkins, Sarah C., Adam J. L. Harris, and R. Murray Lark. 2019. "When Unlikely Outcomes Occur: The Role of Communication Format in Maintaining Communicator Credibility." *Journal of Risk Research* 22 (5): 537–554. doi:10.1080/13669877.2018.1440415.

Kahneman, Daniel, and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47 (2): 263–292. doi:10.2307/1914185.

Kasperson, Roger E., Ortwin Renn, Paul Slovic, Halina S. Brown, Jacque Emel, Robert Goble, Jeanne X. Kasperson, and Samuel Ratick. 1988. "The Social Amplification of Risk: A Conceptual Framework." *Risk Analysis* 8 (2): 177–187. doi:10.1111/j.1539-6924.1988.tb01168.x.

Keller, Carmen, and Michael Siegrist. 2009. "Effect of Risk Communication Formats on Risk Perception Depending on Numeracy." *Medical Decision Making* 29 (4): 483–490. doi:10.1177/0272989X09333122.

Keller, Carmen, Michael Siegrist, and Vivianne Visschers. 2009. "Effect of Risk Ladder Format on Risk Perception in High-and Low-Numerate Individuals." *Risk Analysis* 29 (9): 1255–1264. doi:10.1111/j.1539-6924.2009.01261.x.

Killias, Martin, David Scheidegger, and Peter Nordenson. 2009. "The Effects of Increasing the Certainty of Punishment: A Field Experiment on Public Transportation." *European Journal of Criminology* 6 (5): 387–400. doi:10.1177/1477370809337881.

LaTourrette, Tom. 2012. "The Benefits of Security Depend on How Different Security Measures Work Together." In *Efficient Aviation Security: Strengthening the Analytic Foundation for Making Air Transportation Security Decisions*, edited by Brian A Jackson, Tom LaTourrette, Edward W Chan, Russell Lundberg, Andrew R Morral and David R Frelinger. Arlington VA: RAND Corporation.

LaTourrette, Tom, Brian A. Jackson, Edward W. Chan, Russell Lundberg, Andrew R. Morral, , and David R. Frelinger. 2012. "Introduction: The Goal of Efficient Security." In *Efficient Aviation Security: Strengthening the Analytic Foundation for Making Air Transportation Security Decisions*, 1–10. Arlington VA: RAND Corporation.

Lee, Murray, and Alyce McGovern. 2016. "Logics of Risk: police Communications in an Age of Uncertainty." *Journal of Risk Research* 19 (10): 1291–1302. doi:10.1080/13669877.2015.1115423.

Lum, Cynthia, Peter Zachary Crafton, Rebecca Parsons, Dale Beech, Tarren Smarr, and Michael Connors. 2015. "Discretion and Fairness in Airport Security Screening." *Security Journal* 28 (4): 352–373. doi:10.1057/sj.2012.51.

Nguyen, K. D., and R. S. John. 2018. "Perceptions and Affective Responses to Alternative Risk-Based Airport Security." In *AHFE 2017 International Conference on Human Factors in Transportation, 2017*. Berlin: Springer Verlag.

Nguyen, K. D., H. Rosoff, and R. S. John. 2017. "Valuing Equal Protection in Aviation Security Screening." *Risk Analysis: An Official Publication of the Society for Risk Analysis* 37 (12): 2405–2419. doi:10.1111/risa.12814.
Overbye, M. 2017. "Deterrence by Risk of Detection? An Inquiry into How Elite Athletes Perceive the Deterrent Effect of the Doping Testing Regime in Their Sport." *Drugs: Education, Prevention and Policy* 24 (2): 206–219. doi:10.1080/09687637.2016.1182119.
Paternoster, Ray. 2010. "How much do we really know about criminal deterrence?" *The Journal of Criminal Law and Criminology* 100 (3): 765–824. doi:10.2307/25766109.
Peters, Ellen. 2008. "Numeracy and the Perception and Communication of Risk." *Annals of the New York Academy of Sciences* 1128 (1): 1–7. doi:10.1196/annals.1399.001.
Peters, Ellen. 2012. "Beyond Comprehension: The Role of Numeracy in Judgments and Decisions." *Current Directions in Psychological Science* 21 (1): 31–35. doi:10.1177/0963721411429960.
Peters, Ellen, Daniel Västfjäll, Paul Slovic, C. K. Mertz, Ketti Mazzocco, and Stephan Dickert. 2006. "Numeracy and Decision Making." *Psychological Science* 17 (5): 407–413. doi:10.1111/j.1467-9280.2006.01720.x.
Ridinger, G., R. S. John, M. McBride, and N. Scurich. 2016. "Attacker Deterrence and Perceived Risk in a Stackelberg Security Game." *Risk Analysis : An Official Publication of the Society for Risk Analysis* 36 (8): 1666–1681. doi:10.1111/risa.12547.
Scheider, M. C. 2001. "Deterrence and the Base Rate Fallacy: An Examination of Perceived Certainty." *Justice Quarterly* 18 (1): 63–86. doi:10.1080/07418820100094821.
Scurich, Nicholas, and Richard S. John. 2014. "Perceptions of Randomized Security Schedules." *Risk Analysis : An Official Publication of the Society for Risk Analysis* 34 (4): 765–770. doi:10.1111/risa.12126.
Slovic, Paul. 2006. *The Perception of Risk*. London, UK: Earthscan.
Stewart, Mark G., and John Mueller. 2014. "Cost-Benefit Analysis of Airport Security: Are Airports Too Safe?" *Journal of Air Transport Management* 35: 19–28. doi:10.1016/j.jairtraman.2013.11.003.
Stotz, Tamara, Angela Bearth, Signe Maria Ghelfi, and Michael Siegrist. 2020. "Evaluating the Perceived Efficacy of Randomized Security Measures at Airports." *Risk Analysis* 40 (7): 1469–1480. doi:10.1111/risa.13474.
Transportation Security Administration. 2020. "TSA PreCheck." Last Modified 20.01.2020. https://www.tsa.gov/precheck.
Tversky, Amos, and Daniel Kahneman. 1974. "Judgment under Uncertainty: Heuristics and Biases." *Science (New York, N.Y.)* 185 (4157): 1124–1131. doi:10.1126/science.185.4157.1124.
Ushynskyi, Sergey. 2009. "Pan Am Flight 103 Investigation and Lessons Learned." *Aviation* 13 (3): 78–86. doi:10.3846/1648-7788.2009.13.78-86.
Viscusi, W. Kip., and Richard J. Zeckhauser. 2003. "Sacrificing Civil Liberties to Reduce Terrorism Risks." In *The Risks of Terrorism*, edited by W. Kip Viscusi, 1–22. Boston, MA: Springer US.
WHO. 2016. Global Health Observatory (GHO) data. 2016. Random Breath Testing by Country. edited by World Health Organization.

Appendix

Table A1. Number of participants, row percentages - preference of departure airport.

		Airport A -traditional (%)	Airport B – randomized (%)	No preference (%)
Original scenario	Both have equal detection probabilities (n = 107)	21 (19.6)	27 (25.2)	59 (55.1)
	Higher detection probability at airport A or B (n = 211)	119 (56.4)	53 (25.1)	39 (18.5)
	Total (n = 318)	140 (44.0)	80 (25.2)	98 (30.8)
New scenario	Both have equal detection probabilities (n = 145)	30 (20.7)	31 (21.4)	84 (57.9)
	Higher detection probability at airport A or B (n = 161)	80 (49.7)	48 (29.8)	33 (20.5)
	Total (n = 306)	110 (35.9)	79 (25.8)	117 (38.2)
Total	Both have equal detection probabilities (n = 252)	51 (20.2)	58 (23.0)	143 (56.7)
	Higher detection probability at airport A or B (n = 372)	119 (53.5)	101 (27.2)	72 (19.4)
	Total (N = 624)	250 (40.1)	159 (25.5)	215 (34.5)

Table A2. Number of participants, row percentages - preference of airport to smuggle illegal objects.

		Airport A -traditional (%)	Airport B – randomized (%)	No preference (%)
Original scenario	Both have equal detection probabilities (n = 107)	11 (10.3)	50 (46.7)	46 (43.0)
	Higher detection probability at airport A or B (n = 211)	28 (13.3)	156 (73.9)	27 (12.8)
	Total (n = 318)	39 (12.2)	206 (64.8)	73 (23.0)
New scenario	Both have equal detection probabilities (n = 145)	19 (13.1)	64 (44.1)	62 (42.8)
	Higher detection probability at airport A or B (n = 161)	35 (21.7)	97 (60.2)	29 (18.0)
	Total (n = 306)	54 (17.6)	161 (52.6)	91 (29.7)
Total	Both have equal detection probabilities (n = 252)	30 (11.9)	114 (45.2)	108 (42.9)
	Higher detection probability at airport A or B (n = 372)	63 (16.9)	253 (68.0)	56 (15.1)
	Total (N = 624)	93 (14.9)	367 (58.8)	164 (26.3)

Table A3. Mean values, standard deviations and confidence intervals (95%) of the factors personnel costs, strictness, fairness, airport security and crime deterrence of participants.

			M	SD	N	CI LL	CI UL
"Which airport is better regarding … ?"	Wait time	Both have equal detection probabilities	3.40	1.54	252	3.21	3.60
		Higher detection probability at airport A or B	3.53	1.64	372	3.37	3.70
	Personnel costs	Both have equal detection probabilities	3.29	1.34	252	3.13	3.46
		Higher detection probability at airport A or B	3.24	1.49	372	3.09	3.39
	Strictness	Both have equal detection probabilities	3.13	1.38	252	2.96	3.31
		Higher detection probability at airport A or B	2.65	1.49	372	2.50	2.80
	Fairness	Both have equal detection probabilities	2.50	1.01	252	2.37	2.62
		Higher detection probability at airport A or B	2.30	1.13	372	2.19	2.42
	Airport security	Both have equal detection probabilities	2.60	0.88	252	2.49	2.71
		Higher detection probability at airport A or B	2.22	1.29	372	2.08	2.35
	Crime deterrence	Both have equal detection probabilities	2.28	1.00	252	2.15	2.40
		Higher detection probability at airport A or B	1.99	1.24	372	1.87	2.12
"How important are these factors?"	Wait time	Both have equal detection probabilities	3.54	1.12	252	3.40	3.68
		Higher detection probability at airport A or B	3.42	1.18	372	3.30	3.55
	Personnel costs	Both have equal detection probabilities	2.67	1.06	252	2.53	2.80
		Higher detection probability at airport A or B	2.62	1.13	372	2.50	2.73
	Strictness	Both have equal detection probabilities	4.15	0.99	252	4.03	4.27
		Higher detection probability at airport A or B	4.18	1.08	372	4.07	4.29
	Fairness	Both have equal detection probabilities	4.03	0.88	252	3.92	4.14
		Higher detection probability at airport A or B	3.97	1.15	372	3.84	4.08
	Airport security	Both have equal detection probabilities	4.45	0.89	252	4.34	4.56
		Higher detection probability at airport A or B	4.44	1.00	372	4.33	4.53
	Crime deterrence	Both have equal detection probabilities	4.12	1.01	252	4.00	4.25
		Higher detection probability at airport A or B	4.12	1.11	372	4.01	4.24