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Introduction

The United States Safe Drinking Water Act Amendments of 1996 required that utilities send annual water quality reports, including a table of the amounts of contaminants found in the water, to their customers beginning in 1999.[1] As part of a larger effort to understand how best to communicate such information, I conducted a preliminary survey in 1998 of what one New Jersey utility's customers thought of the concept of this "Consumer Confidence Report" (CCR), as Congress termed it. Included in this study was an experiment to test people's responses to alternative formats for the table of water quality data (such as using whole versus decimal numbers, or a narrative versus numerical report for a violation of a water quality standard) proposed in the U.S. Environmental Protection Agency's (EPA) then-draft regulations.

Research Design

A water utility in central New Jersey agreed to collaborate on a survey of its customers in exchange for including questions about customer service and related topics in the questionnaire. The utility selected a random sample of 977 customers from the 53,000 single-home residential customers in its customer base. (The initial sample size 600 was expanded to 977 out of concern that too few responses would be obtained with the smaller sample.) Customers in different service

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1 Pub. L. No. 104-182 (codified as amended throughout 42 U.S.C. §§300g-300j, 33 U.S.C. §1263 (a)).

areas of the utility drew their drinking water from different sources: surface water only, ground water only, or a mixture of each. Eight versions of the questionnaire (identical except for the experiment section) were randomly assigned to members of this sample.

The utility chose to mail the surveys with return envelopes addressed to me because of concern for its customers' anonymity. The mailing was done in only two waves, contrary to standard (modified Dillman) survey practice. The initial mailing included a cover letter, a questionnaire, and an addressed, stamped return envelope. A reminder was mailed two weeks after the initial mailing. The first mailing, intended for June 1998, was postponed because of publicity about "yellow tongues" and other alleged symptoms in some workers expanding a water treatment facility of the utility (and later among some nearby residents). Although media coverage stressed that there was no relation between the symptoms and the drinking water, the utility suggested that the mailing be postponed until the media attention waned. The first mailing eventually occurred in late August, just before the Labor Day holiday.

Valid responses were received from 269 people out of the valid sample of 975 (two addresses were wrong), a response rate of 28%. This low response rate raises questions about how well the results represent the answers if all of the customers had been surveyed. The original sample and respondents had the same distribution of water sources serving them (Chi-square = 1.47; d.f. = 2; $p < .50$) — when differences in source waters (and thus actual quality) might affect perceptions of water quality — and had the same distribution of zip codes (Chi-square = 17; d.f. = 13; $p < .25$).

I also compared my respondents to U.S. Census data. Census data from 1990 for the utility service area[2] were no different than the

2 For 1990 Census comparisons, I used an NJDEP geographic information system to identify census tract block groups partly (62) or wholly (139) within the service area of the utility. For partial block groups, I assumed that residents were equally distributed across this area, adjusting block group census data by the proportion of its land area within the service area. This assumption is wrong in any one case, but over the entire service area is likely to be roughly correct, and in any event makes this comparison possible. Besides summing these "service area" census data, I also ran the calculations again while adjusting for the proportion of owner-occupied housing in the block group, since 98% of the survey respondents were homeowners and renters often have different demographics. With one exception, noted in the text, this second adjustment made no difference to the outcome.

respondents for sex (Chi-square = 1.7; d.f. = 1; p < .25), or for having children in the household (Chi-square = 1.22; d.f. = 1; p < .25). According to 1990 data, residents of the service area were significantly lower than respondents in education (Chi-square = 46.6; d.f. = 3; p < .001) and the proportion of residents 65 years old or greater (Chi-square = 22.9; d.f. = 1; p < .001), and greater in the proportion of residents who speak a language other than English at home (Chi-square = 11.7; d.f. = 1; p < .001). The 1990 Census respondents were significantly less "white" than survey respondents as well (Chi-square = 7.8; d.f. = 1; p < .01), although this ethnic difference disappeared when I adjusted for rates of owner-occupied housing (nearly universal for survey respondents) in census tract block groups (Chi-square = 1.7; d.f. = 1; p < .75). Compared to 1998 U.S. Census estimates for the entire county, there were no differences for sex (Chi-square = 2.4; d.f. = 1; p < .25), but survey respondents were significantly more "white" (89% versus 73%; Chi-square = 60.8; d.f. = 1; p < .001).

It is impossible to say to what degree the observed significant differences are due to changes between the 1990 census and the 1998 survey, the assumptions needed to make this comparison, the limitations in the way census data are reported (e.g., children are included in ethnicity figures), or the absolute real differences in demographic proportions between the census and survey data. As cited below under "Results," such demographic variables were not significant predictors of important survey answers. My calls to non-respondents elicited no common reason that might bias results. The general pattern of survey responses to questions about ratings of drinking water quality and the usage of bottled water and home filtration equipment were similar to those in several high-response-rate surveys I have conducted with customers of other New Jersey utilities, as well as to responses to a random statewide telephone survey.[3] Caution is still warranted in extrapolating the results of this survey, but that caveat applies to any survey regardless of its response rate. In short, I see no reason to be unduly concerned about response rate bias in the results reported below.

3 Results from my other utility surveys, averaging 60% response, have been submitted for publication and are available upon request. *Environmental Attitudes in New Jersey: Treading (Dirty) Water,* The Star-Ledger/Eagleton-Rutgers Poll, Release EP125-4 (April 2, 2000) (reporting that 60% of respondents used bottled or filtered water for drinking; only 14% used tap water exclusively).

The final sample was 53.1% male; had a mean age of 54 (S.D. = 14, range 23-86); 41% had a high school education or less; 46% had some college or a college degree; 15% spoke a language other than English at home; 89% reported an ethnicity of "white"; 40% had children under 18 living at home; 98% owned their own home; and the median range of 1997 household income was $60,000–$79,999.

Results

General beliefs and attitudes about drinking water quality, water quality information, and management of drinking water quality are reported first, followed by the experiment results.

Attitudes and Behavior Regarding Drinking Water

Consumers tended to rate "the quality of the drinking water provided by your utility" as good (38%, 32%) or fair (33%, 31%) in separate ratings for overall water quality and for taste, odor, clarity or color, respectively. Proportions were similar in ratings of drinking water safety, except that 31% of respondents professed ignorance about this, which is the topic that the CCR is intended to address. Factor analysis found the overall water quality ratings and esthetic ratings loading on the same dimension (at 0.88 and 0.84, respectively) and a scale based on these two items was reliable (Cronbach's alpha = 0.78).[4] A majority (74%) felt water quality had been unchanged during their "experience with it." Trust in the utility (24% "very much"; 51% "somewhat") correlated with ratings of water quality ($r = 0.43$; $p = 0.05$) and of the utility's overall job performance ($r = 0.47$). Overall assessment of the utility's performance was strongly related to ratings of its performance on water quality ($r = 0.75$).

When asked about their sources for drinking water, 70% (including those who used both tap water and bottled water equally) responded that they used tap water for at least half of their drinking water; 38% responded that they drank only tap water. However, 43% (including the same equal-consumption group) responded that they used bottled water for at least half of their drinking water, and 12% responded that they drank only bottled water. A plurality (40%) thought bottled water

4 Ignoring the numerous "don't know" responses (N = 167), all three ratings load highly (0.91 – 0.96) on the same factor, producing an even more reliable scale (Cronbach's alpha = 0.92).

was safer in general than tap water and 34% thought the two sources were "about the same" in regard to safety.[5]

General Information about Drinking Water Quality

Some 54% rated it "very important" and 36.4% rated it "important" to know more about the quality of their drinking water. This response correlated significantly with overall trust in the utility ($r = 0.24$; $p < 0.05$). I conducted multiple regression analyses of this personal interest in information about drinking water quality. With five demographic independent variables only, the adjusted R^2 was too low to measure (-.00). Using only responses to ten questions about various judgments of the utility (e.g., trust) and ratings of water quality as independent variables (N = 113), the adjusted R^2 was .12 ($p = .01$), with overall trust in the utility the only significant independent variable (beta = .27). With 15 independent variables comprising beliefs about water management in general (e.g., utility water quality will be more strictly regulated in the next two decades) and risk in general (e.g., experts should make decisions on health risks), the variance explained dropped to 9% ($p = .003$; N = 227). The significant variables in this regression analysis, both with betas of .16, were agreement that people drinking water with contamination above a public health standard "will definitely experience health effects" and agreement that "When the risk is very small, it is OK for society to impose that risk on individuals without their consent." Finally, a multiple regression analysis using all three categories of independent variables (N = 85) found that the explanation of variance in the importance of knowing about drinking water quality rose to 28% ($p = .009$). The significant independent variables were overall trust in the utility (beta = .37) and a willingness to pay 5% more in utility bills to help the utility achieve public health standards (beta = .33; willingness to pay to better the standards was asked in a separate question, which was not a significant predictor).

Respondents rated several potential sources of information on their water quality: the local water utility; the local health department; the New Jersey Department of Environmental Protection (overseeing

5 However, "improving drinking water quality" ranked only fifth out of seven public policy issues that respondents were asked to rate "on the priority each should get from public and private groups in New Jersey," with a mean value of 2.13 on a scale from 1 (highest priority) to 4 (lowest priority).

utilities' water quality); the New Jersey Department of Health and Senior Services; the EPA; experts from an area university; medical doctors; an environmental group; the local newspaper; the local TV station; and "neighbors, friends and family." Overall, survey respondents felt they had very little information about their drinking water's quality from any source. Even the most informative sources (utility; mass media; social networks) were reported as providing "a lot of information" or "some" by a total of less than 22%. The most trusted information source was the local health department (66% selected the top two trust choices in a four-item Likert scale), although it has no authority over drinking water. The utility, with legal responsibility to provide water quality reports, was rated as trustworthy by 57% of the respondents, seventh among the eleven sources. The lowest-rated sources were the mass media with 48% rating newspapers as trustworthy and 47% rating television as trustworthy.

Only four of eleven sources showed a significant correlation between the level of trust they elicited and the level of information about water quality reportedly received from them: utilities ($r = 0.33$), doctors ($r = 0.17$), newspapers ($r = 0.30$), and television ($r = 0.38$). Overall trust in the utility did not correlate with trust in it as a source of information about drinking water quality.

Nine percent agreed and 30% disagreed that the "utility provides every year to its customers, by mail or on request, a detailed water quality report" (at the time it was provided only upon request) and 61% said they did not know. Little publicity on the forthcoming CCR had appeared in New Jersey at the time of the survey: 19% said that the utility would "provide a detailed water quality report every year to its customers in the near future"; 3% said it would not; and 77% said they did not know.[6] About two-thirds (67.7%) said that they would read an annual water quality report "carefully every year," and another 12% said they would "read it carefully the first time [I] receive it, but casually or not at all afterwards." Sixty percent said they would call a

6 After much discussion during the regulation's development, the EPA chose not to mandate how to deliver Consumer Confidence Reports (CCRs) (whether enclosed with the water bill or mailed separately) and also chose to free small utilities of the requirement to mail the CCR to each customer. Thirty-four percent of my survey respondents claimed to "always" "read information that is included in the envelope with my water bill"; another 59% said that they read such information "sometimes."

number listed in the report to obtain "further information about water quality" from the utility; 15% would not; 25% did not know. A third (39%) of the total sample said they would visit the utility's web site if one existed.

Table 1
Factor Loadings of Desired Water Quality Information

Information (percentage "very interested" in item)	*Factor 1**	*Factor 2***
(When level is above standard) nature of violation and possible health effects, health reasons for substance regulation, what has/will be done to stop violation/recurrence (74.3%)	0.89	0.36
The source(s) for the water (68.1%)	0.90	0.35
Probable source(s) of substances (71.8%)	0.91	0.35
Substances found in water for which utility is not required to test (72.6%)	0.85	0.39
Violations of reporting, monitoring, public notification, record keeping, and treatment requirements, including violation's potential health effects and what was or is being done to correct the violation (73.7%)	0.90	0.39
Any exemptions from regulations for the utility, including reasons, current status, and chances for public comment (65.1%)	0.80	0.34
Explanation of potential health effects for parasite Cryptosporidium (74.8%)	0.86	0.41
Brief statement on substances likely to be in all drinking water, including bottled water (78.8%)	0.88	0.41
Telephone number for more information (61.3%)	0.79	0.37
Opportunities for public participation in decision-making on drinking water issues (45%)	0.68	0.32
Levels of microorganisms, chemicals, or radiation detected in the water (75.6%)	0.46	0.81
How much of each substance government standards permit in the water (70.0%)	0.42	0.88
Maximum of each substance government ultimately wants in all water (68.1%)	0.32	0.89
How much lower than the standards are levels of substances found in the water (70.6%)	0.35	0.91
How levels in the water compare to levels found in other utilities' water (62.8%)	0.37	0.87

*Factor 1 explains 8% of variance; bold items form a reliable scale (Cronbach's alpha=0.98).
**Factor 2 explains 4.6% of variance; bold items form a reliable scale (Cronbach's alpha=0.95).

Surveyed customers were asked about their level of interest in fifteen different kinds of information; EPA requires that thirteen of these appear in a utility's CCR. Two items had been proposed by two focus groups I had conducted earlier with customers of a different utility: (1) "how much lower than the standards are levels of substances found in the water;" and (2) "how levels in the water compare to levels found in other utilities' water."[7] A principal components factor analysis (varimax normalized) of the answers extracted two factors, shown in Table 1. Nine items loading high on the first factor seem to distinguish qualitative or narrative information about drinking water quality and water quality management. A tenth item, on public participation, just missed the standard threshold of 0.70 for significant loadings. That 45% of respondents said they were "very interested" in this information is a strikingly high percentage given the proportion of utility customers who do, or are likely to, participate in utility-related decision-making. The five items loading high on the second factor appear to be quantitative data about drinking water quality.

Separate multiple regression analyses were conducted to try to understand demand for these two sets of information, using the same categories of independent variables used for the multiple regression analysis of self-reported importance of knowing about their drinking water quality. With regard to the first factor, the variance explained in the four analyses was 4% (demographics; N = 195), 14% (utility judgments; N = 112), 12% (water management and risk beliefs; N = 225), and 37% (all categories together; N = 83), respectively. In the latter regression analysis, significant independent variables were disbelief that someone exposed to a carcinogen "will probably get cancer some day" (beta = .32); unwillingness to pay more to achieve standards (beta = .31); low desired priority for drinking water quality in public and private agendas (beta = .31); and trust in the utility (beta = .28). With regard to the second factor, interest in quantitative water quality information, variance explained was similar: 3% (demographics; N = 192), 10% (utility judgments; N = 110), 20% (water management and risk beliefs; N = 222), and 44% (all categories together; N = 84). In

7 Branden B. Johnson, *'Consumer Confidence Reports' for Drinking Water Contamination: Initial Studies on Public Response,* Presented at the Society for Risk Analysis meeting (Dec. 10, 1997).

the latter regression analysis, significant variables were the personal importance of knowing about one's drinking water quality (beta = .40), disagreement that "Decisions about health risks should be left to the experts" (beta = .32), and (surprisingly) low frequency of worry about "possible long-term health effects from contaminants in the environment" (beta = .26). In other words, demand for the non-quantitative information appeared to come from people who lacked concern about water quality and its management, whereas demand for the quantitative results came from those who did have such concerns.

A few of the 51 comments about "other information" that people would like in a water quality report concerned topics other than those the EPA requires in a CCR. These included self-protective actions; illness clusters in the area; how composition and quality of water distribution pipes affect water quality; "if and when recycling is done in your plants"; causes of water hardness and mineral deposits; water prices; frequency of testing; and sources of data compiled in water quality reports. Four people explicitly asked for comparative information: three of the utility's tap water with bottled water, one of "town vs. town," and one of "national and state averages as they compare with local water quality."[8]

General Beliefs About Drinking Water Management

Most respondents reported, correctly, that they did not know the source of their utility's water or whether there were any incidents in 1997 that threatened or harmed the quality of local drinking water. Both topics are ones that the CCR must report, which could reduce this ignorance. Only 25% agreed, correctly, that their utility was "upgrading its treatment operations to provide better-quality water," with 72% saying they did not know; and 48% agreed, incorrectly, that the water was fluoridated, with 44% saying they did not know. The EPA and the American Water Works Association (AWWA) had argued during the development of the regulations that the CCR offered an opportunity for utilities to educate their consumers about such topics.

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8 *See* Branden B. Johnson, *Risk Comparisons in a Democratic Society: What People Say They Do and Do Not Want*, 10 RISK 221 (1999) (for similar citizen requests for risk comparisons to inform household-level decisions).

Table 2 shows the percentage of respondents who agreed or disagreed with various statements about drinking water management. Between one-quarter and three-quarters of respondents answered "don't know" to each statement, so most people believe themselves uninformed about drinking water management. Two-thirds (63%) correctly agreed that "Tap water and bottled water must meet the same quality standards," and the majority of those with an opinion (48% of the total) correctly agreed that drinking water regulation would be getting stricter. Of the very small proportion who chanced an answer, a majority (20% of total) correctly agreed that some New Jersey standards are stricter than federal standards. A majority of those chancing an answer (although only 18% of total) agreed that such standards assume lifetime exposure, which is correct for carcinogen standards (for non-carcinogens, the assumption is "chronic exposure"). Just about half agreed with the experts that technology can treat most drinking water contamination (52%) and health is unlikely to be affected by contamination that is less than the applicable standard (50%). Only 9% correctly agreed that utilities regularly test for contaminants. A majority held opinions that most risk professionals would dispute including: (1) that industry is the primary cause of drinking water pollution (57% agreed) and (2) that contamination exceeding public health standards means "people who drink the water will definitely experience health effects" (66% agreed).

Format Experiment

One purpose of this survey was to explore the effect of variations in formats of the water quality table in the CCR on public responses. In the absence of any data on how best to convey the results of water quality tests,[9] the EPA had understandably made decisions on how it must be done by utilities, but these decisions could be tested after the fact. The experimental format was a hypothetical mini-table of contaminants – only two per version, whereas in a real CCR the table reporting water quality reports might list tens of contaminants.[10]

9 "Risk communication experts" (including myself) consulted by the EPA noted that no research examined whether whole or decimal numbers, for example, would better convey test results to lay audiences. They disagreed on whether whole numbers would be less confusing, without making water quality look worse when they produce large numbers for some standards.

10 In 1998, EPA-regulated contaminants numbered 85; any of these detected in the utility's

Table 2
Beliefs About Drinking Water Quality Management (percentages)

Beliefs	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*	*Don't Know/ No Opinion*
Utilities regularly test their water for contaminants.	2.7	44.2	9.3	0.0	43.8
Modern technology can treat most pollution of drinking water.	3.5	13.6	39.9	11.6	31.4
The quality of utility-provided water will be more strictly regulated in the next 20 years.	1.2	3.4	33.1	14.4	47.5
Contamination of drinking water is usually due to industrial pollution.	1.9	13.1	37.3	20.0	27.7
If drinking water has more contaminant in it than allowed by government standards, people who drink the water will definitely experience health effects.	1.5	9.2	38.3	28.0	23.0
Tap water and bottled water must meet the same quality standards.	3.5	10.8	42.5	20.5	22.8
Some New Jersey State standards for drinking water safety are stricter than federal standards.	0.8	3.5	17.3	2.3	76.2
People are unlikely to suffer harm if they drink water with LESS of a possibly harmful substance in it than government standards allow.	3.1	16.3	39.9	9.7	31.0
Government standards for contaminants in drinking water are intended, using worst-case assumptions, to protect people who drink this amount of the contaminant for 70 years.	2.3	8.6	14.1	3.9	71.1

water would have to be reported in the first (1999) CCR.

Specifically, my aims were to explore whether people would have different reactions to such information if there were:

- a zero or non-zero MCLG[11] (the EPA traditionally sets zero MCLGs for carcinogens);
- one or no violation of a MCL;[12]
- a violation of the MCL presented numerically only, or in the narrative format required in EPA regulations;
- information presented in whole numbers (as required by the EPA) or in decimals;[13]
- a high (e.g., 700) versus low (e.g., 5) MCL; or[14]
- varying amounts of health effects information including: (1) none at all; (2) for the one item in the table whose MCL has been violated (as required by EPA regulations); or (3) for all items in the table, regardless of whether violations occurred (as some environmentalists wanted, in discussions about draft regulations).

Except for the invented "amounts found," and certain variations (e.g., whole versus decimal numbers), the contents of the tables came from EPA appendices to its proposed regulations, so the contaminant name, its MCL and MCLG, its health effects, and its generic sources were accurate. These mini-tables varied from those required by having only two contaminants (most utilities would detect, and have to report on, many more contaminants), and to reduce jargon, for example, one row was labeled "Public Standard for Highest Level Allowed (Maximum Contaminant Level–MCL)" rather than highlighting the jargon of "MCL." The tables also reported a single number for the level of a substance found in the water, rather than a range of detected levels as required by the final regulations (published in August 1998, just before the survey was mailed).[15] Because the experiment aimed at

[11] The Maximum Contaminant Level Goal (MCLG) must be defined in CCRs, by EPA regulation, as "the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety." The MCLG is a non-enforceable target.

[12] The Maximum Contaminant Level (MCL) must be defined in CCRs, by EPA regulation, as "the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology." In other words, the MCL is the enforceable public health standard for a drinking water contaminant.

[13] *Supra* note 9.

[14] The expert panel wondered whether a high detected level of a substance in drinking water that did not exceed a high MCL might be more alarming than a low detected level that did not exceed a low MCL.

testing the above variations with "real" data, no control was arranged for possible effects of contaminant names.[16]

Table 3 shows the full list of variations in the experiment. Figure 1 shows one example.

Table 3
Versions of Information Table Tested in Experiment

Version	*MCL Violation*	*High/Low MCL*	*Positive/Zero MCLG*	*Whole/Decimal Numbers*	*Health Effects*
1 (N=34)	Yes	High	Positive	Whole	One
2 (N=35)	Yes	High	Zero	Decimal	One
3 (N=30)	Yes	Low	Positive	Decimal	One
4 (N=40)	Yes	Low	Zero	Whole	One
5 (N=34)	No	High	Zero	Whole	None
6 (N=30)	No	High	Zero	Decimal	None
7 (N=34)	No	High	Zero	Whole	All
8 (N=31)	Yes (narrative explanation)	High	Positive	Whole	One

The table was preceded by a note that the table "is an example of a small portion of a table that could be included in a future water quality report from your utility. (This information describes a hypothetical situation, and does not necessarily reflect conditions at your utility.)" Thirty to forty responses were received for each of the eight versions of the experimental table.

After reading one of these tables, people were asked to indicate their agreement with ten statements. Three statements asked whether the information was understandable and useful. Five statements asked various attitudinal or behavioral intent measures of concern. For example: "This water seems to pose a serious health risk"; "If this was my tap water's quality, I'd use bottled water for all my home drinking

15 The range rule did not appear in draft regulations, on which the experiment was based. I tested the effect of reporting ranges on customer response in a later survey experiment.

16 Familiar names, such as "arsenic," might evoke responses based on beliefs other than those evoked by the table's data. *See* George L. Carlo et al., *The Interplay of Science, Values, and Experiences Among Scientists Asked to Evaluate the Hazards of Dioxin, Radon, and Environmental Tobacco Smoke*, 12 Risk Anal. 37 (1992). A name like dichlorodifluoromethane, on the other hand, might arouse concern for its unfamiliarity alone. Contaminants used in these experiments included atrazine, benzene, beryllium, ethylbenzene, heptachlor, PCBs, picloram, and trichloroethylene.

and cooking"; and "I would actively work to get my water supply cleaned up." One question was a trust measure ("If the utility told me my water was safe given this information, I would believe them"), and one question checked whether people had accurately noticed whether "The standard was violated for one contaminant." An eleventh measure was created to indicate whether the answer to the last question was accurate (63% were correct). Although factor analysis suggested that several concern measures, plus that for trust, loaded high on the same factor, they produced no reliable scale at all. As a result, tests of the comparisons listed above were done for each of the eleven measures separately.

Figure 1
Sample Experimental Table (version 1, in Table 3)

Contaminant	*Ethylbenzene*	*Picloram*
Average amount in utility water	770 parts per billion	400 parts per billion
Public standard for highest level allowed (maximum contaminant level--MCL)	700 parts per billion	500 parts per billion
Health goal (maximum contaminant level goal)	700 parts per billion	500 parts per billion
Possible sources of contaminant	Discharge from petroleum refineries	Herbicide runoff
Health concerns resulting in regulation (These effects happen only if contaminant levels in the water are greatly above the standard and people drink it for a long time.)	People who drink water containing ethylbenzene in excess of the MCL over many years could experience problems with their liver, kidneys, central nervous system, or eyes.	

Differences were analyzed with Kruskal-Wallis ANOVA by ranks (using STATISTICA). The K-W test assumes a continuous variable but requires only a minimum of ordinal measures since the status of a four-item "Strongly disagree to Strongly agree" Likert scale as either a ratio or ordinal measure is debated. This seemed to be an appropriately cautious approach. "Don't know/no opinion" answers were recoded for analysis to "3," creating a 5-item Likert scale from "Strongly disagree" (1) to "Strongly agree" (5). The number of responses per experimental treatment was low (30-40), which would ordinarily raise questions about the ability of analysis to identify significant differences. However, the numbers used in the analyses reported below were much larger (except for one cell each in the health statement and narrative-versus-numerical-violation analyses, cell sizes ranged from 64 to 197) because these comparisons involved combinations of treatments. For example, three of the eight experimental versions involved no violation of the MCL and responses to these versions were aggregated before testing whether violations (aggregated over five versions) and non-violations elicited different reactions. Unless otherwise noted, only measures significant at $p < 0.05$ are reported below and in Table 4.[17]

Zero versus Non-zero MCLG

Three of eleven comparisons were significant. Readers of the zero-MCLG table were less likely to agree that "I would actively work to get my water supply cleaned up" given the information in the table, and less likely to agree that "The standard was violated for one contaminant." Those reading a positive MCLG table were far better than those reading a zero-MCLG table at correctly identifying a MCL violation.[18]

One or No Violation of a MCL

Two of the eleven comparisons found significant differences. Readers of the violation tables were understandably more likely to agree that a violation had occurred (although surprisingly only a bit over a third agreed) and more likely to be correct. A separate comparison of no-violation versions and the numeric presentations of MCL violations (i.e., without the narrative of violation, see next paragraph; N=97 and 139) found no differences.

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17 To test further the statistical power available with these sub-sample sizes, I re-analyzed the data using a significance criterion of $p < 0.10$; results varied little.

18 People who saw a table with zero MCLGs were more likely (41% versus 26%) to "strongly agree" with the statement "I need to know more before I can understand what this means for my health and safety" than those who saw a table with positive MCLGs; this comparison just missed significance ($H(1, N = 251) = 3.56$, $p = 0.0592$).

Table 4
Experiment Results

Experiments (N)		*Usable Information*	*Actively Clean Up*	*Standard Violated*	*Correct On Violation*
MCLG:	Zero (171)		51.%*	24.%**	43.%*****
	Non-zero (95)		65.%	44.%	100.%
MCL Violation:	Yes (170)			38.%*	100.%*****
	No (97)			20.%	29.%
Violation Report:	Numerical (139)			32.%	
	Narrative (31)			63.%*	
Numbers:	Whole (171)	63.%**** [a]			
	Decimal (95)	54.%			
MCLs:	High (197)			36.%*	51.%
	Low (70)			21.%	100.%*****
Health Effects:	None (64)	52.%		25.%	19.%
	One (Violation) (170)	60.%		38.%	100.%*****
	Two (No Violation)(33)	76.%**		10.%**	42.%

Only statistically significant results (p < .05) are shown. Percentages given are those agreeing with the statement, except for the last column, which is the percentage correctly identifying violations.
*p < .05 **p < .01 ***p < .001 ****p < .0001 *****p < .0000
[a] With "don't know" responses removed from the analysis.

Numerical versus Narrative Presentation of MCL Violation

One of the experimental tables presented a MCL violation in terms of the narrative (when, why, how addressed) required by EPA regulations (Figure 2), while other violation tables showed them only in numbers.

Only one of eleven comparisons was significant and narrative readers were more likely to say that the standard was violated, but there was no difference in accuracy of violation identifications.

Figure 2[19]

Experimental Version of MCL Violation Narrative (version 8, Table 3)

NOTICE OF VIOLATION

On March 15, 1997 we found ethylbenzene at 10 parts per billion (ppb) — compared to the public standard for the highest level of ethylbenzene allowed (Maximum Contaminant Level, MCL) in utility water, 700 ppb — which triggered a government requirement for quarterly water samples. The June 15, 1997 sample was 3054 ppb; the September 15 sample was 15 ppb, and the December 15 sample was 1 ppb. (The March 15, 1998 sample was 0.3 ppb.) An immediate search in March 1997 found an accidental discharge at a petroleum refinery (the main source of ethylbenzene) into the ground water; the resulting contaminant plume affected a utility well as it moved by (with the peak about June). State regulators and the refinery are cleaning up the spill, and taking steps to prevent another; the utility has received a permit to add additional treatment, and hopes to have it working by the end of 1999. As required by federal law, the utility notified all customers of this incident immediately; the utility also provided water trucks in the affected areas during the peak period of contamination.

In 1997, the quarterly samples of ethylbenzene resulted in an annual average of 770 ppb, which exceeded the MCL of 700 ppb (equal to the ultimate health goal, or Maximum Contaminant Level Goal). People who drink water containing ethylbenzene in excess of the MCL over many years could experience problems with their liver, kidneys, central nervous system, or eyes. Because this exposure was above the MCL for a few months at most, and the utility offered affected customers an alternate water supply during that period, it is very unlikely that customers will experience these health effects.

Whole Numbers versus Decimals

In its final regulations, the EPA said that it believes that whole numbers make it easier for consumers to compare the level of a contaminant in the system's water with the MCL.[20] However, many consumers have trouble understanding decimal points. This was evident in the focus groups, in which people found reports containing mostly whole numbers much easier to read than reports where the significant digits came after multiple zeros. The AWWA found similar results in EPA focus groups.[21] Going on to note that "[s]ome commenters

19 Joan Kryak of the Bureau of Safe Drinking Water, NJDEP, advised on the violation-narrative text, but I am responsible for any errors. EPA rules require such a narrative, but do not specify its content, so this text's representativeness of violation narratives actually reported by utilities is unknown.

20 *See National Primary Drinking Water Regulation: Consumer Confidence Reports; Final Rule*, 63 Fed. Reg. 44517 (1998).

expressed concerns that whole numbers would look like big numbers and would scare people," the EPA modified its rule slightly "to allow MCLs to be expressed as any number greater than 1.0."[22]

Overall, there were no significant differences between reactions to the whole-number and decimal formats. With "don't know" responses removed from the analysis, readers of whole-number tables were more likely to agree that "This is information I can use" than readers of decimal-number tables.

High versus Low MCLs

As noted above, there was some concern among people commenting upon EPA draft regulations that high MCLs would frighten utility customers. Only two of eleven comparisons of responses to high-MCL and low-MCL tables were significant, and none involved concerns, judged risk, or judged behavioral intentions to switch to bottled water. The high MCLs elicited more agreement that a violation had occurred; but low-MCL readers were much more likely to correctly identify violations. The reason for this difference in identifying violations is unknown. Possibly people have greater difficulty in comparing multi-digit numbers than comparing single-digit numbers, but I am unaware of such a finding.

Varying Health Effects Information

EPA rules require that the health effects that led to a substance being regulated appear in the CCR when the MCL for that substance is violated. This portion of the experiment varied the amount of health effects provided from none, with no violations; for one item whose MCL has been violated; and for both items in the table, without violations (as some environmentalists wanted). Three of eleven comparisons were statistically significant. Readers of the both-items version were more likely than the other two to agree that they could use the information in the table, but far less likely to say the MCL had been

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21 *See* Macro International, *Focus Groups on Consumer Confidence Reports: Focus Group Report* (submitted to the EPA, Office of Ground Water and Drinking Water, April 27, 1998); Bob Hurd and Joan Becker, *AWWA Focus Groups to Develop and Test Effective Water Quality Reports: Responding to CCR Requirements in the SDWA (WITAF Project No. 408, Final Report)* (1998).

22 *See supra* note 9. As noted in the text, this final rule was promulgated too late to be reflected in the whole number versions of this experiment; its impact would have been to reduce or eliminate the distinction between "high" and "low" MCLs (see Table 3).

violated. Readers of the one-item version were more likely to be correct about whether the standard was violated (H (2, N = 268) = 267; p = 0.000).

Respondents were asked what other information should be included in such a table in a water quality report; again, few of their suggestions went beyond required information. Those that did included water testing (frequency; sampling location); variations in contaminant levels over time; health effects (of less-than-MCL levels; variations across consumers of different ages); the MCL-setting process; descriptions of contaminants and their uses; protective actions consumers could take; and a summary of the water quality table's "meaning" (presumably a judgment of its safety or lack of safety).

Discussion

In many respects the results reported here convey good news for utilities sending water quality reports to their customers under the EPA regulations. Clearly, consumers wanted the information to be provided in the federally-mandated "Consumer Confidence Reports," and the way water quality information is to be reported under EPA regulations appears to create no major problems. Although there were a couple of situations (zero-level MCLGs; high MCLs) that seemed to make it difficult for readers to correctly identify when violations had occurred, this problem will likely be avoided by the narrative approach that the EPA requires (but see next paragraph). Furthermore, ratings of concern, risk, and intention to drink bottled water instead of the tap water whose quality is being reported did not vary across the reporting variations tested.

This survey also shows, however, some problems for communicating water quality information. Of particular interest is that it seems difficult for people, even in a table of only two contaminants, to recognize whether a violation has occurred. Only 32% agreed correctly that there was a violation when they had to compare numbers in the table, and even with a narrative statement having a boldface heading of "Notice of Violation" the proportion of correct agreement only increased to 63%.

Another problem is that utilities and regulators do not share with utility customers many important beliefs about drinking water quality and its management. Customers lack important information about drinking water management, including even whether water is tested regularly, and distrust primary information sources. The AWWA focus groups[23] revealed that trust in utilities seemed unrelated to utility compliance with standards, but seemed to be a complex outcome of overall relations with the utility, esthetic quality of the water, and other such factors. In this study, customers reported less trust in the information source that is legally responsible for providing them with water quality information (i.e., their utility) than in other sources. Furthermore, expressed interest in the quantitative data on water quality came particularly from people who distrusted the utility and other authorities, making it unclear whether no-violation results in these data would reassure this subgroup. Despite such distrust, in order for water quality reports to be credible utilities and regulators must promote a wider view and discussion of drinking water management, rather than simply list contaminants found in the water.

The majorities in this survey who wanted various kinds of information about their drinking water probably show far more enthusiasm about the prospect of a water quality report than an actual report is likely to receive. But this enthusiasm offers an opportunity for drinking water managers to meet and exceed that demand, and in the process bridge the gap between managers and customers so as to improve the quality of both drinking water and its management.

23 *See supra* note 21.