

Social identification moderates the effect of crowd density on safety at the Hajj

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Crowd safety is a major concern for those attending and managing mass gatherings, such as the annual Hajj or pilgrimage to Mecca (also called Makkah). One threat to crowd safety at such events is crowd density. However, recent research also suggests that psychological membership of crowds can have positive benefits. We tested the hypothesis that the effect of density on safety might vary depending on whether there is shared social identification in the crowd. We surveyed 1,194 pilgrims at the Holy Mosque, Mecca, during the 2012 Hajj. Analysis of the data showed that the negative effect of crowd density on reported safety was moderated by social identification with the crowd. Whereas low identifiers reported reduced safety with greater crowd density, high identifiers reported increased safety with greater crowd density. Mediation analysis suggested that a reason for these moderation effects was the perception that other crowd members were supportive. Differences in reported safety across national groups (Arab countries and Iran compared with the rest) were also explicable in terms of crowd identification and perceived support. These findings support a social identity account of crowd behavior and offer a novel perspective on crowd safety management.

social cure | social support | social groups

The annual Hajj, or pilgrimage to Mecca (also called Makkah) in Saudi Arabia, is one of the world's largest mass gatherings. The official number of pilgrims who attended in 2012, for example, was over 3 million. The safety of pilgrims has long been a concern to those organizing and attending the Hajj. The Hajj involves rituals at specified spiritual locations during a certain 5-d period each year. Given the number of people seeking to be in the same locations at the same time, therefore, one possible threat to crowd safety is the level of crowd density.

The link between crowd density and risk to crowd safety has been suggested in a number of accounts (see, for example, refs. 1 and 2). High-density flows are said to be a proximal cause of crushing disasters at the Hajj (3). Thus, this was one explanation for the disaster in 2006 when 346 pilgrims died as they attempted to "stone the devil" (4). Furthermore, the period in which the number of pilgrims attending the Hajj doubled from 1 million to 2 million (i.e., 1982–2010) also saw a large number of major crowd disasters (1994, 1998, 2001, and 2004), which again suggests a link between crowd density and risk to crowd safety.

Following these crowd disasters, considerable resources were invested in improving crowd safety at Hajj locations, including most notably the redesign of Jamarat Bridge (5). Indeed, since 1992 over £200 billion has been spent on these projects (6). Although crowd safety has been hugely enhanced at the Hajj since 2006 and a more scientific approach to risk assessment has developed, arguably there has been a neglect of the positive potential of the crowd itself to crowd safety. Overwhelmingly, crowd safety solutions have been understood as purely technological in nature, comprising contributions from engineering, mathematics, and architecture, but not crowd psychology. In existing approaches to understanding and enhancing crowd safety at the Hajj, therefore, the crowd is either excluded or,

worse, treated as simply an inherent source of pathology, for example, through "stampedes" and the spread of diseases (7, 8).

An alternative perspective on crowd safety is suggested by the social identity approach in psychology (9). This approach has been applied to understanding a wide range of crowd phenomena, including crowding and "personal space" (10), urban riots (11), football crowds (12), protest demonstrations (13), mass emergency behavior (14), and audience experiences at music festivals (15). The social identity approach has also been applied to analyzing behavior at religious mass gatherings, through a program of research on the Indian Mela pilgrimage (16, 17).

The social identity approach suggests that, as well as personal identities (which are unique and which differentiate us from other individuals), we have multiple social identities, which are based on our group or social category memberships (9). Sharing a social identity with others in a crowd—defining these others as "us" (or "in-group") rather than "them"—has cognitive, behavioral, and affective consequences (18). Importantly, one of these consequences is increased expectations of social support from others in the crowd (14, 19, 20; cf. 21).

In situations of high crowd density, dangers include that of falling and being trampled or, far more commonly, of being crushed while upright (1, 22). However, such dangers will be reduced where others are considerate and ready to come to one's aid. Based on the previous research, we suggest that the expectation that there is such support will be enhanced where there is shared social identification in the crowd (23). If this formulation is correct, social identification should moderate the negative effect of crowd density on reported safety at the Hajj.

However, these hypotheses have not yet been tested. Indeed, there is a distinct lack of social psychological research on mass gatherings. Although recent studies of the Hindu Mela investigated the role of social identification on factors, such as wellbeing (24),

Significance

A large-scale survey of pilgrims on the Hajj to Mecca (also called Makkah) showed that where there is identification with the crowd the negative effect of crowd density on safety is diminished or even reversed: a new finding. The reason that identification with the crowd moderates the effect of density on safety is because crowd identification increases the perception that others will be supportive. This process also helps to explain national differences among pilgrims in feelings of safety during the event. In contrast both to engineering approaches, which neglect crowd psychology, and traditional crowd psychology, which assumes that the crowd is inherently a "problem," this study shows how the crowd can be part of the solution in crowd safety management.

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noise (25), and cold (26), they did not examine crowd density or safety issues. More specifically, very little social psychological research has been carried out on the Hajj, despite its huge cultural significance and the number of serious crowd accidents that have occurred there in the past. An exception is the study by Clingingsmith et al. (27); but this surveyed pilgrims only after traveling to Mecca, and provided no analysis of crowd behavior. Therefore, no previous study has examined the role of social psychological factors in crowd safety among pilgrims during the Hajj, which was the aim of the present study.

The Present Study

The present study focused on crowd density, social identification, and reported safety in the specific location of Al-Masjid Al-Haram, or Holy Mosque, in Mecca. The Holy Mosque contains the Kaaba, a small black cube-shaped building that is the holiest site on earth to Muslims. During the Hajj, pilgrims attend the Holy Mosque for daily prayers throughout their time in Mecca. The pilgrims must also perform Tawaf inside the Mosque, in which they move seven times in an anticlockwise direction around the Kaaba. [Pilgrims begin the Hajj by performing Tawaf on arrival at Mecca. On the first full day of Hajj (8th Dhul-Hijjah) most pilgrims travel to Mina. The next day is spent in Arafat. Pilgrims leave for Muzdalifah at sunset and stay there until midnight. For the next 3 d they “stone the devil” at Jamarat Bridge in Mina. The pilgrims travel back to the Holy Mosque for a farewell Tawaf. For many pilgrims, however, depending on their time of arrival, Tawaf also takes place during the main days of Hajj.] At the time of the 2012 Hajj (which is the focus of the present study), the Holy Mosque covered an area of 356,800 m² (88.2 acres), including the outdoor and indoor praying spaces (28) (Fig. 1). The Holy Mosque’s total capacity was 2 million. If full, this meant that the building could accommodate an average crowd density level of at least four people per square meter (4 ppm²). However, at certain locations, levels of density have often exceeded this, and as people get closer to the Kaaba levels of 6–8 ppm² have been observed (29). Fig. 2 provides an illustration of a relatively high level of density in the Holy Mosque during the time of the research described here. The Holy Mosque was chosen as the site at which to survey pilgrims because it is an extremely crowded place during the Hajj where there is a clear potential for crowd accidents. Based on the research and theory described above and other considerations, we surveyed pilgrims to test the following hypotheses.

The baseline hypothesis was simply that as crowd density increased, so would the reported level of safety decrease. Second, we expected that each of the following variables would increase

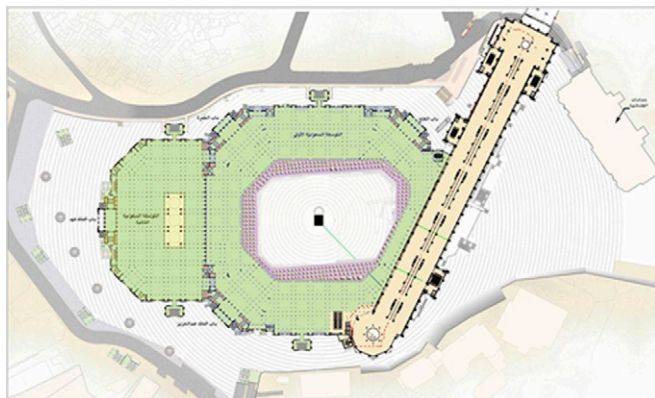


Fig. 1. The Holy Mosque: first floor plan. Image courtesy of Custodian of the Two Holy Mosques Institute of Hajj Research.



Fig. 2. Crowd in Holy Mosque during Hajj 2012. Inset illustrates level of density of 6 ppm².

reported levels of safety: social identification, expected support, and management competence. We measured three loci of social identification: identification as a Muslim, identification with the crowd, and perceptions of other crowd members’ identification as Muslim (i.e., the extent to which they were seen as good in-group members). We included management competence as a predictor of safety on the assumption that pilgrims’ beliefs in the ability of Hajj personnel to manage the events effectively would make them feel safer.

The most novel hypothesis was that social identification would moderate the effects of density on reported levels of safety. Neville and Reicher (15) distinguish between “social identification with a social category” and “shared social identification with others in the crowd.” They authors suggest that the latter is a better predictor of behavior in relation to others in the crowd than the former. We therefore expected to find a relationship of moderation for both identification with the crowd and perceptions of others’ identification as Muslim (because each of these refer directly to shared identification with others in the crowd), but no moderation effect for identification as Muslim (because this corresponds to identification with a social category). A first auxiliary hypothesis for the moderation is that the negative relation between crowd density and safety should only hold for those relatively low in identification. A second auxiliary hypothesis is that density will actually increase safety for those high in identification with the crowd. The reasoning behind this is that, if safety is in part a function of perceived support from those one identifies with, the more of these others present (measured in increased density), the greater the level of safety.

Fourth, we tested the hypothesis that the reason for this moderation effect is because identification with the crowd and perceptions that others identify as Muslims each increase perceptions of support, which in turn increase reported safety.

Finally, if the hypothesized social psychological mechanisms behind (at least some of) the safety of the crowd are correct, we would also expect them to help explain demographic differences in safety. Our specific hypothesis was that any differences among national groups in reported safety would be an indirect effect of both identification with the crowd and perceived support.

Results

Descriptive Statistics and Correlations. Inspection of the density data revealed that 10 cases were outliers: seven participants were scored at 0 ppm² (here the research assistant could not estimate the number of people per square meter) and three were scored at implausibly high density (12 ppm² and 15 ppm²). The data from these participants were removed, leaving 1,184 participants in the final dataset. The modal score for density was 4 ppm², which was below the mean for this measure (Table 1), and the range was 1–9 ppm².

Table 1. Descriptive statistics and correlations

Variable	Mean	SD	2	3	4	5	6	7
1 Density	5.21	1.75	-0.061*	0.098**	-0.157**	-0.077**	-0.111**	0.003
2 Safety	5.83	1.12		0.255**	0.347**	0.427**	0.459**	0.406**
3 Management competence	5.07	1.12			0.093**	0.215**	0.210**	0.272**
4 Identification as a Muslim	6.16	0.92				0.638**	0.504**	0.367**
5 Others' identification as Muslim	6.10	0.85					0.661**	0.477**
6 Identification with the crowd	5.99	0.91						0.562**
7 Perceived support	5.78	1.07						

* $P < 0.01$; ** $P < 0.001$; $n = 1,184$.

Other descriptive statistics are presented in Table 1. It can be inferred that the dependent variable—namely safety—exhibited reasonable response variability, which suggests that the scale adequately captured the participants' responses. At the same time, this measure and the hypothesized predictors and mediators all exhibited scores over the theoretical mean of the scale, which suggests that respondents felt positive about all these factors. Thus, one-sample t tests indicated that safety was significantly greater than the scale neutral midpoint, $t(1,181) = 56.33$, $P < 0.001$, indicating that people felt safe. Scores for management competence were also significantly greater than the scale neutral midpoint, $t(1,183)$, 32.78, $P < 0.001$, indicating high levels of agreement that the Hajj management were competent. Identification as a Muslim was also significantly greater than the scale neutral midpoint, $t(1,183)$, 81.32, $P < 0.001$. Others' identification as a Muslim was also significantly greater than the scale neutral midpoint, $t(1,183)$, 84.66, $P < 0.001$. Identification with the crowd was also significantly greater than the scale neutral midpoint, $t(1,183)$, 74.99, $P < 0.001$. Finally, perceived support was significantly greater than the scale neutral midpoint, $t(1,183)$, 57.11, $P < 0.001$, suggesting that support from others in the crowd was strongly perceived and expected.

Table 1 also shows that the preconditions for the predicted regressions and mediations are all in place, in that there was a negative (but weak) correlation between density and safety, but positive correlations between each of all of the other variables: safety, management competence, identification as a Muslim, others' identification as Muslim, identification with the crowd, and perceived support.

Predictors, Moderators, and Mediators of Safety. To test the baseline hypothesis concerning the effect of density on safety, we carried out a regression analysis. As expected, as density increased so safety decreased, $\beta = -0.061$, $t(1,180) = -2.087$, $P = 0.037$. Density also explained a significant proportion of variance in feelings of safety, $R^2 = 0.004$, $F(1, 1,180) = 4.356$, $P = 0.037$.

A multiple regression was run to test whether safety could be predicted from the five psychological variables. As a set, the five factors accounted for 28% of the variance, $R^2 = 0.28$, $F(5, 1,176) = 82.29$, $P < 0.001$. When controlling for each of the other variables, all were significant predictors: identification as a Muslim ($\beta = 0.09$, $P = 0.005$), others' identification as Muslim ($\beta = 0.12$, $P = 0.002$), identification with the crowd ($\beta = 0.22$, $P < 0.001$), perceived

support ($\beta = 0.16$, $P < 0.001$), and management competence ($\beta = 0.132$, $P < 0.001$). Thus, as expected, each of these variables predicted safety.

To test the hypothesis that identification with the crowd moderates the effect of density on safety, we conducted a moderation analysis using the Hayes Process tool (30, 31). As expected, identification with the crowd reduced the effect of density on safety (Table 2). Simple slopes analysis (Fig. 3) shows that, at relatively low levels of identification with the crowd (blue line), as density increased so safety decreased, $b = -0.07$, 95% BCa confidence interval (CI; $-0.139, -0.001$), $t = -2.00$, $P = 0.05$. However, at high levels of identification with the crowd (beige line), as density increased so safety actually increased, $b = 0.05$, 95% BCa CI (0.01, 0.10), $t = 2.20$, $P = 0.03$.

Further in line with predictions, others' identification as Muslim also moderated the relationship between density and safety, $b = 0.07$, SE $B = 0.03$, 95% BCa CI (0.02, 0.13), $t = 2.47$, $P = 0.01$. Simple slopes analysis found that, at relatively low levels of belief that others identify as Muslims, as density increased so safety decreased, $b = -0.08$, 95% BCa CI ($-0.15, -0.01$), $t = -2.40$, $P = 0.02$. However, at high levels of belief that others identify as Muslims, as density increased, safety did not decrease, $b = 0.04$, 95% BCa CI ($-0.01, 0.09$), $t = 1.60$, $P = 0.11$. Again in line with predictions, identification as a Muslim did not moderate the relationship between density and safety, $b = 0.03$, SE $B = 0.03$, 95% BCa CI ($-0.03, 0.09$), $t = 0.91$, $P = 0.36$.

To test the prediction that perceived support would mediate the relationship between identification with the crowd and safety, we conducted mediation analyses based on 5,000 bootstrap samples using the Process tool (31). As expected, there was a significant indirect effect of identification with the crowd on feeling safe through perceptions of support, $b = 0.15$, 95% BCa CI (0.10, 0.20), $\kappa^2 = 0.11$, which represents a medium effect (32). In other words, perceived support mediated the effect of identification with the crowd on safety (Fig. 4). Given that perceptions that others in the crowd identified as Muslims also moderated the negative effect of density on safety, we also carried out a mediation analysis on this variable. As expected, there was a significant indirect effect of perceptions that others identify as Muslims on feeling safe through perceptions of support, $b = 0.16$, 95% BCa CI (0.11, 0.22), $\kappa^2 = 0.12$, which again represents a medium effect (32).

Table 2. Linear model of identification with crowd and density as predictors of safety, with 95% CIs

Variable	b	SE B	t	P
Constant	5.83 (5.78, 5.89)	0.03	198.28	<0.001
Identification with the crowd (centered)	0.56 (0.45, 0.67)	0.05	10.26	<0.001
Density (centered)	-0.01 (-0.04, 0.02)	0.02	-0.55	0.58
Identification with the crowd \times density	0.07 (0.01, 0.12)	0.03	2.45	0.01

$R^2 = 0.22$.

Demographic Factors in Safety. We now present tests of difference in safety across the major demographic divisions in the sample: sex, age, and nationality (organized by regional Hajj establishment). Where meaningful, we examined whether any such differences were at least partly explicable in terms of identification and perceived support in the crowd.

Analysis of variance indicated that there was no significant difference in safety between males (mean = 5.85, SD = 1.09) and females (mean = 5.78, SD = 1.14), $F(1, 1,180) = 1.09, P = 0.29, \eta^2 = 0.001$. Analysis of variance indicated an overall significant difference in safety across the different age categories, $F(4, 1,177) = 3.12, P = 0.015, \eta^2 = 0.01$. Bonferroni post hoc tests showed that the difference between 40–49 y olds (mean = 5.91, SD = 1.02) and 20–29 y olds (mean = 5.56, SD = 1.58), was significant, $P = 0.037$, with the former reporting greater safety than the latter. There were no other significant differences between the age groups.

Analysis of variance indicated an overall significant difference in safety across participants from the six different Hajj establishments, $F(5, 1,176) = 15.09, P < 0.001, \eta^2 = 0.06$. Table 3 displays means and SDs. Bonferroni post hoc tests showed that there was a significant difference in safety between pilgrims from the Arab countries and those from the following establishments: South-East Asia ($P < 0.001$), South Asia ($P < 0.001$), America, Australia, and Europe ($P < 0.001$), and non-Arab African countries ($P = 0.003$). There were also significant differences in safety between pilgrims from Iran and those from the following establishments: South-East Asia ($P < 0.001$), South Asia ($P < 0.001$), America, Australia, and Europe ($P < 0.001$), and non-Arab African countries ($P < 0.001$). There was no difference in safety between pilgrims from Iran and those from Arab countries ($P = 0.662$). We then examined whether the process behind these differences in safety was a function of crowd identification and thus perceived support. Because there was a significant difference in safety between two particular establishments (Arab countries and Iran) and the rest, we used this as the basis for further tests. If identification with the crowd and perceived support were behind the difference in safety between the establishments, then we would expect pilgrims from Iran and Arab countries to differ from pilgrims from other establishments on these measures as

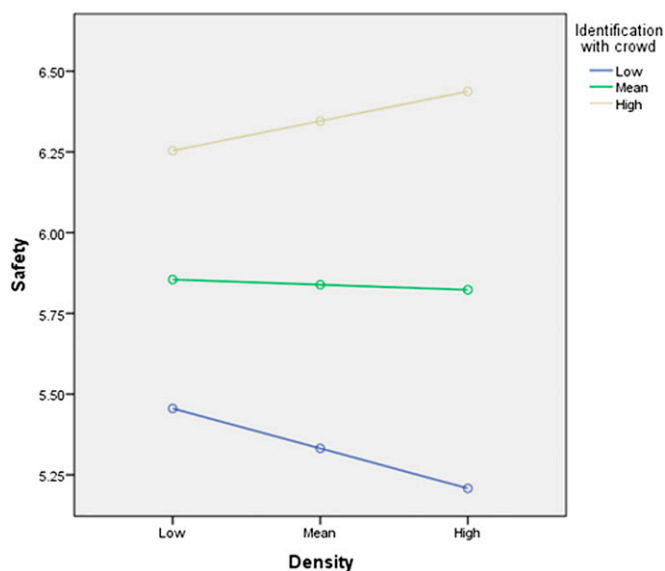


Fig. 3. Simple slopes equations of the regression of safety on density at three levels of identification with the crowd. Note: Low = 1 SD below the centered mean; high = 1 SD above the centered mean.

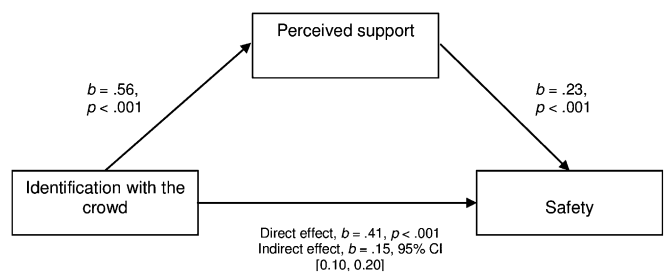


Fig. 4. Model of crowd identification as predictor of safety, mediated by perceived support. The confidence interval for the indirect effect is a BCa bootstrapped CI based on 5,000 samples.

well. Table 3 provides some support for this assumption. The two highest scoring establishments for safety were also the two highest scoring establishments for identification with the crowd. Similarly, two of the three highest scoring establishments for perceived support are those same two establishments: Arab countries and Iran. The final step was to run a mediation analysis by coding the Arabian and Iranian participants as 1 and those from all of the other establishments as 0. Identification with the crowd and perceived support were entered simultaneously as mediators, with safety as the dependent variable (33). As expected, there was a significant indirect effect of Hajj establishment on safety through each of perceived support, $b = 0.07, 95\% \text{ BCa CI } (0.03, 0.11)$ and identification with the crowd, $b = 0.16, 95\% \text{ BCa CI } (0.10, 0.23)$. In other words, it was (at least in part) because of perceived support and identification with the crowd that those from Arab countries and Iran felt especially safe at the Hajj compared with pilgrims from the other countries.

Discussion

This survey of pilgrims attending the 2012 Hajj showed that, although increasing levels of crowd density reduced feelings of safety, this effect was moderated by identification with the crowd and perceptions that others identified as Muslim. Specifically, those who were high in identification with the crowd actually felt more safe as density increased. In addition, those who were high in perceptions that others identified as Muslims were not affected by the increase in density. Mediation analysis was consistent with the idea that this moderation effect was because of the perception that others in the crowd were supportive, which was higher the more that people identified with the crowd. This same relationship was found for those pilgrims from Arab countries and Iran compared with those from other countries, whose greater reported safety was explicable in terms of their crowd identification and perceptions of support.

Although the Hajj has a number of unique features, the design of the present study gives us some confidence in the validity and generalizability of these findings. On validity, the measure of crowd density was taken independently of, and hence was uncontaminated by, respondents' perceptions. Furthermore, the measures of pilgrims' feelings of safety were taken when they were actually in the crowd, and therefore could not be subject to distortions of memory. On generalizability, we sampled across the different language groups in proportion to their representation at the Hajj. Our sample was also representative of the sex division and partly representative of the different nationalities of those present at the Hajj. Therefore, the findings cannot easily be attributed to particular features of the sample.

The conclusion we draw from our findings is that the Hajj crowd can contribute to crowd safety. This conclusion is novel and goes beyond existing work on the Hajj crowd in the physical sciences, computer modeling, architecture, engineering, and medicine (3–5, 7, 8), which largely neglects the positive contribution of

Table 3. Means and SDs for safety, identification with the crowd, and perceived support of pilgrims from the different geographical establishments

Hajj service provider	n	Safety		Identification with the crowd		Perceived support	
		M	SD	M	SD	M	SD
Arab Countries	421	6.06	0.82	6.23	0.67	5.98	0.84
South East Asia	154	5.57	1.54	5.47	1.42	5.56	1.50
South Asia	161	5.52	0.95	6.06	0.51	6.04	0.59
America, Australia and Europe	218	5.61	1.35	5.89	1.05	5.44	1.29
Non-Arab African Countries	107	5.63	1.05	5.71	0.90	5.53	1.10
Iran	121	6.29	0.81	6.20	0.58	5.79	0.87

crowd behavior to crowd safety. Importantly, the notion that the crowd can reduce danger also contradicts an assumption of classic crowd psychology, that the crowd is a conduit for pathology (34–36). Instead, the findings presented here are in line the social identity approach, echoing not only early social identity research on crowds (37), but also recent evidence of the “social cure” (38) in small groups, which similarly shows that identification with others reduces stress through increasing perceived and expected support (39).

To our knowledge, the present study is the first to investigate social psychological questions through surveying pilgrims during the Hajj. There are a number of reasons for the previous neglect of this event in psychological research, including difficulties of access. For the researcher who is able to enter Mecca, there are still difficulties that will necessarily impinge upon research design. For example, understandably people may not be willing to give time to be surveyed, because praying to God is far more important to them. Thus, it is possible that our sample (i.e., those who did not refuse) were somewhat self-selecting. This aspect may be reflected in an overrepresentation in our sample of those with higher levels of education, who were perhaps the people more likely to recognize the value of scientific research. However, because there are no official figures on the educational background of pilgrims at the Hajj, this point must remain somewhat speculative.

Like most survey studies and mediation analyses, the present results are essentially correlational. Although the sequence of relations tested here made theoretical sense, others are also possible. For example, perceiving that others are acting supportively could increase the belief that they are “good Muslims.” However, in this case, the measure of perceived support also included an item on expected support, which makes the reverse reading less plausible. Moreover, some possible reverse interpretations of our findings are still in line with the self-categorization theory being tested here; for example, feeling safe might lead high-identification Muslims to gravitate to the most dense areas of the crowd (10). Indeed, researchers examining effects of social identification on other aspects of health and wellbeing have reported a similar reversed causal sequence, which, like the present finding, can be seen as evidence of a “virtuous circle” of identification, social support, and wellbeing (40). A final caveat is that these findings should not of course be interpreted to mean that there is a linear effect of increasing density on safety for those high in identification with the crowd. At a certain level (>7–8 ppm²), crowd density becomes dangerous; people lose the ability to move independently (1), let alone to be considerate or give support to others.

Although this study provides evidence for the role of crowd behavior in enhancing safety within a dense crowd at one of the largest mass gatherings in the world, it also showed that intergroup relations were important. Thus, the perception that those in management are competent was also associated with increased feelings of safety, as was expected. We referred at the

start of this report to the huge amount of resources and intellectual energy that has been poured into the Hajj to enhance crowd safety. These infrastructure and technological improvements to the management of the Hajj have increased crowd safety since 2006, even as the numbers arriving in Mecca have increased further as world travel becomes accessible for more people. The findings of this report, based on predictions from social psychology, complement these advances in crowd safety. The findings also point to the need among those managing the Hajj to include pilgrims’ views and perceptions, as well as the standard behavioral indices, in their risk-assessment calculations. We therefore hope that these findings contribute to a broadening in the understanding of crowd safety so that the behavior of the crowd is seen as a potential “solution” instead of inherently a “problem.”

Methods

Participant Recruitment. We surveyed 1,194 pilgrims, with an estimated sampling error of <3%. We sampled by the main languages shown in previous research to be broadly in proportion to their representation at the Hajj (41): 420 (35%) were Arabic speakers, 150 (13%) of Malay, 150 (13%) of Urdu, 120 (10%) of French, 120 (10%) of Persian, 120 (10%) of Turkish, and 114 (9%) of English. We sampled pilgrims across the three phases of the Hajj in which the Holy Mosque would be most busy. Three-hundred and eighty-three (32.1%) participants were sampled in the 9 d before the Hajj rituals when pilgrims came to the mosque for their first Tawaf, 536 (44.9%) were sampled during Hajj over 3 d, and 275 (23.1%) were sampled in the 6 d after the Hajj rituals. The number of participants surveyed inside the Holy Mosque was 436 (36.4%) whereas the number surveyed on the plaza immediately outside the Holy Mosque was 758 (63.3%).

Sample Characteristics. Of the participants, 768 (64.1%) were male and 426 (35.6%) were female. This result matches exactly the proportion of males to females in the population attending Hajj in 2012 (42). The study included participants from 72 countries. The majority of pilgrims attend through arrangement with six Hajj travel establishments, or travel agencies, who are organized by country or geographical region. Because they are delineated geographically, this provides a useful summary of the nationalities of our participants. There were 242 participants (35.1%) from Arab countries, 221 (18.4%) from America, Australia, and Europe (including Turkey), 165 (13.8%) from South Asia (including India, Pakistan and Bangladesh), 155 (12.9%) from South East Asia (including Indonesia and Malaysia), 121 (10.1%) from Iran, and 111 (9.3%) from the non-Arab African Countries. These proportions are partly in line with official figures on the distribution of pilgrims from the different Hajj establishments [i.e., Arab and Arabian Gulf countries 23%, America, Australia and Europe 14%, South Asia 29%, South East Asia 16%, Iran 4% and non-Arab African Countries 11% (43, 44)].

Participants who took part in this study were all adults (18 y old or older); 17 (1.4%) were aged under 20 y old, 101 (8.5%) were aged 20–29; 224 (18.8%) were aged 30–39, 465 (38.9%) were aged 40–49, and 387 (32.4%) were aged 50 y and over. In terms of education levels, 68 participants (5.7%) were illiterate, 198 (16.5%) were at “read and write” level, 205 (17.1%) were at primary school education level, 240 (20.0%) were at secondary school level, 397 (33.1%) were at degree level, 78 (6.5%) had Master’s degrees, and 8 (0.7%) had doctorates. The employment status of the sample was as

follows: 724 (60.6%) were employed, 366 (30.7%) were retired, and 104 (8.7%) were unemployed. Of the sample, 367 (30.9%) had been on Hajj before, whereas for 817 (68.8%) this was their first Hajj. Most had made the pilgrimage in a group; just 96 (13.7%) of our sample indicated that they were attending alone.

Measures. Twelve research assistants were trained to estimate the number of people per square meter, which is the standard measure of crowd density in the crowd safety industry (e.g., ref. 45). Other variables (safety, management competence, identification as a Muslim, others' identification as Muslim, identification with the crowd, and perceived support) were measured with self-report items on the questionnaire. See *Supporting Methods* for details.

Procedure. The research questionnaire was translated from the English original into Arabic, French, Urdu, Persian, Turkish, and Malay. All versions were also

translated from these different languages into Arabic, author H.A.'s first language, to check the quality of translation.

Each research assistant approached individual pilgrims in the crowd close to and inside the Holy Mosque with the questionnaire. Before each respondent provided any information, the researcher recorded the level of density in the part of the crowd where they were standing. The questionnaire took around 38 min to complete.

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1. Fruin JJ (2002) The causes and prevention of crowd disasters. Originally presented at the First International Conference on Engineering for Crowd Safety, London, England, March 1993 (Revised exclusively for crowdsafe.com, January 2002.) Available at www.crowdsafe.com/FruinCauses.pdf. Accessed May 25, 2014.
2. Moussaïd M, Helbing D, Theraulaz G (2011) How simple rules determine pedestrian behavior and crowd disasters. *Proc Natl Acad Sci USA* 108(17):6884–6888.
3. Algadhi SAH, Mahmassani HS (1990) Modelling crowd behavior and movement: Application to Makkah pilgrimage. *Transportation and Traffic Theory*, ed Koshi M (Elsevier, Oxford), pp 59–78.
4. Helbing D, Johansson A, Al-Abideen HZ (2007) Dynamics of crowd disasters: An empirical study. *Phys Rev E Stat Nonlin Soft Matter Phys* 75(4 Pt 2):046109.
5. Still GK (2014) *Introduction to Crowd Science* (CRC Press, Boca Raton, FL).
6. Ministry of Municipal and Rural Affairs, Centre for Development Projects Media Centre (2013) *Ministry News* (Ministry of Municipal and Rural Affairs, Riyadh, Kingdom of Saudi Arabia).
7. Abubakar I, et al. (2012) Global perspectives for prevention of infectious diseases associated with mass gatherings. *Lancet Infect Dis* 12(1):66–74.
8. Memish ZA, Stephens GM, Steffen R, Ahmed QA (2012) Emergence of medicine for mass gatherings: lessons from the Hajj. *Lancet Infect Dis* 12(1):56–65.
9. Turner JC, Hogg MA, Oakes PJ, Reicher SD, Wetherell MS (1987) *Rediscovering the Social Group: A Self-Categorization Theory* (Basil Blackwell, Oxford).
10. Novelli D, Drury J, Reicher S, Stott C (2013) Crowdedness mediates the effect of social identification on positive emotion in a crowd: A survey of two crowd events. *PLoS ONE* 8(11):e78983.
11. Reicher S, Stott C (2011) *Mad Mobs and Englishmen? Myths and Realities of the 2011 Riots* (Constable and Robinson, London).
12. Stott C, Adang O, Livingstone A, Schreiber M (2007) Variability in the collective behaviour of England fans at Euro2004: 'Hooliganism', public order policing and social change. *Eur J Soc Psychol* 38(1):75–100.
13. Reicher S (1996) 'The Battle of Westminster': Developing the social identity model of crowd behaviour in order to explain the initiation and development of collective conflict. *Eur J Soc Psychol* 26(1):115–134.
14. Drury J, Cocking C, Reicher S (2009) Everyone for themselves? A comparative study of crowd solidarity among emergency survivors. *Br J Soc Psychol* 48(Pt 3):487–506.
15. Neville F, Reicher S (2011) The experience of collective participation: Shared identity, relatedness, and emotionality. *Contemporary Social Science* 6(3):377–396.
16. Cassidy C, et al. (2007) Social identity and collective behaviour: Some lessons from Indian research at the Magh Mela at Prayag. *Psychol Stud (Mysore)* 52(4):286–292.
17. Prayag Magh Mela Research Group (2007) Living the Magh Mela at Prayag: Collective identity, collective experience and the impact of participation in a mass event. *Psychol Stud (Mysore)* 52(4):293–301.
18. Reicher S (2011) Mass action and mundane reality: An argument for putting crowd analysis at the centre of the social sciences. *Contemporary Social Science* 6(3):433–449.
19. Drury J, Reicher S (1999) The intergroup dynamics of collective empowerment: Substantiating the social identity model. *Group Process Intergroup Relat* 2(4):381–402.
20. Drury J, Reicher S (2005) Explaining enduring empowerment: A comparative study of collective action and psychological outcomes. *Eur J Soc Psychol* 35(1):35–58.
21. Haslam SA, Jetten J, O'Brien A, Jacobs E (2004) Social identity, social influence, and reactions to potentially stressful tasks: Support for the self-categorization model of stress. *Stress Health* 20(1):3–9.
22. Gill JR, Landi K (2004) Traumatic asphyxial deaths due to an uncontrolled crowd. *Am J Forensic Med Pathol* 25(4):358–361.
23. Drury J (2012) Collective resilience in mass emergencies and disasters: A social identity model. *The Social Cure: Identity, Health, and Well-Being*, eds Jetten J, Haslam C, Haslam SA (Psychology Press, Hove, UK), pp 195–215.
24. Tewari S, Khan S, Hopkins N, Srinivasan N, Reicher S (2012) Participation in mass gatherings can benefit well-being: Longitudinal and control data from a North Indian Hindu pilgrimage event. *PLoS ONE* 7(10):e47291.
25. Shankar S, et al. (2013) A calming cacophony: Social identity can shape the experience of loud noise. *J Environ Psychol* 36:87–95.
26. Pandey K, Stevenson C, Shankar S, Hopkins NP, Reicher SD (2013) Cold comfort at the Magh Mela: Social identity processes and physical hardship. *Br J Soc Psychol*, 10.1111/bjso.12054.
27. Clingingsmith D, Khwaja AI, Kremer M (2009) Estimating the impact of The Hajj: Religion and tolerance in Islam's global gathering. *Q J Econ* 124(3):1133–1170.
28. Ministry of Foreign Affairs (2014) The service of Islam and Muslims. Available at <http://embassies.mofa.gov.sa/sites/NewZealand/AR/AboutKingdom/KingdomAchievements/Pages/default.aspx/>. Accessed May 25, 2014.
29. Fouda A (1998) *A Study to Estimate the Number of Worshippers at the Grand Mosque*. Government report. (Umm Al-Qura Univ, Makkah, Kingdom of Saudi Arabia).
30. Field A (2013) *Discovering Statistics Using IBM SPSS Statistics* (Sage, London), 4th Ed.
31. Hayes AF (2013) *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach* (Guilford, New York).
32. Preacher KJ, Kelley K (2011) Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychol Methods* 16(2):93–115.
33. Kenny DA (2013) Mediation. Available at <http://davidakenny.net/cm/mediate.htm>. Accessed May 25, 2014.
34. Allport FH (1924) *Social Psychology* (Houghton Mifflin, Boston).
35. Le Bon G (1968) *The Crowd: A Study of the Popular Mind* (Norman S. Berg, Dunwoody, GA).
36. Zimbardo PG (1970) The human choice: Individuation, reason and order versus de-individuation, impulse and chaos. *Nebraska Symposium on Motivation 1969*, eds Arnold WJ, Levine D (Univ of Nebraska, Lincoln), pp 237–307.
37. Reicher S (1984) The St Pauls' riot: An explanation of the limits of crowd action in terms of a social identity model. *Eur J Soc Psychol* 14(1):1–21.
38. Jetten J, Haslam C, Haslam SA (2012) *The Social Cure* (Psychology Press, Abingdon, UK).
39. Haslam SA, O'Brien A, Jetten J, Vormedal K, Penna S (2005) Taking the strain: Social identity, social support, and the experience of stress. *Br J Soc Psychol* 44(Pt 3):355–370.
40. Gleibs IH, Haslam C, Haslam SA, Jones JM (2011) Water clubs in residential care: Is it the water or the club that enhances health and well-being? *Psychol Health* 26(10):1361–1377.
41. Abdelrhman AM (2011) *Questionnaire About Hajjis' Views About New Development Expansions in Makkah El Mokramah 1432h* (Umm Al-Qura University, Custodian of the Two Holy Mosques Institute of Hajj Research, Makkah, Kingdom of Saudi Arabia).
42. Ministry of Economy and Planning, Central Department of Statistics and Information, Saudi Arabia (2014) The latest statistical information. Available at www.cdsi.gov.sa/index.php. Accessed May 25, 2014.
43. Ministry of Economy and Planning, Central Department of Statistics and Information, Saudi Arabia (2012) *Statistics for 2012 Hajj* (Ministry of Hajj, Mecca, Kingdom of Saudi Arabia).
44. Ministry of Hajj (2013) *Deputy Ministry for Planning and Development, the General Directorate for Information Technology Hajj 1433* (Ministry of Hajj, Makkah, Kingdom of Saudi Arabia).
45. Health and Safety Executive (1999) *Guide to Health, Safety and Welfare at Pop Concerts and Similar Events (The Purple Guide)* (Health and Safety Executive, London).