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Fern K. Willits
The Pennsylvania State University, fkw@psu.edu

Gene L. Theodori
Sam Houston State University

A. E. Luloff
The Pennsylvania State University

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SELF-REPORTED FAMILIARITY OF HYDRAULIC FRACTURING AND SUPPORT FOR NATURAL GAS DRILLING: SUBSTANTIVE AND METHODOLOGICAL CONSIDERATIONS*

FERN K. WILLITS
THE PENNSYLVANIA STATE UNIVERSITY

GENE L. THEODORI
SAM HOUSTON STATE UNIVERSITY

and

A.E. LULOFF
THE PENNSYLVANIA STATE UNIVERSITY

ABSTRACT

The widespread use of hydraulic fracturing in the natural gas industry in the United States has led to criticism by environmentalists and the public who see the process as threatening both the quality and quantity of local water supplies. However, there has been little research directed to assessing the extent to which citizens believe they are familiar with the process of hydraulic fracturing and little analysis dealing with the correlates of subjects' sociodemographic characteristics with such familiarity or its effects on individual's support or opposition to natural gas drilling. The current paper examines these issues using data from a 2012 study of 800 residents in the core area of the Marcellus natural gas region in Pennsylvania. Substantive and methodological implications of the findings are discussed, as are suggestions for future research.

Rapid development of the US natural gas industry over the last decade has been fueled primarily by technological advances in horizontal drilling and high-volume, multistage hydraulic fracturing (IEA 2012). Hydraulic fracturing – an industrial process frequently called fracking, fracing, or frac'ing – involves flushing large volumes of frac fluid (i.e., a mixture of water and proppant, along with small volumes of friction reducers, disinfectants, and other chemicals) into wells at extremely high pressure levels to create and/or magnify small fissures, or fractures, in the shale formations (King 2012; Theodori et al. 2014). The fracturing of shale gas formations increases recovery by enabling higher permeability through the reservoirs to the wellbores (King 2012).

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Of late, the topic of hydraulic fracturing has increasingly dominated public discourse and popular press writings (Dobb 2103; Marsa 2011; Walsh 2011). Environmental, social, and behavioral scientists have also begun studying various environmental/natural resource, social, and public health issues associated with increased hydraulic fracturing and shale gas and oil development (Colborn et al. 2011; Olmstead et al. 2013; Shonkoff, Hays, and Finkel 2014; Weber, Geigle, and Barkdull 2014). Citing both perceived and objective environmental and health concerns, lawmakers in municipalities across the country – and recently at a state level (New York) – have passed legislation banning the process of high-volume, multistage hydraulic fracturing within their jurisdictions.

The purpose of this paper is to add to the sociological literature on issues associated with hydraulic fracturing. Recent studies have sought information on American's views of hydraulic fracturing from national samples of residents (Boudet et al. 2014; Davis and Fisk 2014) but do not focus on the views of residents living in areas such as Pennsylvania that are most affected by the rapid development of the natural gas industry. Other studies provide information on the views of selected stakeholder groups and community and/or key informants (Brasier et al. 2011; Ceresola and Crowe 2015; Ladd 2013; Schafft et al. 2014) rather than assessing residents' views directly. A 2009 survey of Pennsylvania residents in the Marcellus Region provided early baseline information about residents' perceptions (Alter et al. 2010), and a subsequent study (Willits, Luloff, and Theodori 2013a) documented changes in residents' views in the intervening years. The current analysis drew upon the latter survey data to assess residents' self-reported familiarity with hydraulic fracturing and its association with support or opposition to the development of natural gas. Specifically, the following research questions were addressed:

> *Research Question 1*: To what extent do residents report they are familiar with hydraulic fracturing and how does reported familiarity differ depending upon the individuals' sociodemographic characteristics, primary sources of information, density of well development in their counties, and the mode of data collection?

> *Research Question 2*: How does perceived familiarity with hydraulic fracturing relate to residents' support or opposition to development of the natural gas industry in their area?

DATA

In 2012, random samples of persons living in 21 counties in the Marcellus Shale region in Pennsylvania were contacted and asked to participate in a survey

concerning their opinions about natural gas development. All counties were located in the central core or tier one areas of the Marcellus region as defined by geologists at the time (Dell et al. 2008), and all had experienced at least some Marcellus Shale drilling activity. However, the well densities of the areas varied widely. Twelve of the counties contained between 1 and 128 wells in 2012, with 12 or fewer wells per 100 square miles of land area. The remaining nine counties each had two hundred to more than one thousand wells, with densities between 20 and 93 wells for every 100 square miles. To secure opinions from respondents within this region that reflected gas-industry activity differences, the sample was chosen to reflect the views of individuals living in counties with "low" well densities (fewer than 12 wells per 100 square miles) and those living in counties with "high" well densities (20 or more wells per 100 square miles). Coincidentally, 50% of the total population in the 21 counties included in the sample fell in the low well density counties and 50% fell in the high well density counties (Willits, Luloff, and Theodori 2014).

The survey was part of a larger study designed to assess differences between how subjects responded to various types of questions depending upon whether the data were obtained through mailed questionnaires or by telephone interviews. Although the research record is inconclusive, some evidence suggests that respondents may be more forthcoming in expressing their views in mail surveys, as they may feel more anonymous than in an interview situation. Moreover, time pressures and the inability to review answers in an interview may limit respondents' opportunity to reflect and review alternatives, resulting in "top of the head" responses (Dillman, Smyth, and Christian 2014; Willits, Luloff, and Theodori 2013b).

To explore (and control for) possible mode differences, random samples of residents' telephone numbers and post office addresses were obtained from a commercial sampling organization and contacted to obtain survey data from area residents. Data collection continued until survey responses were obtained from a total of 800 respondents – 200 telephone interviews from low well density areas and 200 in high well density areas, and 200 returned mailed surveys from low and 200 from high well density areas. The questions/items used in the mail and telephone surveys were identical in wording and in the instructions provided to the respondents.

The telephone survey was conducted over the period June 11, 2012, to August 30, 2012, using state-of-the-art CATI software. Two thousand random telephone numbers were entered into a telephone bank. Of these, 2000 telephone numbers, 496 were unusable (393 were nonworking/disconnected/other; 43 were computer/fax lines; 60 were business lines/nonresidential). Hence, the usable telephone survey sample was reduced to 1504. Of these, 400 individuals completed the survey 200 in

the low well density areas and 200 in the high well density areas, resulting in a 27% completion rate.

For the mail survey, 800 names and addresses of persons with listed telephone numbers were randomly selected from the low well density counties, and 800 similar names and addresses were randomly selected from the high well density counties. An initial mailing, including a cover letter and a printed questionnaire, was sent to these sample members in July 2012, followed by three follow-up reminder letters with duplicate questionnaires over the next three months. A total of 43 questionnaires in the low well density counties and 52 questionnaires in the high well density counties were returned as undeliverable. Since one objective of the larger study was to examine the differential effects of results from telephone and mail surveys the same protocol used in the conduct of the telephone survey was used in the mail survey. Hence, only the first 200 replies received from each of the well-density categories were included in the current analysis, resulting in an overall usable response rate of 27% from the valid addresses.

While far from ideal, a 27% response rate for a general population survey is not atypical. Despite efforts to increase responses through attention to survey length, form, content, and the employment of multiple contacts/mailings and various incentives, response rates have increasingly declined across time (Baruch and Holtom 2008; Connelly, Brown, and Decker 2003; Curtin, Presser, and Singer 2003). However, recent studies have challenged the presumption that low response rates imply inaccurate findings. Indeed, past and ongoing research suggests that findings of studies with low rates of response may differ little, if at all, from those with higher rates of participation (Berdie 1989; Curtin, Presser, and Singer 2005; Keeter et al. 2000; Langer 2003).

MEASUREMENT

Respondents were asked about their familiarity with hydraulic fracturing using the following three survey items:

- Natural gas development in the Marcellus Shale relies heavily on the practice of hydraulic fracturing. On a scale from 1 to 7, where 1 is "Extremely Unfamiliar" and 7 is "Extremely Familiar," how would you assess your familiarity with the process of hydraulic fracturing?
- The term "frac flowback water" refers to water that returns to the surface after a gas well is hydraulically fractured. On a scale of 1 to 7, where 1 is "Extremely Unfamiliar" and 7 is "Extremely Familiar," how would you assess your familiarity with the management and disposal of frac flowback water in the Marcellus Shale?

- Technologies that remove contaminants from frac flowback wastewaters in natural gas field operations currently exist and continue to be refined. On a scale of 1 to 7, where 1 is "Extremely Unfamiliar" and 7 is "Extremely Familiar," how would you assess your familiarity with frac flowback wastewater treatment technology?

Ratings on response scales such as these are conventionally treated as quantitative measures when four or more categories are used, and have been shown to be appropriately used as interval scales in parametric statistical analysis (Baker, Hardyck, and Petrinovich 1966; Borgatta and Bohrnstedt 1980 Carifio and Perla 2007; Norman 2010; Willits, Luloff, and Theodori 2015), Velleman and Wilkinson 1993).

Although the familiarity expressed by residents differed for each of these three items, the correlations among their responses were high – ranging from 0.67 to 0.83. As a result, the scored responses to the three items were combined to form a single "Familiarity Index" for each sample member by calculating the arithmetic mean of the individual's ratings for the three items. The reliability coefficient (Cronbach's alpha) for the composite index was 0.90.

Based on the extant literature emerging around shale gas development, possible correlates of respondents' reported familiarity with hydraulic fracturing were explored. These included:

- The extent to which respondents indicated the natural gas industry and conservation/environmental groups contributed to their *familiarity* with hydraulic fracturing;
- Sociodemographic characteristics of the respondents – their gender, age, education, and income level;
- Well density in the respondent's county of residence; and
- Whether the individual responded to the survey via a telephone interview or by mail questionnaire.

For scoring/coding of these and the other variables, see Table 1.

Before conducting the analysis, interrelationships among the independent variables were examined for evidence of multicollinearity (Table 2). The correlation between the contribution of conservation/environmental groups and the natural gas industry to the respondents' familiarity with of hydraulic fracturing was positive and statistically significant, but low enough to allow for consideration of these as two separate variables ($r = 0.35$). Income was positively related to education ($r = 0.47$) and negatively correlated with gender ($r = -0.21$) and age ($r = -0.22$). The remaining correlations were all smaller than 0.20.

TABLE 1. MEASUREMENT OF VARIABLES USED IN THIS ANALYSIS.

VARIABLE	SURVEY ITEM	VALUES
Source of Info: Natural Gas Industry	Amount contributed to what you know	0 = None; 1 = Very Little; 2 = Some; 3 = Great Deal
Source of Info: Conservation/ environmental groups	Amount contributed to what you know	0 = None; 1 = Very Little; 2 = Some; 3 = Great Deal
Gender	What is your gender?	1=Male; 2=Female
Education	Highest level of education completed?	1 <= High School; 2 = High School Grad; 3 = Some College; 4 = Four-year College Degree; 5 = Education Beyond College
Age	Age in years	Actual years
Income	What was your total income (before taxes) last year?	1<= $15,000; 2=$15,000-24,999; 3=$25,000-34,999; 4=$35,000-49,999; 5=$50,000-74,999; 6=$75,000-99,999; 7=$100,000 or more
Well density	Well density in the county	1 = Fewer than 20 per 100 square mile; 2 = 20+ wells per 100 square miles
Mode	Method of data collection	1 = Mail; 2 = Telephone
Opp/Neu/Sup	Considering everything, how do you feel about natural gas extraction from the Marcellus Shale in this region?	1 = Strongly Oppose; 2 = Somewhat Oppose 3 = Neither Oppose Nor Support; 4 = Somewhat; Support; 5 = Strongly Support
NoOpin/Opin	Ditto	0 = No Opinion (category 3) 1 = Opinion (categories 1,2,4,5)
Opp/Supp	Ditto	0 = Opposed (categories 1,2) 1 = Support (categories 4,5)

TABLE 2. INTERRELATIONSHIPS AMONG THE INDEPENDENT VARIABLES IN THE ANALYSIS (N=630).

VARIABLES	SOURCE OF INFO: GAS INDUSTRY	SOURCE OF INFO: CONSERV / ENVIRON GROUPS	GENDER	EDUCATION	AGE	INCOME	COUNTY WELL DENSITY
Source of info: conserv. / environ Groups. .	.35***						
Gender	-.14***	-.03					
Education.	.02	.11**	-.08*				
Age	-.07	-.01	-.07	-.10*			
Income	.17***	.12**	-.21***	.47***	-.22**		
County well density	.13**	.03	.03	.02	-.01	.05	
Mode of data collection	.04	.03	.14***	-.12**	-.10*	-.10*	.03

NOTE: *p <= .05; **p <= .01; ***p <= .001.

The second research question asked how, if at all, the respondents' perceived familiarity with hydraulic fracturing related to their support or opposition to development of the natural gas industry in their area. The survey form asked a single item to measure this idea:

> Considering everything, how do you feel about natural gas extraction from the Marcellus Shale region?

Response categories included: (1) strongly oppose, (2) somewhat oppose, (3) neither oppose nor support, (4) somewhat support, and (5) strongly support. Responses to such Likert-type items are routinely scored from 1 to 5 and treated as a quantitative measure. Such scoring assumes a single, latent structure with opposite feelings at the endpoints. Thus, "strongly opposed" is taken as the direct opposite of "strongly support" with the middle category representing a position midway on that continuum. This 5-point scoring (called Opp/Neu/Sup) was initially used in the current analysis.

However, some methodologists have argued such 5-category response items are *bi*polar rather than *uni*polar and that choice of the middle category reflects one or more differing meanings: (1) respondents may have no opinion; (2) their feelings are "balanced" in terms of evaluation; (3) they have no clearly defined attitude; (4) they are indifferent or do not care; and/or (5) they do not understand the question (Shaw and Wright 1967; Dubois and Burns 1975; Tourangeau, Smith, and Rasinski 1997; Kulas and Stachowski 2009). From this perspective, then, the middle category would *not* simply be the midpoint on a continuum from low to high, but a *qualitatively* different idea than its adjacent categories. Therefore, it should *not* be scored *quantitatively* as lying halfway between them.

To address this concern, the current study used three complementary but separate measures. First, we used the traditional 5-category scoring of 1-to-5 with 3 in the middle. In addition, we used a measure that referenced whether the respondent expressed an opinion or not. For this dichotomous variable, the middle category ("neither oppose nor support") was taken to mean "no expressed opinion." Although respondents may have chosen this response for any of the reasons cited above (or others), they all shared a reluctance or inability to indicate a position relative to supporting or opposing the natural gas industry's development. For this variable (identified as NoOpin/Opin), the middle response category was coded "0" to mean no stated opinion; the other categories (1, 2, 4, & 5) were coded "1" to indicate that an opinion was stated.

A second dichotomous measure (Opp/Supp) applied only to respondents who stated an opinion (categories 1, 2, 4, & 5). Those who chose the middle category (3)

were omitted. The remaining responses were coded as 0=Opposed (response categories 1 & 2) and 1=Supported (categories 4 & 5).

ANALYSES

Research Question 1: To what extent do residents report they are familiar with hydraulic fracturing and how does reported familiarity differ depending upon the individuals' sociodemographic characteristics, their primary sources of information, the density of well development in their counties, and the mode of data collection?

Most respondents indicated they had little or no understanding of hydraulic fracturing. The mean score for the Familiarity Index, which combined responses to the three items dealing with familiarity with the hydraulic process, the management and disposal of frac flowback water, and wastewater treatment technology, was 3.2 on a 7-point scale with a standard deviation of 1.7. More than half of the sample had scores of 3 or less. Only one in five (20%) had scores of 5 or more.

Correlation/regression analysis was used to assess the relationships of sources of information (contribution of natural gas industry and contribution of conservation/environmental groups), respondent's gender, education, age, and income, county well density, and mode of data collection (mail vs. telephone) to respondents' reported familiarity with hydraulic fracturing. Stepwise regression reduced the original regression model until only statistically significant ($p < 0.05$) variables remained (Table 3). In the bivariate analysis, and when the other variables were controlled, by far the strongest contributor to residents' familiarity with hydraulic fracturing was information from the natural gas industry. Conservation/environmental groups were also significant contributors to residents' familiarity with fracturing, but the strength of this relationship was much lower, suggesting the latter groups were less effective in providing information to the public on the processes, management, disposal, and treatment of frac fluids than the gas industry. Men and those respondents with higher education were more familiar with hydraulic fracturing than women and those with less education. Respondents living in counties with low and high well densities did not differ significantly in their familiarity with hydraulic fracturing, and the mode of data collection (mail vs. telephone) did not significantly affect reported familiarity.

Research Question 2: How does perceived familiarity with hydraulic fracturing relate to residents' support or opposition to development of the natural gas industry in their area?

TABLE 3. REGRESSION ANALYSIS RELATING SOURCES OF INFORMATION, RESPONDENTS' SOCIODEMOGRAPHIC CHARACTERISTICS, WELL DENSITY IN THE COUNTY, AND MODE OF DATA COLLECTION TO RESPONDENTS' FAMILIARITY WITH HYDRAULIC FRACTURING (N=630).

INDEPENDENT VARIABLES	CORR	ORIGINAL MODEL		FINAL MODEL	
		b-value	β coeff.	b-value	β coeff.
Info from natural gas industry	.52***	.73***	.43	.75***	.44
Info from conserv. / environ groups	.34***	.29***	.17	.29***	.17
Gender	-.20***	-.40***	-.12	-.44***	-.13
Education	.16***	.14**	.10	.19***	.13
Age	-.05	.00	-.01		
Income	.23***	.05	.05		
Well density	.09*	.09	.03		
Mode of data collection	-.05	-.14	-.04		
Constant		1.92		1.90	

NOTE: *$p <= .05$; **$p <= .01$; ***$p <= .001$.

To address this question, three separate analyses were conducted using, in turn, the three measures of opposition vs. support discussed above. For all three analyses, controls for the reported contributions of the natural gas industry and conservation/environmental groups to the individual's familiarity, respondent's gender, education, age, and income, well density of the county, and mode of data collection were used.

For the first of these analyses (Table 4), the dependent variable (Opp/Neu/Supp) was scored: 1=strongly oppose, 2=somewhat oppose, 3=neither oppose nor support, 4=somewhat support, 5=strongly support; Opp/Neu/Supp was treated as a quantitative measure. The relationship of respondents' familiarity with hydraulic fracturing was not significantly related to views about gas drilling when the control variables were included in the model, and even in the bivariate case, the correlation (although statistically significant) was weak (r = 0.10). Based on this analysis, then, one cannot conclude that perceived familiarity with hydraulic fracturing is related to one's feelings of support or opposition to drilling.

For the second analysis, the dependent variable assessed only whether the respondent had an opinion about gas well drilling or not (NoOpin/Opin). Here, those who indicated they "neither opposed nor supported" drilling (response code 3) were coded as 0; those who had an opinion, either opposing or supporting drilling (response categories 1, 2, 4, 5) were coded as 1 (Table 5). In this analysis, the

TABLE 4. MULTIPLE REGRESSION ANALYSIS RELATING FAMILIARITY WITH HYDRAULIC FRACTURING, SOURCES OF INFORMATION, SOCIODEMOGRAPHIC CHARACTERISTICS, WELL DENSITY IN THE COUNTY AND MODE OF DATA COLLECTION TO THE FIVE CATEGORY VARIABLE MEASURING OPPOSITION OR SUPPORT OF MARCELLUS GAS DRILLING (Opp/Neu/Supp) (N=630).

INDEPENDENT VARIABLES	CORR	ORIGINAL MODEL b-values	ORIGINAL MODEL β coeff.	FINAL MODEL b-values	FINAL MODEL β coeff.
Familiarity Index . . .	.10**	.01	.01		
Info from natural gas industry	.21***	.30***	.24	.31***	.24
Info from conserv / environ groups . .	-.17***	-.35***	-.27	-.35***	-.27
Gender	-.20***	-.40***	-.15	-.38***	-.15
Education.	-.04	-.11*	-.10	-.11*	-.10
Age	.06	.01**	.10	.01*	.10
Income	.16***	.13***	.18	.13***	.18
County well density	.13**	.27**	.10	.27**	.11
Mode of data collection	.03	.16	.06		
Constant.		2.73		3.01	

NOTE: *p <= .05; **p <= .01; ***p <= .001.

Familiarity Index was significantly related to respondents' answers both in the bivariate case and when control variables were introduced into the model. The greater the respondents' perceived familiarity with hydraulic fracturing, the more likely they were to express an opinion. Age and education were also both positively related to the individual's likelihood of reporting an opinion. Further, the more respondents reported the natural gas company contributed to what they knew about fracturing, the more likely they were to have formed an opinion. Contribution to familiarity by conservation/environmental groups had no significant relationship to opinion formation.

The third analysis omitted subjects who did not express an opinion on how they felt about drilling (i.e., those indicating they "neither opposed nor supported" drilling). The remaining cases were classified as "opposed" (respondents who indicated they "strongly opposed" and those who were "somewhat opposed" were coded as 0). Those who reported they "somewhat supported" or "strongly supported" drilling were coded as 1 (Table 6). The Familiarity Index was not statistically related to whether respondents opposed or supported drilling. In the final model, the following relationships were found:

TABLE 5. LOGISTIC REGRESSION ANALYSIS RELATING FAMILIARITY WITH HYDRAULIC FRACTURING, SOURCES OF INFORMATION, SOCIODEMOGRAPHIC CHARACTERISTICS, WELL DENSITY IN THE COUNTY AND MODE OF DATA COLLECTION TO WHETHER OR NOT RESPONDENTS' STATED AN OPINION IN REGARD TO OPPOSITION/SUPPORT FOR NATURAL GAS DRILLING (NOOPIN/OPIN) (N=630).

		LOGISTIC REGRESSION ORIGINAL MODEL		LOGISTIC REGRESSION FINAL MODEL	
INDEPENDENT VARIABLES	CORR	b-value	Odds Ratio	b-value	Odds Ratio
Familiarity index . . .	.20***	.26**	1.30	.27**	1.31
Info from natural gas industry	.18***	.29	1.34	.32*	1.38
Info from conserv / environ groups . .	.11**	-.01	1.00		
Gender	-.09*	-.21	.81		
Education.	.11**	.23	1.25	.24*	1.27
Age	.09*	.02*	1.02*	.02*	1.02
Income	.12**	.04	1.04		
Well density	.11**	.16	1.18		
Mode of data collection	.01	.32	1.38		
Constant.		-1.65		-1.09	

NOTE: *$p <= .05$; **$p <= .01$; ***$p <= .001$.

- The more the natural gas industry contributed to the person's familiarity of fracturing, the more likely the individual was to support natural gas drilling;
- The more respondents indicated conservation/environmental groups contributed to their familiarity of fracturing, the less likely they were to support drilling;
- Men were more likely than women to support drilling;
- Education was negatively related but income was positively associated with support for drilling;
- Respondents living in areas with high well densities were more supportive than those living in areas with lower well densities; and,
- Subjects who answered mailed questionnaires did not differ significantly from those who participated in telephone interviews in terms of support or opposition to drilling.

TABLE 6. LOGISTIC REGRESSION ANALYSIS RELATING FAMILIARITY WITH HYDRAULIC FRACTURING, SOURCES OF INFORMATION, SOCIODEMOGRAPHIC CHARACTERISTICS, WELL DENSITY IN THE COUNTY AND MODE OF DATA COLLECTION TO WHETHER RESPONDENTS OPPOSED OR SUPPORTED NATURAL GAS DRILLING (OppSupp) (N=536).

		LOGISTIC REGRESSION ORIGINAL MODEL		LOGISTIC REGRESSION FINAL MODEL	
INDEPENDENT VARIABLES	CORR	b-value	Odds Ratio	b-value	Odds Ratio
Familiarity index . . .	.02	-.06	.94		
Info from natural gas industry	.14***	.53***	1.70	.49***	1.64
Info from conserv / environ groups . .	-.20***	-.67***	.51	-.68***	.51
Gender	-.17***	-.67**	.51	-.62**	.54
Education.	-.07	-.22*	.80	-.24*	.79
Age	.09*	.02*	1.02	.02*	1.02
Income	.12**	.24***	1.28	.24***	1.27
Well density	.11**	.54*	1.72	.54*	1.71
Mode of data collection	.01	.24	1.27		
Constant.		-.29		-.02	

NOTE: *$p <= .05$; **$p <= .01$; ***$p <= .001$.

DISCUSSION

What substantive findings can be drawn from these data? First, although the overall level of familiarity with hydraulic fracturing among residents was low, there was some variation—with about one in five respondents having Familiarity Index scores of 5.0 or more on a 7-point scale. Familiarity level was most strongly related to the extent to which respondents indicated they received their information from the natural gas industry. Contributions to such understanding from conservation/environmental groups, while also statistically significant, paled in comparison to the effect of that of the gas industry. Such a finding suggests the industry has been somewhat effective in providing information about the hydraulic fracturing process and the management, disposal, and possible uses of flowback waters in convincing the public the process is safe. Conversely, conservation/environmental groups may be more likely to focus on situations where the planned or ideal processes failed and to underscore the risks of drilling. It also seems likely that the money and resources devoted by the gas industry to public education may far outweigh that available for conservation/environmental

groups. Whatever the reason, these data indicate the contributions of the gas industry to residents' familiarity with hydraulic fracturing outpaced those from conservation/environmental groups.

Furthermore, familiarity with hydraulic fracturing was related to whether respondents stated an opinion concerning their opposition to or support of drilling, but it was not related to what the opinion was. Thus, the higher the perceived familiarity with hydraulic fracturing, the less likely respondents were to indicate they "neither opposed nor supported" natural gas extraction and the more likely they were to state an opinion. However, among those who stated an opinion, the degree of perceived familiarity with fracturing was not significantly related to whether they opposed or supported drilling.

There were also differences between how other factors related to having an opinion or not and those associated with opposition vs. support of drilling. The amount of familiarity obtained from gas industry sources was positively related to the likelihood of respondents stating an opinion, while the amount of familiarity obtained from conservation/environmental sources had almost no relationship to whether or not respondents expressed an opinion. However, among respondents who had an opinion, those reporting the natural gas industry contributed to their familiarity were more likely to support drilling. On the other hand, those reporting conservation/environmental groups contributed to their familiarity were more likely to oppose drilling. Whether the information obtained from these different sources convinced respondents to choose their position or whether they selectively sought information related to pre-existing opinions could not be determined with the present data, although it seems likely both occurred.

Men and women did not differ in the likelihood of having an opinion, but among respondents who did, women were more likely than men to oppose drilling. As respondents' educational levels increased, they were increasingly more likely to have stated an opinion and were more likely to oppose drilling. Older people were more likely than their younger counterparts to state an opinion and support drilling. Well density in the county was not significantly associated with whether or not respondents stated an opinion, but of those who stated an opinion, those living in high well-density counties were more likely than those in counties with low well density to support drilling. There were no significant differences in responses related to mode of data collection.

Beyond providing insights into the correlates of respondent views of hydraulic fracturing and natural gas drilling, this analysis contributes to broader methodological research issues. First, these findings suggest that, when dealing with responses to 5-category Likert-type items, it may be meaningful, as posited by Willits, Theodori, and Luloff (2015), to treat the middle category as a qualitatively different idea meaning "no stated opinion" rather than as a midpoint on a

quantitative scale. Doing so will allow for assessment of whether the factors associated with reporting an opinion or not differed from those related to the nature of the stated opinion. Given the widespread use of 5-category Likert-type items, researchers could reexamine their analysis of similarly formatted items to assess whether such differences are found in other domains. As well, different question formats could be developed to address the meaning of "no opinion." A lead question asking whether respondents have an opinion, followed by a second item dealing with the basis of a no-opinion response – "not interested," "have mixed feelings," "don't know anything about it" – could help clarify the meaning of this answer. Clearly, more information is needed if researchers are to disentangle the meaning of "no opinion" in attitudinal research studies.

A second methodological issue addressed in the current study concerned the issue of whether findings of answers to opinion questions differed for data obtained via mail or telephone surveys. Previous analysis of information from this data set found significant mode differences in the responses to many items on the survey, including all of the variables used in the current analysis *except* the 5-category Likert item dealing with support/opposition to development (Willits, Luloff, and Theodori 2013b, 2014). However, the previous analysis did not explore whether these mode effects on individual items would seriously affect their overall *relationships* to other variables. In that context, we suggested:

> Analysis … of data would be improved by the inclusion of "survey mode" as a control variable. Such a procedure not only would minimize the impact of mode differences on conclusions but also could contribute to the accumulation of research findings related to the incidence and nature of possible mode effects in surveys (Willits, Luloff, and Theodori 2014:1357).

Accordingly, we incorporated "mode" into the current analysis. In no case was mode significantly related to the dependent variables either bivariately or in the multivariate predictive models. In addition, separate analyses (data not reported here) were conducted to determine if the observed *relationships* of the remaining predictor variables differed depending upon whether the data were collected by mail or telephone. The results for the subsorted data were similar to those for the total sample, indicting there was no evidence of an interactive effect of mode and any of the other predictor variables on the dependent variables considered here.

CONCLUDING COMMENTS

In short, the purpose of this paper was to add to the emerging sociological literature surrounding issues associated with shale gas development and hydraulic fracturing. The production of shale gas and, concomitantly, the use of hydraulic

fracturing have greatly increased over the past decade. So too have the debates – both pro and con – and the anti-drilling/anti-fracking grassroots social movements. Our findings in this survey of Pennsylvania residents on self-reported familiarity of hydraulic fracturing essentially mirror the findings from recent national survey data (Boudet et al. 2014). Similar to Americans overall, members of the public living in the Marcellus Shale region of Pennsylvania are not overly familiar with the process of hydraulic fracturing. Unlike the findings at the national level, though, self-reported familiarity was not a clear predictor of opposition to natural gas development in the Marcellus Shale. Instead, these data suggest that – at least in Pennsylvania – certain sociodemographic factors are essential indicators of support/opposition. Future studies examining these and other sociodemographic measures, as well as additional studies on the factors associated with self-reported familiarity of hydraulic fracturing are warranted to decipher what Boudet et al. (2014: 65) aptly termed " . . . a complex portrait of the nation's perceptions of, and attitudes towards, unconventional oil/gas development using hydraulic fracturing,"

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