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POPULATIONS AT RISK ACROSS THE LIFESPAN: POPULATION STUDIES

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Noise concerns of residents living in close proximity to hydraulic fracturing sites in Southwest Pennsylvania

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Abstract

Objective: Noise associated with nontraditional gas industry (NTGI) sites (e.g., hydraulic fracturing well pads, compressor stations, processing plants) may create disturbances and anxiety in rural populations. This study evaluated levels of concern among residents of Southwestern Pennsylvania residing near NTGI sites.

Design: Noise measurements were collected inside and outside residences, and surveys were administered to residents.

Results: Daytime instantaneous sound levels ranged between 45.0 and 61.0 dBA. Dosimeter studies recorded day–night levels (L_{dn}) of 53.5–69.4 dBA outside and 37.5–50.1 dBA inside, exceeding United States Environmental Protection Agency guidelines. Respondents indicated the NTGI noise disturbed their sleep, and the majority of respondents (96%) reported being worried about their overall health as a result of the noise.

Conclusions: Health care professionals serving rural areas impacted by hydraulic fracturing (fracking) should be aware of potential noise stressors on the populations they serve.

KEYWORDS
fracking, hydraulic fracturing, noise, rural health concerns

1 | BACKGROUND

Hydraulic fracturing, or "fracking," have become common words to rural Pennsylvanians and others situated on top of the Marcellus shale natural gas field formation. Although common, the words (and industry) are not always well received. For example, New York state has banned fracking altogether, citing health risks (Kaplan, 2014), and Maryland has a moratorium on fracking in place. However, Pennsylvania, Ohio, and West Virginia have welcomed the industry. Between 2004 and 2016 in Pennsylvania alone, the industry has developed more than 9,000 well sites (Bradwell, 2016), mostly in the southwestern and northeastern regions ("Pennsylvania Frack Wells," n.d.). One report predicted between 7,000 and 16,000 new sites in the state by 2030 (Johnson et al., 2010).

Fracking, used to access oil and natural gas trapped in shale rock, is known as an "unconventional" or "non-traditional" form of gas development. It entails injecting large volumes of a water, sand, and chemical compound mixture into a drilled well at high pressure in order to break up the shale rock and release natural gas. Because of this injection process and the noise associated with the drilling and processing of the shale rock, two areas of concern surround nontraditional gas industry sites: the contamination of the water, soil, and air caused by the injection process, and the high levels of noise generated by the development and drilling process.

1.1 | Water, soil, and air contamination

Researchers have been studying effects of nontraditional gas industry activities on air quality (Brown, Lewis, & Weinberger, 2015; Colborn, Schultz, Herrick, & Kwiatkowski, 2014; McKenzie, Witter, Newman, & Adgate, 2012; OSHA & NIOSH, 2012), soil quality (Finkel, Hays, & Law, 2013), and water quality (Osborn, Vengosh,

Warner, & Jackson, 2011; Vengosh, Warner, Jackson, & Darrah, 2013) for several years. Radioactive contaminants, gas seepage, hydrocarbons, heavy metals, benzene, toluene, diesel fuel, and radon gas have all been identified in air, soil, and water samples collected throughout many fracking sites (Finkel et al., 2013). People living within 0.8 km (1/2 mile) of a well site are at greater risk for health effects, including benzene-related cancers and neurologic, respiratory, hematologic, and developmental problems (McKenzie et al., 2012). Asthmatics in close proximity to active well sites are 1.5–4 times more likely to experience an attack (Rasmussen, Ogburn, McCormack, Casey, Bandeen-Roche, Mercer, & Schwartz, 2016). An increase in newborn health problems has also been associated with proximity to fracking sites (McKenzie et al., 2014).

1.2 | Noise generation

The fracking process can be divided into two main phases: well development (which involves drilling and fracturing) and production. The development phase is noisier than production, with the majority of fracking noise occurring within the first 50–100 days. This is from access road construction, well pad preparation and construction, drilling and fracturing processes, and the increased traffic to and from the well site. Up to 2,000 truck trips are required during the first year of a well's operation, not including the removal of fuel (Dobb, 2013). For access road construction, New York state estimated truck and equipment noise levels in the range of 57 dBA at 610 m (2000 ft), up to 89 dBA at 15 m (50 ft). The well pad preparation and construction noise estimates ranged from 52 dBA at 610 m up to 84 dBA at 15 m. Estimated noise levels at the well site ranged from 44 dBA at 610 m up to 76 dBA at 15 m for the drilling process and 72 dBA at 610 m up to 104 dBA at 15 m for the pumper trucks (New York State Department of Environmental Conservation, 2011).[1]

People living near well pads, compressor stations, and processing plants are exposed indirectly to the noise created by the heavy earth-moving equipment used to shape the site, and to the noise created by any additional equipment needed for placing and operating the drilling rig. The drilling rig noise is usually created by diesel engines; noise will fluctuate depending on the engine speed and load. As drill pipe is placed into the wellbore for the tubular preparation and cleaning processes, noise levels increase. As more pipe is connected, the release of air pressure continues to generate intense noise.

But engine and equipment noises are not the only cause of industrial noise in this case. Anecdotal reports from residents living around well pads and compressor stations indicate that 2–3 hr "blow-downs" are primary concerns for noise, that is, the processes by which solids or liquids are removed from a pipe using pressure. Blow-downs occur when a gas pipeline is taken offline for maintenance, in the event of emergencies, or to accommodate fluctuating demand (Hamilton, 2017; Transcanada, 2005). The *Generic Environmental Impact Statement* (GEIS) acknowledged that "construction of well pads and wells associated with high-volume hydraulic fracturing will result in temporary, but adverse, impacts relating to noise." (New York State Department of Environmental Conservation, 2011).

Although the development phase of fracturing is noisier, the processing phase is also loud. Well pads often have multiple wells on one site, so drilling may be extended over several months. Multiple well sites feed into compressor stations and processing plants; these are a less noisy but constant source of noise for decades. For example, 11 West Virginia homes located near compressor stations exceeded United States Environmental Protection Agency (USEPA) and World Health Organization (WHO) day–night guideline levels (Boyle, et al., 2017).

1.3 | Health concerns from fracking noise

Health symptoms and stressors specifically associated with hydraulic fracturing (Ferrar et al., 2013) are skin, digestive, upper respiratory, and central nervous system symptoms. The most frequently described symptom was "stress," while a "concern for health" was the predominant stressor (Ferrar et al., 2013). In addition to noise pollution, additional stressors include fear of information withholding or falsification, fear of having complaints/concerns ignored, and the feeling that corruption was occurring (Ferrar et al., 2013).

Noise and vibrations have documented negative health effects, including high blood pressure, low birth weights, birth defects, annoyance, anxiety, stress, emotional instability, argumentativeness, increase in social conflicts, neurosis, hysteria, and psychosis (Belojević, Jakovljević, Stojanov, Slepcević, & Paunović, 2008; Berglund, Lindvall, & Schwela, 1999; Stansfeld & Matheson, 2003). Although a recent study of 4,548 participants did not associate self-reported occupational noise exposure to blood pressure problems (Gan & Mannino, 2018). However, much of this research concerns airport, traffic, and other industrial noise. To date, the health-related concerns associated with fracking noise have not been thoroughly investigated, with most estimates in the form of extrapolations, algorithms, or construction noise models (New York State Department of Environmental Conservation, 1992, 2011).

1.4 | Regulatory agencies and noise recommendations

The Pennsylvania Oil and Gas Act (Act 223) requires that compressor stations and processing plants have a setback distance of 229 m (750 ft). The Act also requires that noise not exceed an instantaneous sound level of 60 A-weighted decibels (dBA) at the nearest property line. The setback distance is 152 m (500 ft) from existing buildings or water wells, unless the owner grants consent (Ellis, Reed, Scarnati, & White, 2011). To avoid sleep disturbances, the WHO recommends indoor noise levels in sleep areas to be below 30 dBA averaged over

[1]For reference purposes, noise levels produced by a normal conversation or dishwasher are recorded around 60 dB, while noise levels produced by a lawn mower or leaf blower are recorded around 90 dB. Sound measured from the environment is "A-weighted," thus noises are reported as "dBA" and account for the way in which the ear responds to different frequencies of sound.

the 8 hr of night (L_{Aeq}) with continuous maximum level (L_{Amax}) limited below 45 dBA for single sound events. Daytime indoor levels should be limited to L_{Aeq} of 35 dBA, and outdoor daytime levels to 55 dBA for serious annoyance or 50 dBA for moderate annoyance averaged over the 16 hr of daytime and evening (Berglund et al., 1999). The USEPA recommends that a 24-hr equivalent level ($L_{eq(24)}$) should be ≤70 dBA to prevent hearing loss, and a day–night level (L_{dn}) should be ≤55 dBA for outdoor activity or ≤45 dBA for indoor residential areas (USEPA, 1974). Day–night levels are 24-hr equivalent levels with a "penalty" of 10 dB added to levels measured at night between 22:00 hours (10:00 pm) and 07:00 hours (7:00 am).

1.4.1 | Research question

This study measured sound pressure levels in neighborhoods adjoining hydraulic fracturing well pads, compression stations, and processing plants in Southwest Pennsylvania, and residents in those areas were surveyed on hearing and health concerns. The sound levels and survey responses were used to probe for perceived health effects and perceptions from the fracking noise generated in those locations. This research is the first to look at actual noise levels (not modeled levels or algorithms) and perceived impacts on rural communities when regulations do not challenge or prevent nontraditional gas industry development in a specific area.

2 | METHOD

2.1 | Design

Sound level data (using sound level meters and dosimeters) and survey responses were collected from residential areas north and south of Pittsburgh, Pennsylvania. The residents were identified and recruited by three sources: employees at the Southwest Pennsylvania Environmental Health Project (SWPA-EHP), a nonprofit health organization; members of Moms Clean Air Force, a concerned citizens' group based near Pittsburgh; and an employee with the Oil and Gas Accountability Project of Earthworks, a New York-based nonprofit organization dedicated to protecting the environment from adverse impacts caused by mineral and energy development. The study was conducted with the approval of the Indiana University of Pennsylvania Institutional Review Board, protocol 14-097. Sound measurements and survey collection occurred from February 2014 until July 2016.

2.2 | Sample

Three locations were sampled. Participants lived near a well pad in Finleyville, southeast of Pittsburgh, in a neighborhood adjacent to a well pad in Valencia, northeast of Pittsburgh, and around a compressor station and processing plant in the Yellow Creek/Evans City area, north of Pittsburgh. All surveys were self-administered in paper and pencil format (see Data S1 for complete survey form). There were eight Likert scale questions (Q1-Q8), 13 yes/no questions, and 12 perception questions (N1-N12) participants were asked to place an "X" next to if the statement applied to them.

Twenty-four surveys were returned; one was removed from the study due to the resident's extended distance from the well pad (>2.2 km) for a total sample of 23. The number of surveys distributed from 2014 through 2016 is unknown; therefore, a response rate cannot be calculated.

2.3 | Noise measures

Sound pressure levels were measured in all three neighborhoods using two sound level meters: a SoundTrack LxT (Larson Davis) and the SoundMeter+ App on an iPhone. In the Valencia and Yellow Creek/Evans City locations, Edge eg4 dosimeters (3M-Quest) were added to measure noise levels for 64± hr time intervals. The sound measurements were taken for 1-min intervals at various locations in neighborhoods near the well pad, processing plant, and compressor station. The dosimeters measure sound levels over the course of the 1-min period, then calculate and record the average equivalent level during the minute (L_{eq}). The dosimeters also have a floor of 62 dBA. Therefore, the minute-by-minute data was reviewed and levels at the noise floor were replaced by an assumed 0 dBA. The noise floor correction of averaging 0 dB for those minutes below the floor would allow the calculated value to be below the noise floor of 62 dBA, but the calculation would likely underestimate the actual sound level. In the end, the calculated values should be assumed to be at least that high. Also, 10 dB was added to each minute L_{eq} within the 22:00–07:00 hours time zone as the nighttime penalty for day–night levels, and then the L_{dn} calculated across 24 hr periods. Measurement sites were located within yards in which a family may routinely play, complete yard work, or enjoy the outdoors (e.g., next to porches, pools, and/or sheds). Sound level measurements were taken in 13 separate locations throughout the three neighborhoods, but dosimeter measures were taken in only four separate locations throughout two of the neighborhoods (no dosimeter readings were taken in Finleyville).

3 | RESULTS

Participants consisted of 8 males and 15 females, aged 29–67 (average = 53.8) years who lived 151 m to 2.2 km from the site for 4 months to 200 months (average = 59 months). Table 1 summarizes the demographics of the participants.

Instantaenous sound levels measured outside in the Yellow Creek/Evans City neighborhoods near the compressor station and processing plant ranged from 48.3 to 56.0 dBA with the sound level meters, all during daylight hours. Dosimeter studies in those areas produced calculated day–night levels (L_{dn}) of 53.5–69.4 dBA outside and 50.1 dBA inside one residence.

The instantaneous measured outside daylight hours sound levels in the Valencia and Finleyville neighborhoods near the pad were

TABLE 1 Participant demographic descriptive statistics

Particpant demographic	Question wording	*M*	*SD*	Range
Age	Age in years	53.83	9.32	29–67
Gender	8 = male (35%), 15 = female (65%)			
Distance	Your approximate distance from the well site: _____ yards (converted to meters)	504.39	535.51	151–2,287
Time	The length of time you have been living with the well site in place _____ (converted to months)	59.05	63.92	4–200

48.4–56.5 dBA, and 45.0–61.0 dBA, respectively. Dosimeter studies completed in the Valencia neighborhood produced calculated day–night levels (L_{dn}) of 57.3–61.5 dBA outside and 37.5–42.3 dBA inside one residence. Table 2 summarizes results of noise surveys. Measurements from all outside areas had at least some levels exceeding the USEPA recommended L_{dn} limits of 55 dBA for outside noise. One measurement from inside a residence near the compressor station exceeded the recommended L_{dn} limit of 45 dBA for noise measured inside homes (USEPA, 1974).

Figure 1 illustrates the fluctuation in noise levels over a 2-day period. Residents reported this fluctuation in noise levels as being particularly bothersome. The fluctuations are greater than those typically experienced in rural areas.

3.1 | Noise concerns

Likert questions Q1 (bothered) and Q4 (sleep disturbed) were related to the noise experienced by participants in their neighborhoods and homes. The majority (*n* = 13; 57%) were bothered "a great deal" by the noise, and the majority (*n* = 12; 52%) indicated their sleep was disturbed "a great deal" by the noise. When asked to place an "X" next to a series of applicable statements, most respondents (*n* = 16; 70%) indicated that they found the noise "extremely bothersome," but few (*n* = 2; 9%) felt the noise was "not very bothersome." Likewise, many (*n* = 16; 70%) considered the noise damaging to their health, many (*n* = 15; 65%) considered it dangerous to their family's health, and many (*n* = 18; 78%) reported it disturbing their sleep. At the extreme perception, some of the respondents (*n* = 5; 22%) felt it was "the loudest noise I have ever experienced." Only a few of the respondents (*n* = 2; 9%) described it as "not very loud" and "not a problem." This was supported by a similar number (*n* = 3; 13%) describing it as "not too loud" (Table 3). Age was correlated with being bothered by noise, with older respondents more likely to be annoyed. Also, distance to the site was negatively correlated to noise disturbing sleep, so that folks living closer were more likely to be disturbed. Lastly, time living near the site was negatively correlated to noise disturbing sleep. This suggests that the more recent intrusion of noise was more disturbing to sleep.

3.2 | Health concerns

Likert question Q7 stated, "I believe that my overall health is being affected by the noise created by the well site near my home," and the majority (*n* = 15; 65%) believed their overall health was being affected by the noise, with about half of those respondents (*n* = 11; 48%) believing it "a great deal."

Additionally, when asked about their health concerns with different formats of questioning, respondents consistently reported concern. An overwhelming number of respondents (*n* = 22; 96%) responded "Yes" to "Since people have begun preparing and working on the well site near my home, I have worried about my health." A majority (*n* = 19; 83%) also reported noticing changes in their health, and more than half (*n* = 13; 57%) self-reported having been diagnosed with health problems during that same time (Table 4). Many respondents (*n* = 15; 65%) indicated they felt the noise was "dangerous to my family's health," and similar numbers (*n* = 16; 70%) indicated they thought the noise "damaging" to their own health (N8 and N9 in Table 3).

TABLE 2 Noise survey results from the three locations

Location and noise source	Outside daylight instantaneous noise levels (dBA)	Outside day–night levels (L_{dn}, dBA)	Inside day–night levels (L_{dn}, dBA)
Valencia, PA (well pad)	48.4–56.5	57.3–61.5	37.5–42.3
Finleyville, PA (well pad)	45.0–61.0		
Yellow Creek/Evans City, PA (processing plant)	48.3–56.0	53.5–69.4	50.1
USEPA limits		≤55	≤45

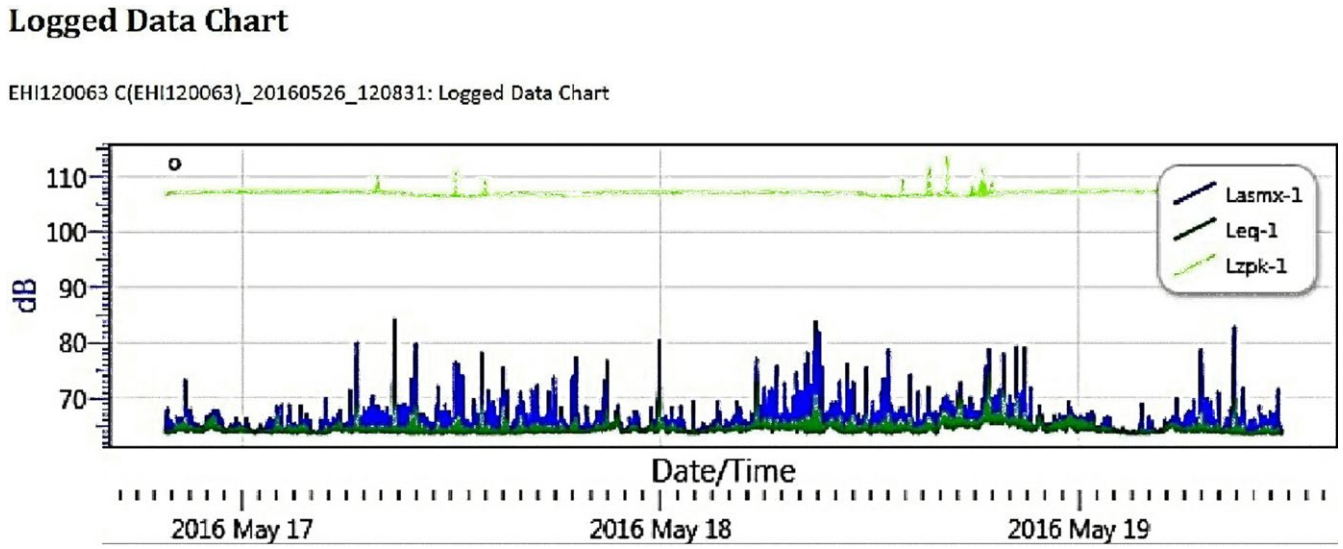

FIGURE 1 Example noise dosimetry data taken outside a residence [Color figure can be viewed at wileyonlinelibrary.com]
Notes. $L_{asmx\text{-}1}$ denotes the maximum measured sound level, in A-weighted decibels, on slow response settings, for a given minute. $L_{eq\text{-}1}$ denotes the equivalent sound level (the average) in dBA, on slow response settings, for the given minute. $L_{zpk\text{-}1}$ denotes the peak (highest) instantaneous sound level, in unweighted (Z-weighted) decibels, and independent of time response settings.

Only one item on this survey addressed "safety" concerns (see S1). One "Yes/No" statement asked, "Since people have begun preparing and working on the well site near my home, I have worried about my safety." Although this safety concern cannot be linked directly to the noise around the well site, most respondents (*n* = 20; 87%) had a concern for overall safety.

3.3 | Hearing concerns

Likert question Q8 stated, "I believe that my hearing is being affected by the noise created by the well site near my home," and about a third of the respondents (*n* = 8; 35%) believed their hearing was not being affected by the noise at all. Only a few respondents (*n* = 3; 13%) were concerned "a great deal." Hearing concerns were positively correlated to being bothered by people and health concerns, but not to being bothered by noise or having sleep disturbed by noise. These results were supported with alternate format survey items. Only a quarter of the respondents (*n* = 6; 26%) considered the noise "damaging to my hearing" (N4 in Table 3). Also, an equal number (*n* = 11; 48%) reported being worried about their hearing as did those who reported not being worried about their hearing (Table 4). A majority of respondents had not noticed hearing changes (*n* = 15; 65%) or been diagnosed with hearing loss (*n* = 20; 87%).

4 | DISCUSSION

The health-related concerns associated with higher noise levels caused by the fracking process are relatively unstudied and often anecdotal in nature. There are several possible reasons for this:

TABLE 3 Participant response rates to "I consider the noise created by the well site near my home as…"

Survey identifier	Statement	Response rate
N1	"not very bothersome."	9% (2/23)
N2	"the loudest noise I have ever experienced."	22% (5/23)
N3	"not very loud."	9% (2/23)
N4	"damaging to my hearing."	26% (6/23)
N5	"pleasant to listen to."	0% (0/23)
N6	"disturbing to my sleep."	78% (18/23)
N7	"not too loud."	13% (3/23)
N8	"dangerous to my family's health."	65% (15/23)
N9	"damaging to my health."	70% (16/23)
N10	"not a problem."	9% (2/23)
N11	"not as bothersome as the lights."	4% (1/23)
N12	"extremely bothersome."	70% (16/23)

1. People may accept the increased noise of technologically advancing society as a necessary evil.
2. Society may ignore environmental noise the way tobacco use was ignored in the 1950s (Goines & Hagler, 2007).
3. Many factors affect environmental noise levels. Distance from well pad to homes, schools, offices, and other living areas decreases the noise levels. Background noise masks the fracking noise. Also, large outdoor spaces, atmospheric pressure, relative humidity, topography, and vegetation affect sound levels (Driscoll, Stewart, & Anderson, 2000).

TABLE 4 Percentages of responses to the health statements in the "Yes/No" section of the survey when asked to complete the statement "Since people have begun preparing and working on the well site near my home…"

Statement	Yes	No
I have worried about my health.	96% (22/23)	4% (1/23)
I have noticed changes in my health.	83% (19/23)	17% (4/23)
I have thought about going to a physician because of changes in my health.	74% (17/23)	26% (6/23)
I have gone to my doctor because of changes in my health.	52% (12/23)	48% (11/23)
I have been diagnosed with health problems.	57% (13/23)	43% (10/23)
I have worried about my safety.	87% (20/23)	13% (3/23)
I have worried about my hearing.**	48% (11/23)	48% (11/23)
I have noticed changes in my hearing.	35% (8/23)	65% (15/23)
I have noticed ringing or other noises in my ears.**	52% (12/23)	43% (10/23)
I have noticed dizziness and/or loss of balance.**	39% (9/23)	52% (12/23)
I have thought about going to an audiologist or hearing specialist because of changes in my hearing.**	26% (6/23)	70% (16/23)
I have gone to a hearing specialist because of changes in my hearing.	13% (3/23)	87% (20/23)
I have been diagnosed with hearing loss.	13% (3/23)	87% (20/23)

Asterisks (**) indicate not all respondents gave an answer to all items.

4. The health-related problems associated with noise created by fracking may seem diminished, since actual hearing loss may not be associated with the community noise around well pads. Air, ground, and water pollution may seem more "urgent" for exposed persons than noise pollution.

A key component of residents' perception of concerns for noise seems to be the change in environmental noise due to an identifiable source. The USEPA presented information on levels of annoyance and attitudes in communities for noise in the environment. Driscoll et al. (2000) summarized the information into table format. For instance, the typical background L_{dn} levels range from 35 to 50 dBA in rural areas and 50–55 dBA in suburban areas. Unexpected noise events, or a change in background noise, can cause anxiety in residents. In fact, an increase of more than 5 dBA will tend to cause "many complaints," an increase of 14 dBA "Threat of legal action," and an increase of 21 dBA "Vigorous reaction." Figure 1 illustrates changes of greater than 5 dBA over a relatively short period of time.

This study did not collect background environmental noise levels in the residents' areas before energy industry operations began, so it is difficult to assess the residents' concerns compared to the change in objective noise measurements. However, day–night sound pressure levels of the ambient outdoor noise conditions obtained in the three neighborhoods (53.5–69.4 dBA) exceeded the typical levels listed in Driscoll et al. (2000) for both rural and suburban areas. It is of interest that instantaneous measurements taken during the day in December 2015 of 48.4–56.5 dBA indicated the Valencia neighborhood ambient noise near the well pad during development was above suburban levels, as well. The time history of the dosimetry day–night levels showed numerous repeated and randomly timed noise level excursions of 70 dBA up to 85 dBA. This would be a noteworthy change in ambient background noise, such as the instantaneous readings of 48–56 dBA.

Overall, health concerns outweighed hearing concerns in the group of respondents for the current study. As indicated within the survey responses, the noise experienced by many of these participants was bothersome, disruptive, and worrisome. Also indicated by these respondents was the fact that noise concerns outweighed concerns about lighting and the presence of workers. These results corroborated reports in the Ferrar et al. (2013) study. In that study, 45% of the original 33 participants reported noise pollution as a stressor (Ferrar et al., 2013).

The results of this study must be taken with consideration of underlying limitations. First is the small sample size (n = 23). The survey questionnaire was pilot tested and feedback incorporated, but not evaluated for reliability. Also, the survey was sent out to groups of individuals already concerned about the impacts from hydraulic fracturing activities. Several residents were unwilling to complete the survey, citing renting concerns, preconceived beliefs that their concerns would not be heard, disagreements with neighbors, ongoing legal battles between residents and gas companies, etc. The collected noise samples were biased, convenience samples obtained on public property or where residents allowed the collection of measurements. Finally, the dosimeters used for measuring sound had an artificial "floor" as explained in the methods section, in which noise levels could not be recorded below 62 dBA. The actual calculated L_{dn} levels seen in dosimeter recordings would have been greater had the equipment been able to measure levels below 62 dBA. Regardless of these limitations, the research suggests that residents are concerned about the impacts of fracking noise to their health.

4.1 | Future research and implications

The presence of nontraditional gas industry activities in and around residential areas has been, and will continue to be, of concern to many. This study has the potential to provide results that public health nurses, future investigators, and prospective homeowners may find useful. These results should lead to further investigation involving more specific sound measures and survey questions. While this current research is limited in scope (by a small, select sample size, as well as equipment measurement limitations) the results clearly show the need for more research on the effects of noise in communities affected by nontraditional gas industry operations, and any synergistic effects resulting from the combination of noise exposure and other pollutants. Coordinated efforts are needed for the further evaluation of environmental impacts and health consequences resulting from increased noise levels, as well as consideration of regulations and community recommendations for control and abatement. Public health nurses serving rural communities impacted by fracking should consider adding questions related to noise concerns to patient interviews. Specific attention should be given to questioning regarding changes in sleeping patterns, changes in mood, feelings of anxiety or stress. Nurses should also watch for, and explicitly ask about, indicators of stress-related health outcomes in areas near nontraditional gas industry sites. Cases involving hypertension should be explored more fully. Nurses should note unexpected changes in blood pressure, heart rate, or pulse amplitude with no physiological explanation. Appropriate referrals should be made for patients exhibiting psychological impact.

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None.

DISCLAIMER

This document is the work of the authors and does not represent the position of the United States Department of Defense or the United States Air Force.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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