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Public Understanding of Ebola Risks: Mastering an Unfamiliar Threat

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Ebola was the most widely followed news story in the United States in October 2014. Here, we ask what members of the U.S. public learned about the disease, given the often chaotic media environment. Early in 2015, we surveyed a representative sample of 3,447 U.S. residents about their Ebola-related beliefs, attitudes, and behaviors. Where possible, we elicited judgments in terms sufficiently precise to allow comparing them to scientific estimates (e.g., the death toll to date and the probability of dying once ill). Respondents' judgments were generally consistent with one another, with scientific knowledge, and with their self-reported behavioral responses and policy preferences. Thus, by the time the threat appeared to have subsided in the United States, members of the public, as a whole, had seemingly mastered its basic contours. Moreover, they could express their beliefs in quantitative terms. Judgments of personal risk were weakly and inconsistently related to reported gender, age, education, income, or political ideology. Better educated and wealthier respondents saw population risks as lower; females saw them as higher. More politically conservative respondents saw Ebola as more transmissible and expressed less support for public health policies. In general, respondents supported providing "honest, accurate information, even if that information worried people." These results suggest the value of proactive communications designed to inform the lay public's decisions, thoughts, and emotions, and informed by concurrent surveys of their responses and needs.

KEY WORDS: Decision making; judgment; probabilistic estimates

1. INTRODUCTION

Prior to Summer 2014, few people had more than a vague awareness of Ebola. The ensuing months offered saturation media coverage.[(1)] Responding effectively to the threat required members of the public to learn about the disease, its transmission pathways, and the institutions responsible for its control. Moreover, they needed that knowledge in the quantitative terms required for decision making. For example, they needed to know not just that face masks might help, but how much protection they provided, before deciding whether to rely on masks when visiting potentially contaminated places. They needed to know not just that asymptomatic individuals can transmit the disease, but also how transmissible it is, before deciding whether to endorse stringent quarantine policies.

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Here, we report responses of a nationally representative U.S. sample to a survey conducted in early 2015, at the beginning of a lull of indeterminate length in Ebola's U.S. presence. Our analyses ask the practical question of what members of the lay public had learned about Ebola, despite the chaotic media environment; the methodological question of whether they could express their beliefs in quantitative terms; and the theoretical question of what was the combined effect of the cognitive, social, and affective processes potentially activated by the threat at a time of at least temporary relief, following an emotionally intense period.

We elicited beliefs in the quantitative terms needed to inform decisions (e.g., the probability of transmission, death toll, and case-fatality rate). Such judgments reflect not only respondents' knowledge, but also their ability to translate it into numeric terms. As a result, we adopt a construct validity approach, comparing these judgments to one another, for internal consistency, and to self-reported behaviors and policy preferences, for logical consistency.(2) Our approach parallels that used in studies examining adolescents' judgments of the probability of significant life events on the 1997 National Longitudinal Survey of Youth(3,4) and experts' beliefs about avian flu.(5) Specifically, we ask how consistent quantitative judgments are with (1) other judgments using the same response mode (e.g., related probabilities), (2) quantitative judgments using different response modes (e.g., the probability of transmission and the estimated death toll), (3) related behaviors (e.g., protective actions and policy preferences), and (4) available scientific knowledge (comparisons that vary in the risk of artificially imposed consistency(6)). Such consistency would demonstrate respondents' ability to extract quantitative information from a noisy media environment and express it in numerical terms. Its absence could reflect their failure or that of those entrusted with informing them.(7–13)

On theoretical grounds, there were reasons to expect both poor and good public understanding, depending on the intensity and interplay among the cognitive, affective, and social processes that such national events can evoke. Media reports (often sensationalized) could have evoked affective responses creating exaggerated feelings of risk,(14,15) while enhancing the cognitive availability of negative events.(16,17) Conversely, sober, factual reporting could be found amidst the noise, creating opportunities to learn about the disease and create useful mental models of the factors affecting its spread.(18,19) Social processes could have amplified risks, but also warn the public about the possibility of risks being manipulated to political ends, in the run-up to the 2014 U.S. mid-term elections. It is possible that the ebbing of the threat by the time of our survey had created a "sweet spot" for public understanding. In terms of affective processes, it was close enough to the crisis to prompt active engagement, but not so close as to cloud judgment. In terms of cognitive processes, health authorities were still trying to inform the public, having absorbed lessons about how to manage and communicate about the disease. However, it is also possible that emotions had ebbed without an attendant increase in understanding, ready to be reactivated, perhaps with increased intensity, should an epidemic emerge in the United States. The present research examined how these theoretically plausible processes played out, in aggregate, in the specific context of the Ebola public health crisis in early 2015.

2. METHODS

2.1. Sampling

Respondents were drawn from the GfK KnowledgePanel,(20) which uses address-based random sampling methods to recruit individuals in U.S. households. Panelists complete Web-based surveys in return for compensation or free Internet. The individuals studied here all had participated in a study about responses to the Boston Marathon bombing, conducted between April 29 and May 13, 2013.(14) This study included 4,675 individuals, with oversamples of metropolitan Boston (n = 846) and New York City (n = 941), and the remainder representing the rest of the United States (79.1% participation rate). Between December 29, 2014 and February 27, 2015, all those still in the panel (N = 3,196) or still willing to be contacted (N = 1,140) were invited to participate in a study about Ebola. Among them, 3,114 completed the survey online and 333 by mail, for a retention rate of 73.7%. Over 90% of the surveys were completed online; of these, 95% completed the survey before January 24, 2015. The remainder of the surveys were completed in hard copy and returned to GfK by mail. See the Supporting Information for details.

2.2. Protection of Human Subjects

The Institutional Review Board of the University of California, Irvine, approved all procedures. All participants provided informed consent.

2.3. Survey Protocol

Individuals drawn from a representative sample of U.S. households, with oversampling in the Boston and New York City metropolitan areas, completed the survey. All had participated in a Spring 2013 survey of responses to the Boston Marathon bombing (prompting the oversampling of the metropolitan areas of Boston and New York City, given its history with terrorism). Both were, as it happened, areas with Ebola cases. Prior to answering the questions analyzed here, respondents reported on their psychological distress,[21] physical and emotional functioning,[22] worry about Ebola,[23] and direct or media exposure to Ebola.[24] They then received questions, in a fixed order, regarding (1) *personal risk*, from Ebola and other illnesses; (2) *risks to the average American*, from the same sources; (3) *transmissibility*, in an office and on public transportation; (4) *behavioral responses to Ebola*; (5) *Ebola death toll*, to date and in the next year; (6) R_0, the basic reproduction number; (7) *public policies*; and (8) *trust in information sources*.

2.4. Probability Response Mode

Probability questions asked respondents to "Please provide a number between 0 and 100%," with the first such judgment adding, "The next questions ask you to give the percent chance that something will happen in the next year. If you are certain the event will not happen in the next year, then say 0%. If you are certain that it will happen, then say 100%. If you're not sure what will happen, then you can use any number between 0% and 100% to tell us the percent chance that the events will occur in the next year. If you're not sure what to say, then just give your best guess at what the chances might be."

2.5. Statistical Analysis

2.5.1. Weighting

Poststratification weights were iteratively constructed from respondents' design weights (which adjust for factors from GfK's initial sampling strategy, various forms of nonresponse and noncoverage, and panel attrition over time), using probability estimates based on multiple demographic characteristics, region of residence, and internet access. These weights then adjust for sample attrition as well as discrepancies between the final obtained sample and U.S. Census benchmarks, so as to enable population-based inferences. The final weighted sample closely matches December 2013 U.S. census data, both overall and by sampling area (i.e., metropolitan Boston and New York City, national). The text reports results using weights that maintain proportions reflective of the oversampling in the Boston and New York metropolitan areas. The Supporting Information reports main results with the sample reweighted to be nationally representative.

2.5.2. Statistical Significance

Given the large sample size and number of potential comparisons, we discuss only those for which $p < 0.001$, two-sided. Unless otherwise indicated (e.g., creation of the transmissibility index), all analyses were determined before examining the data.

2.5.3. Treatment of "50" Responses

Research has found that people sometimes answer probability questions with "50" in the sense of "fifty-fifty," rather than as a numeric probability.[25,26] We estimated the prevalence of nonnumeric 50s, sometimes viewed as expressing *epistemic uncertainty* (i.e., not knowing what to say), using the *averaging method,* which compares the number of observed 50s with the number expected, based on all other responses.[27]

2.5.4. Data analytic Plan

As noted above, after reporting results preserving the oversampling, we report on reweighting them to reflect a nationally representative sample. In post-hoc analyses, we examine correlations between risk judgments and self-reported gender, age, education, income, and political conservatism, as individual and demographic differences that are often related to risk- and health-related behaviors.[28–32] The Supporting Information provides additional details.

2.5.5. Correlations

Given the many nonnormal distributions in the responses, all correlations use the nonparametric Kendall's tau (τ).

Table I. Responses to Risk Perception Questions

Item (What do you think is the percent chance that you will . . .)	Number of Respondents	Mean (%)	Median (%)	*SD*	Percentage of Responses			
					0%	50%	100%	Excess 50%
1. Eat pizza sometime in the next 12 months?	3,406	87.5	100	29.1	3.5	3.2	80.4	2.7
2. Travel outside the United States in the next 12 months?	3,417	23.8	0	35.6	50.3	9.4	10.9	8.7
3. Get the ordinary (seasonal) flu in the next 12 months?	3,399	28.4	20	28.6	16.5	18.3	6.3	16.6
4. Be seriously ill in the next 12 months?	3,379	12.0	5	17.5	32.3	7.9	0.7	7.3
5. Get sick with Ebola in the next 12 months?	3,376	2.1	0	7.8	73.2	1.2	0.1	1.2
6. Die if you get sick with Ebola?	3,371	22.5	1	31.0	48.1	16.7	3.8	15.6
7. Catch Ebola if you spend a day working in the same office as someone who has the Ebola virus but no symptoms at all?	3,404	28.0	10	31.6	29.6	16.3	5.1	14.4
8. Catch Ebola if you spend a day working in the same office as someone who has the Ebola virus and is beginning to feel badly?	3,397	42.6	50	33.8	14.4	18.2	8.3	14.5
9. Catch Ebola if you spend a day working in the same office as someone who has the Ebola virus who is seriously ill?	3,393	55.2	50	37.1	12.8	14.5	18.0	11.9
10. Catch Ebola if you spend half an hour on a bus or subway car as someone who has the Ebola virus but no symptoms at all?	3,399	21.9	7	28.6	34.1	13.4	3.2	11.7
11. Catch Ebola if you spend half an hour on a bus or subway car as someone who has the Ebola virus and is beginning to feel badly?	3,394	34.4	25	32.1	17.9	15.9	5.1	12.2
12. Catch Ebola if you spend half an hour on a bus or subway car as someone who has the Ebola virus and is seriously ill?	3,392	45.9	50	36.7	14.6	13.4	11.6	10.4

3. RESULTS

3.1. Probability Responses

Table I shows the key features of responses to the probability questions. The first two rows are warm-up questions. They are followed by judgments of personal risks, transmissibility, and risks to the average American.

3.2. Personal Risks

As seen in row 3, most respondents saw some chance of getting the ordinary (seasonal) flu. The mean (28.4%) and median (20%) are at the high end of Centers for Disease Control's annual estimates[33] (and might include people who misdiagnose other forms of sickness as flu[34]). Judgments of the probability of getting seriously ill (row 4) were appropriately higher, with the actual value depending on how respondents define "serious." Row 5 shows that 73.4% saw no chance of getting Ebola in the next year (with another 12.4% seeing 1% chance). Row 6 shows that 48.1% of respondents saw no probability of dying, should they get sick with Ebola. Respondents who saw a higher probability of getting seriously ill also saw a higher probability of getting seasonal flu ($\tau = 0.30$) and Ebola ($\tau = 0.23$), suggesting an individual difference in perceived vulnerability.

As noted (Section 2.5.3), studies have found that, when answering probability questions, people sometimes say "50" in the sense of "fifty-fifty," rather than as a numeric probability, especially with open-ended response modes and negative events—both present here.[35] The right-most column reports the proportions of "excess 50%," beyond what would have been expected without that response bias.[27] The response distributions for both flu and seriously ill have excess 50s, suggesting that respondents had difficulty in answering those questions. However, there were few excess 50s for Ebola, suggesting no such difficulty. Consistent with a heightened sense of personal vulnerability, respondents who gave higher conditional probabilities of dying from Ebola also saw themselves as more likely to get seasonal flu ($\tau = 0.13$), be seriously ill ($\tau = 0.22$), and catch Ebola ($\tau = 0.19$).

3.3. Transmissibility

Row 7 shows the probability judgments for "catching Ebola if you spend a day working in the same office as someone who has the Ebola virus but no symptoms at all." The modal estimate was 0%, chosen by 29.6% of respondents, with median = 10% and mean = 28.0%; 16.3% said 50% and 5.1% said 100%. As the actual rates for such exposures are unknown, the accuracy of these judgments could not be evaluated. Their internal consistency is seen in the probabilities being higher when the coworker was "feeling badly" (row 8), rather than asymptomatic, and even higher when the coworker was "seriously ill" (row 9). Rows 10–12 show the similar patterns for judgments of the probability of catching Ebola "if you spend half an hour on a bus or subway car with someone who has the Ebola virus."

The six transmissibility judgments (rows 7–12) were strongly correlated (Cronbach's $\alpha = 0.93$), indicating an individual-difference tendency to see transmission as more (or less) likely. We created an index of perceived transmissibility equal to the mean of the six items. Its correlation with the probability of getting sick with Ebola was 0.09 (τ). Thus, judgments of transmissibility were weakly related to judgments of personal vulnerability, consistent with respondents seeing low probability of getting Ebola if they did not expect to be exposed.

3.4. Risks to the Average American

Respondents saw the average American as having a higher probability than they did, personally, of getting seasonal flu (means: 43.6% vs. 28.4%), being seriously ill (27.9% vs. 12.0%), and getting Ebola (8.1% vs. 2.1%). This pattern replicates a common result, sometimes called the *unrealistic optimism bias*.[36] However, respondents saw the average American as having the same probability of dying once sick with Ebola (21.7% vs. 22.5%), consistent with the finding that the bias requires having a feeling of personal control (even if illusory), which may have been lacking with Ebola.[37] The correlations between these judgments were higher for the average American than for the respondent, suggesting that respondents drew finer distinctions among risks for themselves than for others. The correlations (τ) between risk judgments for the average American and for themselves were, respectively, (1) 0.48 and 0.30, between getting seasonal flu and seriously ill; (2) 0.39 and 0.23, between getting seasonal flu and Ebola; (3) 0.24 and 0.11, between getting seriously ill and Ebola.

3.5. Ebola Death Toll

Respondents' median and modal estimate for the death toll from Ebola "so far" was 2, reported by 29.9%, with another 28.3% reporting 1; 76.1% gave estimates ≤3 and 94.5% gave estimates ≤10. These estimates approximate the actual death toll in the United States, with higher values perhaps reflecting the belief that some deaths had gone unreported. Respondents' median "best guess" for the next year was 3 deaths, with a modal estimate of 0; 84.8% gave estimates ≤10 and 98.8% gave estimates ≤100. Respondents' median and modal "worst case" estimate was 10; 88.8% gave estimates ≤100 and 95.3% gave estimates ≤1,000. (See Supporting Information Tables SI–SIII for additional details.)

Respondents' best-guess and worst-case estimates for the next year's death toll were strongly correlated with one another ($\tau = 0.55$), but less so with estimates of the death toll so far ($\tau = 0.35$ and 0.21, for best-guess and worst-case, respectively), suggesting a coherent view of the future, but one that might not resemble the past. Respondents who gave higher best-guess estimates also gave higher probabilities for getting sick with ($\tau = 0.10$) and dying from ($\tau = 0.09$) Ebola for themselves, as well as for the average American ($\tau = 0.22$ and 0.15, for getting sick and dying, respectively). The pattern was similar for worst-case estimates, with corresponding correlations (τ) of getting sick and dying of 0.12 and 0.14 for themselves, and of 0.16 and 0.19 for the average American, respectively. All three estimates were higher for respondents who saw Ebola as more transmissible, with correlations (τ) between the transmissibility index and the estimated death toll of 0.09, 0.16, and 0.17, for to date, best guess, and worst case, respectively.

3.6. R_0

Fig. 1 shows responses to our translation of R_0 into lay terms, "If someone gets Ebola in the U.S., how many people do you think will catch it from them directly, on average?", grouping values chosen by less than 1% of respondents. These estimates indicated relatively low perceived transmissibility, with $R_0 = 0$ for 10.7% of respondents, 1 for 15.4%, 2 for 18.5% (mode), and 3 for 8.3% (median). Except for the highest values, these estimates seem defensible, given the information available to the

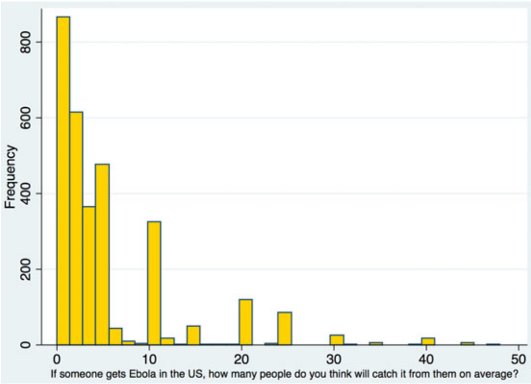

Fig. 1. Judgments of R_0 (pooling values used by <1% of respondents).

general public at the time. Scientific estimates for West Africa ranged from 1.51 to 2.53, depending on the country.[38] In the United States, R_0 declined to 0 as the outbreak was controlled.

Respondents who gave higher R_0 estimates also gave higher transmission probabilities ($\tau = 0.26$ for the index) and higher death tolls ($\tau = 0.22$, 0.35, and 0.36, for to date, best guess, and worst case, respectively). Higher R_0 judgments were associated with higher judged probabilities for being seriously ill, getting sick with Ebola, and dying if sick, both for themselves ($\tau = 0.06$, 0.07, 0.07, respectively) and for the average American ($\tau = 0.13$, 0.21, 0.11, respectively). R_0 judgments were not correlated with probability judgments for the unrelated event of getting the seasonal flu, for oneself or for the average American.

3.7. Behavioral Responses to Ebola

The top section of Table II shows the respondents' reported adoption of four behavioral responses to Ebola. About half (44.4%) reported having washed their hands and used hand sanitizer more often; almost all reported that they would do so if someone in their area had Ebola. Less than 10% reported having done the other three behaviors. About 60% of those who had not done each behavior indicated that they would do it if they knew that someone in their area had Ebola (with the complementary 40% or so reporting that they would not).

The middle section of Table II shows the mean judged probability of dying if sick with Ebola, for respondents reporting each behavioral response. As seen in the first column, respondents who said that they had avoided public spaces and who said that they would, if someone in their area had Ebola, saw similar probabilities of dying (25.9% vs. 25.2%, respectively); those who would not avoid public spaces saw a lower probability (17.4%). The pattern was similar for the other three protective behaviors, with those who would not do them seeing the disease as somewhat less deadly.

The bottom section of Table II offers the analogous breakdown for the transmissibility index. Respondents who had avoided public spaces saw Ebola as about as transmissible as those who would do so if they knew that someone had the disease in their area (48.3% vs. 45.4%); those who would not avoid public spaces saw the disease as much less transmissible (22.8%). The pattern was similar for the other three protective behaviors, with respondents who would not do each seeing the disease as less transmissible. Thus, in these respects, respondents' self-reported behavior and intentions are consistent with their beliefs about the disease's deadliness and transmissibility.

3.8. Trust in Information Sources

Respondents rated six potential information sources on a scale anchored at 1 = strongly distrust and 5 = strongly trust. Mean ratings were highest for "your own healthcare provider" ($M = 3.91$, $SD = 0.93$), followed by "family and friends" ($M = 3.51$, $SD = 1.00$), "federal health officials (e.g., Centers for Disease Control)" ($M = 3.43$, $SD = 1.13$), "local and county health officials" ($M = 3.31$, $SD = 0.99$), "the news media" ($M = 2.58$, $SD = 1.04$), and "elected officials" ($M = 2.44$, $SD = 1.02$). Trust scores for the five professional sources were highly correlated (Cronbach's $\alpha = 0.79$). Based on the mean of these ratings, respondents who trusted these professionals more also saw somewhat lower estimates for the next year's death toll ($\tau = -0.07$, -0.06, for best guess and worst case, respectively). Respondents' trust in their family and friends was unrelated to these risk judgments.

3.9. Risk Management

On a scale anchored at 1 = strongly disagree and 5 = strongly agree, respondents expressed intermediate confidence in scientists' understanding of Ebola ($M = 3.39$; $SD = 1.09$). They had less confidence in having a vaccine ($M = 3.00$, $SD = 1.02$) or a treatment ($M = 2.87$; $SD = 1.06$) within a year, and were disappointed with how well we were prepared ($M = 3.69$; $SD = 1.06$). They strongly agreed with a policy that "Officials should provide Americans

Table II. Self-Reported Behavioral Responses

	Reported Response	Behavior: Avoid public spaces	Behavior: Wash my hands or use sanitizer more often	Behavior: Wear a face mask	Behavior: Avoid public transportation (buses, airplanes, etc.)
Self-reports (%)	I have done this	6.7%	44.4%	4.7%	9.0%
	I would do this if I knew that someone in my area had Ebola	59.2	47.9	54.7	59.5
	I would not do this	34.2	7.8	40.6	31.5
Mean probability of dying if you get sick with Ebola (%)	I have done this	25.9	22.5	18.0	23.6
	I would do this if I knew that someone in my area had Ebola	25.2	24.2	25.3	25.5
	I would not do this	17.4	13.6	19.4	16.3
Mean transmissibility index (%)	I have done this	48.3	43.3	40.7	49.7
	I would do this if I knew that someone in my area had Ebola	45.4	36.3	44.8	43.7
	I would not do this	22.8	19.6	28.4	22.5

Note: The top section shows participants' reported adoption of four behavioral responses to Ebola. The middle section shows the mean probability of dying from Ebola, for participants who reported having done each behavior, intending to do it if they knew that there was a person in their area with Ebola, and who would not do it. The bottom section shows the mean estimates of transmissibility (as expressed in the index) for participants reporting that they had done, would do, or would not do each protective behavior.

with honest, accurate information about the situation, even if that information worries people" ($M = 4.34$; $SD = 0.97$) (replicating a result observed with risks from terrorism[(23)]) along with moderate agreement with "invest more in general capabilities, like better public health services" ($M = 3.84$; $SD = 1.00$) and "help with the costs, such as lost wages" for "people quarantined because of exposure to Ebola" ($M = 3.64$; $M = 1.10$). Views on these three policies were strongly correlated, with those who expressed stronger support for investments in public health also expressing stronger support for compensating people in quarantine ($\tau = 0.33$), providing honest information ($\tau = 0.26$), and believing that we should have been better prepared ($\tau = 0.26$). The Supporting Information (Table SIV) provides additional details, including consistent, but weak, correlations with risk estimates.

3.10. Alternative Sample Weighting

As mentioned above, the study oversampled individuals in the Boston and New York City metropolitan areas. As described in Section 2.5.1, their responses were weighted in the reported analyses to match those populations. The Supporting Information presents versions of Tables I, II, and SIV with the sample weighted to match the U.S. population (SV–SVII). There are no meaningful differences between the corresponding tables. Thus, respondents in Boston and New York City metropolitan areas appeared to view Ebola similarly to respondents elsewhere in the country.

3.11. Group Differences

Table III shows the correlations between risk judgments and five predictors: gender, age, education, income, and political ideology (on a scale anchored at 1 = extremely liberal and 7 = extremely conservative). Following our general analytical strategy, we computed ordinal correlations (Kendall's τ) and report only those significant at $p < 0.001$, reflecting the large sample and many correlations. We also conducted regression analyses using

Table III. Group Differences in Risk Judgments and Attitudes

Question	Gender (Male = 0; Female = 1)	Age	Education	Income	Political Ideology
Warm-up					
pizza				**0.09**	
p(travel)		−0.05	**0.22**	**0.20**	**−0.07**
Self					
p(flu)			0.06		
p(seriously ill)			0.05	*0.01*	
p(get Ebola)		−0.07	0.05		
p(die from Ebola)		*0.04*			
Average American					
p(flu)					
p(seriously ill)	**0.06**			**−0.08**	
p(get Ebola)	0.06		−0.07	**−0.07**	
p(die from Ebola)					
Transmissibility					
Index	0.05			−0.07	**0.06**
R_0			−0.11	−0.07	**0.07**
Death Toll					
To date			−0.10	−0.08	
Best guess			−0.06		
Worst case					
Attitudes					
Understand			**0.09**	0.06	**−0.09**
Vaccine		**0.05**			
Cure					
Honest information		**0.10**	**0.07**		
General capabilities	**0.05**				**−0.17**
Quarantine				*−0.05*	**−0.14**
Better prepared		**0.06**			

Note: All correlations are Kendall's tau-τ. Those in bold were also significant in regressions including all five predictors ($\alpha = 0.001$), with log transforms of R_0 and death-toll estimates. Those in italics were significant only in the regressions (but not the simple correlations). Details are given in Tables SXX–SXLIV.

all five predictors after performing log transformations on the right-skewed distributions of the unbounded estimates (R_0, death tolls), after adding 0.5 to all responses (so as to avoid log 0). Bolded values in Table III were significant in the regressions as well as the simple correlations. Italicized values were significant only in the regressions. Tables SXX–SXLIV in the Supporting Information provide full details. The five predictors were weakly correlated with one another, except that better educated respondents were wealthier (τ = 0.25) and less conservative politically (τ = –0.07).

Warm-up questions: As might be predicted from participants' life experiences, their probability of traveling internationally was higher for wealthier, better educated, and more politically liberal respondents. The only difference with the other warm-up question, for which we had no predictions, was that wealthier respondents saw a higher probability of eating pizza.

Personal illness risks: Better educated respondents reported higher probabilities of getting seasonal flu, getting seriously ill, and getting Ebola, although none of these correlations was significant in the regression analysis. Those reporting higher income also saw lower probabilities of getting seriously ill or Ebola. Older respondents saw themselves as less likely to get Ebola, but somewhat more likely to die from it, if sick. Gender and political ideology were unrelated to any of these risk judgments.

Risks for the average American: Males and respondents reporting higher income saw the average American as less likely to get seriously ill or get Ebola. Age and political ideology were unrelated to any of these beliefs about the average American. The probability of flu and the probability of dying from Ebola, if sick, were unrelated to these demographic factors.

Transmissibility: Lower income and more politically conservative respondents saw Ebola as more transmissible, in terms of both measures. Better educated respondents reported lower values for R_0, although just in the simple correlations.

Death toll: Respondents with higher incomes and more education estimated a lower death toll to date. There was little difference in how the groups saw the future, in terms of their best-guess or worst-case estimates.

Attitudes: More conservative respondents were less likely to endorse investing in strong general capabilities, such as public health, or compensating people in quarantine. They also attributed less understanding to science. Older and better educated respondents were more likely to endorse giving the public honest information, even if it might be worrisome (although those ratings were high all around). Older respondents were also more likely to think that a vaccine would be found and that we should have been better prepared.

4. DISCUSSION

Ebola constituted a special case of a recurrent challenge. An unfamiliar threat, with potentially devastating consequences, suddenly appeared. In order to respond appropriately, people needed to determine how great the threat was, what factors determined its spread, how they could protect themselves, whom to trust for information, and which policies to support.

This challenge was complicated by the need to decode messages from public figures (health officials, politicians, and commentators) who sometimes appeared to be uncertain, disagree with one another, and let politics shape their pronouncements.[39] Here, we ask how successful the public was in extracting the facts essential to making personal decisions and evaluating public policies about Ebola under these circumstances.

Following the decision science paradigm,[40–43] we asked questions that were sufficiently precise for the answers to inform individuals' decision making and officials' planning (when anticipating public behavior). In order to achieve that precision, most questions elicited quantitative estimates, thereby raising the possibility that they were too demanding for respondents.[8–10,18,25,27,41–47] We addressed that possibility by examining the construct validity of their responses, interpreting consistent, plausible beliefs as meaning both that respondents had appropriate beliefs and that they could express them as required by the questions.

Overall, respondents' beliefs were internally consistent. They saw themselves as facing less risk for rarer and more severe events. Those who saw greater risk of catching Ebola also saw the disease as more transmissible when exposed to an infected individual while working in an office or using public transportation. That risk was seen as greater if the infected individual was more symptomatic. These patterns were also found in respondents' judgments of the risks for "an average American." As expected from other research,[36,37] respondents saw themselves as facing less risk than the average American for events over which they might have some personal control, but not for the seemingly uncontrollable event of dying should they contract Ebola.

One methodological consideration is that these positive correlations between probability judgments for risks might reflect a response bias toward giving higher values.[6,25] Weak evidence against that possibility is the lack of correlation between the probabilities assigned to the risks (Table I, rows 3–12) and to the two warm-up events (Table I, rows 1 and 2). Stronger evidence is found in the consistent responses across questions using diverse response modes (probabilities, death tolls, behaviors, attitudes, and R_0), especially when intervening items limit the opportunity (and any implicit pressure) for induced consistency. Such construct validity, with consistent responses across questions with varied formats and topics, was also found with the nationally representative sample of U.S. 15- and 16-year olds in NLSY97.[3]

In addition to their internal consistency, respondents' judgments also had plausible absolute values. Respondents knew roughly how many people had died of the disease in the United States to date. Few predicted a very high future death toll, for either their best-guess or worst-case estimate. Their estimates of R_0 were appropriate for a disease that was slow-moving or controlled, as Ebola appeared to be in the United States when the survey was conducted in early 2015. One limit to respondents' judgments was an apparent tendency to use the response option of "50%" as an expression of epistemic uncertainty,[25,27] rather than a numeric probability (Table I, right-most column).

As seen in the tables, there was considerable variability in these responses. Analyses of group differences (Table III, Tables SXX–SXLIV) considered five variables: gender, age, education, income, and political ideology. These analyses found predictable group differences on a warm-up question, with respondents having more education, more income, and more liberal views also seeing a higher probability of traveling abroad in the next year—consistent with the construct validity of these measures. For most of the risk judgments, however, relationships were sparse. Gender predicted little, other than women seeing the average American as having greater risk of getting seriously ill or getting Ebola. Age was related only to personal risk of getting Ebola (lower) and dying from it (higher), as well as greater demands from public health. Respondents reporting higher income saw smaller personal and population risks. Political ideology was unrelated to most judgments, except that more politically conservative respondents saw Ebola as more transmissible and reported more negative attitudes toward public health policies. Thus, although these measures captured differences in travel expectations and health policy attitudes, they were relatively unrelated to perceptions of the disease in the past and unrelated for the future. It appears that the collective experience had largely leveled group differences about the disease, although not about the institutions managing it.

Respondents' generally consistent and sensible beliefs suggest that many had acquired a basic understanding of this unfamiliar pathogen, despite chaotic media coverage, often with intense affective content. As noted, there were theoretical reasons to expect both such understanding and its absence, depending on the interaction between the complex cognitive, affective, and social processes that Ebola could have evoked.[14,15,17,40–43,46,47] In terms of affective processes, a post-hoc explanation is that the reduced threat and less emotive reporting, at the time of the survey, may have allowed people to think more clearly, basing their judgments on what they had learned, rather than on how they felt.[14,15] In terms of cognitive processes, seeing officials' trial-and-error process of managing the disease, as well as explaining their actions, may have allowed observers to create mental models of the processes shaping the risks.[18,19] In terms of social processes, individuals' limited trust in elected officials and the news media (Section 3.8) may have increased their reliance on health officials and providers, a faith that was rewarded by their having found needed information by the time of the survey, although perhaps not before misinformation (and perhaps disinformation) had undermined public confidence at the peak of the Ebola crisis.[39]

Perhaps our most troubling finding is that many respondents report that they would not adopt some protective behaviors, even if someone in their area had Ebola (Table II). Understanding and addressing that reluctance is a topic for future research. One possible strategy is affording people better mental models of how a disease can spread and be controlled.[18,19,48] By studying these lay mental models prior to a crisis, health officials could develop communications on a general topic (e.g., transmissibility) that could be adapted to specific threats (e.g., pathways for Ebola). During a crisis, officials could also deploy surveys like the present one for tracking the evolution of lay beliefs, attitudes, and behaviors. Basing their communications on evidence, rather than intuition, could help officials to secure and retain the public's attention, before less trustworthy sources muddle the issues.[14,15,39,40] Those messages should honor respondents' strong desire for "honest, accurate information about the situation (even if that information worries people)" (Table SIV). If lay people can make quantitative estimates, as seen here, then they should also be able to absorb such information, if provided with properly developed and tested communications.[18,19,38,40–43,49,50]

In addition to expressing trust in health officials, respondents also reported moderate-to-strong support for three public health policies: "We should invest more in general capabilities, like better public health services," "If people are quarantined because of exposure to Ebola, they should get help with the costs, such as lost wages," and "We should have been better prepared for Ebola" (Table SIV). Knowing the public's preferences can help officials to create, convey, and defend relevant policies.

Although we must extrapolate cautiously to other times in the United States or other settings in the world, other studies have also reported seemingly measured responses, despite expert and pundit concerns about "panic." For example, a U.S. survey conducted near the height of public concern (October 21–November 4, 2014) found that, despite being highly salient, Ebola was viewed only as a moderate risk and evoked only moderately high emotions, with sadness being the strongest.[51] A survey conducted in Italy in early 2015 found even lower concern.[52] Related results have been reported from Germany[53] and Israel,[54] among other places.[55] Where relevant questions are asked, they, too, report incomplete procedural knowledge about transmission and protection, along with a desire for authoritative knowledge. From a theoretical perspective, each such study adds to the picture of how these diverse processes interact in settings without the control that experimental research allows. From a practical perspective, studies in specific settings are needed to guide public officials and health practitioners. Both will be aided by using comparable items, ensuring that questions and responses are interpreted consistently.[12,56] We believe that structured items, like those used here, provide a way to achieve that goal.

Overall, there is a reason for optimism in the present results, which reflect generally consistent, informed beliefs, behaviors, and policy preferences. Moreover, those beliefs were expressed in the precise, often quantitative terms needed to inform decisions and be compared with scientific assessments. We believe that this positive picture of lay understanding emerged because of the demanding questions posed by the survey, rather than despite them, with well-defined questions and answers improving communication between researchers and respondents.[57,58] For example, although R_0 is an unfamiliar statistic for most people, our question provided a clear definition of this measure of transmissibility, while respondents' numeric answers provided a clear expression of their beliefs. Similarly, precise messages could provide the public with the information needed to manage disease risks when making personal choices, evaluating public health policies, and interpreting the pronouncements of politicians and pundits.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's website:

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