An Environmental Scan of Community Noise Ordinances to Inform a Noise Code Framework

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Abstract

Noise exposure is an environmental health problem that affects millions in the United States and even more across the globe. Since the defunding of the U.S. Office of Noise Abatement and Control, local and state governments are tasked with the responsibility of creating policies and laws to abate noise. Using the legal assessment framework developed by LawAtlas, we analyzed the noise ordinances of 60 U.S. communities. We created a 22-question coding scheme to identify key aspects of noise ordinances. We used geospatial mapping to find regional patterns of noise control methods, penalties, and enforcement. The goal of our study was to conduct a literature review and analyze community noise ordinances that might serve to promote action in relation to noise control. Most (72%) of this sample of ordinances were enacted to address noise as an annoyance or nuisance, and 60% focused on noise as a health concern. Only 50% of our sample of noise ordinances include quiet zones as a noise control method. The regional analysis and geospatial mapping revealed that communities on the East Coast, West Coast, and in the South used more noise control methods than did communities toward the center of the nation. Those methods included penalties and enforcement. Quiet zones, or noise-sensitive zones, could be used in ordinances to protect vulnerable communities. State and local governments can use the European Union's Environmental Noise Directive and the World Health Organization's night noise guidelines as frameworks when crafting their legislations. Communities can also create noise complaint databases to identify areas where they have noise issues and the noise levels that are associated with annoyance.

Keywords: Noise, environment, exposure, annoyance, protection, control, policy, regulation, ordinance, zoning, legislation, non-occupational, government, community, school, city, county

Introduction

Noise-induced hearing loss tends to develop over years. It results when our ears are consistently exposed to loud sounds. Often, by the time it is diagnosed, the damage is already at an advanced stage and permanent (Clark & Bohne, 1999). Audiologists measure hearing via audiograms. If an audiogram indicates a drop in certain high frequencies (a notch), it can be classified as a temporary threshold shift. When a person has a history of noise exposure and an audiogram indicates a permanent threshold shift, that person is diagnosed with noise-induced hearing loss (Rabinowitz, 2000). Hearing health is crucial for communication, daily function, and quality of life. Hearing loss can be congenital or acquired, occur swiftly or gradually, and have varying degrees of severity (National Academies of Sciences, Engineering, and Medicine, 2016).

In 2016, the Centers for Disease Control and Prevention (CDC) began initiatives to spread awareness about noise-induced hearing loss in non-occupational settings. Some of the most common sources of exposures linked to non–work-related hearing loss are personal music players, concerts, nightclubs, motorsports, and use of power tools. Globally, hearing loss is expected to become more prevalent.

In a 2017 report, CDC analyzed data from the 2011–2012 National Health and Nutrition Examination Survey (NHANES) on audiometric testing of adults aged 20–69 years. In the United States, 21 million adults (19.9%) who reported not having exposure to loud noises at work had measurable hearing loss. Of the participants who reported good or excellent hearing, 23.5% had notches in audiometric testing, indicating less sensitive hearing. Of those who were exposed to loud noise in the past year, 70% either rarely or never wore hearing protection

(Carroll et. al, 2017). This means that hearing loss can occur outside of the workplace and people might not be aware of the extent of the damage done to their inner ear.

The effects of hearing loss extend far beyond auditory issues. Excessive noise exposure has been linked to stress, high blood pressure, cardiovascular disease, annoyance, headaches, mood changes, nausea, anxiety, depression, restlessness, and impaired performance (Stansfeld & Matheson, 2003). Noise has also been linked to cognitive impairment in children, and sleep disturbance. In high income European countries, WHO estimates that 1 million disability-adjusted life years (DALYs) are lost due to the non-auditory effects of noise (Fritschi et al, 2011). Depending on a person's age at the time of diagnosis, the average cost to society is approximately $297,000 per person in cases of severe hearing loss (REF), mostly (67%) from reduced work productivity (Basner et al, 2014). The rest of the cost is due to special education for children (21%) and the cost of medical care and devices to aid hearing (11%) (Mohr et. al, 2000). In the United States, the number of persons aged ≥20 years with hearing loss is expected to increase from 44.11 million in 2020 to 73.50 million in 2060 (Goman et. al, 2017).

In 1972, the U.S. Congress passed the Noise Control Act, which directed the Environmental Protection Agency (EPA) to protect the health and welfare of the American population from unregulated noise. In response, EPA formed the Office of Noise Abatement and Control (ONAC), which was responsible for setting noise emission standards on products, motor vehicle carriers, and railroads used in interstate commerce. ONAC also provided noise labeling for products, coordinated federal agencies in noise reduction efforts, assisted state and local governments address noise issues, and provided educational materials about the harmful effects of noise (Noise Control Act, 1972).

In 1974, EPA outlined the noise levels recommended in various settings (U.S. Environmental Protection Agency, 1974). EPA measured the equivalent sound exposure using Leq over a 24-hour period. It is sound measure averaged over 24 hours and is a good approximation of how people hear (Namba & Kuwano, 1982). To prevent hearing loss, the recommended noise level should not exceed 70 decibels in 24 hours. For outside and inside activity interference or annoyance, the levels should not exceed 55 and 45 decibels, respectively. These values were produced to protect the health of the U.S. population and did not take cost and feasibility into account (U.S. Environmental Protection Agency, 1974).

EPA distributed a model noise control ordinance that has been adapted for use in communities throughout the nation. Communities were to determine how they would control noise due to their unique needs and the complex nature of noise exposure (Model Noise Control Ordinance, 1975). However, this model ordinance has not been updated since its creation in 1975. In 1978, the U.S. Congress passed the Quiet Communities Act, which amended the Noise Control Act and allowed ONAC to provide grants and technical assistance to state and local governments (Quiet Communities Act, 1978). ONAC was defunded in 1982, thus shifting the complete responsibility of noise abatement to state and local governments. Although these laws have not been repealed, they remain unfunded mandates. Local abatement activities declined after ONAC was defunded. Additionally, the Noise Control Act preempts local jurisdictions from creating their own traffic noise laws that are stricter than the decades-old federal regulations (Dunlap, 2006). No federal agency currently provides guidance on regulating noise pollution (Shapiro, 1991).

Community Ordinances

In 2016, the Noise Pollution Clearinghouse analyzed 491 local community noise ordinances in the United States. Blomberg (2016) reported that those ordinances typically included decibel-based standards, plainly audible standards, nuisance standards, quiet zones, distance, time of day restrictions, and prohibition of specific noise sources. Community ordinances include the following standards:

- A decibel-based standard specifies a decibel level that noise may not exceed.
- A plainly audible standard limits the distance within which a noise may be noticeable.
- A nuisance standard prohibits noises and sound levels that residents would consider disturbing, annoying, or otherwise unreasonable.
- Quiet zones are areas within which communities restrict noise levels more than in other areas to protect certain community members.
- Time-of-day restrictions limit decibel levels during certain times of day or night.
- Prohibition of specific noise sources means that a community has declared it unlawful to use a device because of the noise the device causes.

In a preliminary review, Blomberg (2016) found that 85% of the ordinances included a nuisance standard. Zoning regulations were used in 65% of the ordinances, plainly audible restrictions were included in 61%, and decibel-based rules were found in 55%. In addition, 47% of the ordinances included time of day restrictions and 35% included distance from property line restrictions. Most of these ordinances used multiple standards to regulate noise exposure.

Published scientific studies can influence noise control regulation and encourage reduction of noise levels to protect public health. The goal of our study was to conduct a literature review and analyze community noise ordinances that might serve to promote action in

relation to noise control. This analysis gives examples of clear and obtainable community noise ordinances.

Method

Literature Review

For the current study, the authors submitted a literature search to CDC's Stephen B. Thacker Library. The purpose of the search was to identify current community (city, county, town) noise control regulations. From this search, we identified relevant information from journal articles, conference papers, dissertations, and other sources related to the reduction of environmental noise exposure in non-occupational settings.

The search used the following keywords: noise, environment, exposure, annoyance, protection, control, policy, regulation, ordinance, zoning, legislation, non-occupational, government, community, school, city, county, and regional. The following words were excluded: occupational and workplace. The databases searched were Medline, PsycINFO, CINAHL, Scopus, Compendex Engineering Village, and the Agricultural and Environmental Science Database. Searches using Medline, Psycinfo, and CINAHL were limited to literature published since 2009. The search was limited to English only and humans only. There were no gender limits, no limits by publication type, and no age limits. The preferred scope was narrow, meaning that highly relevant citations were retrieved, but some relevant citations might have been missed. We used EndNote software to identify most of the duplicates, which we then removed from the search results.

From the search, 1,984 articles were identified and the titles were listed in an Excel spreadsheet. Titles and abstracts of the articles were available for review. Three of the co-authors independently ranked titles and filtered those to the 338 most relevant articles. Similarly, three

co-authors independently reviewed the articles and further ranked them for relevance. In the end, we were left with 32 papers. Papers by EPA and articles about noise policy in the United States were found using the Noise Pollution Clearinghouse website (Noise Pollution Clearinghouse, 2018). All other papers were found by searching PubMed and Google Scholar.

Legal Mapping Assessment

One goal of this study is to support developing a legal mapping assessment to evaluate risk and classify existing community ordinances on noise. Noise ordinances were searched June 2017 on local government webpages or via legal code databases such as Municode, American Legal Publishing Corporation, eCode360, Sterling Codifiers, Inc., ClerkBase, and Code Publishing, Inc. The search terms used to find the codes included noise ordinance, noise code, noise, code, and ordinance. To conduct our legal mapping assessment, we used the legal assessment framework developed by The Policy Surveillance Program: A LawAtlas Project (Policy Surveillance Program, 2018). We also consulted with CDC Public Health Law Program's legal mapping competency model. Two researchers each conducted the same five-state policy analysis. In keeping with Blomberg's (2016) classifications, we chose a community noise ordinance from a state from each of five U.S. regions: Northeast, South, Pacific, West, and Midwest. We restricted to communities with populations larger than 65,000 and compiled ordinances from 60 communities. To do this, we used Blomberg's color-coding method to see if ordinances had the key components analyzed. We highlighted red for decibel levels, yellow for vehicles, gray for plainly audible, green for nuisance/annoyance/disturbing the peace, and blue for zoning/time of day/distance/quiet zones. We found that the ordinances we reviewed had a combination of these factors and other variables that we could code. We created our own list of

questions to code and then consolidated them to come up with one list of questions. As we discovered new variables during coding, we added them to our list of questions.

By producing a series of questions and asking whether or not each ordinance contained the relevant information, we were able to develop a coding scheme to evaluate community noise ordinances. We first coded the names of the communities, the geographic identifier, type of community (city, town, village, census designated place, county, or consolidated city-county), and location state. We also coded the 2017 population size, as estimated by the U.S. Census Bureau (or the 2010 census population, if the 2017 estimates were not available), and the source URL of the noise ordinance. We then coded for a series of qualitative (Q) and yes/no (Y/N) questions regarding the ordinances:

1) Who has authority? (Q)
2) Is the primary reason for the ordinance health-related? (Y/N)
3) Is the primary reason for the ordinance related to annoyance, nuisance, or disturbance? (Y/N)
4) Does the ordinance utilize time-of-day restrictions? (Y/N)
5) Does the ordinance include zoning restrictions? (Y/N)
6) Does the ordinance restrict noise based on decibel levels? (Y/N)
7) Does the ordinance restrict noise based on the distance it travels? (Y/N)
8) Does the ordinance have a plainly audible standard? (Y/N)
9) Does the ordinance list sound sources? (Y/N)
10) Does the ordinance restrict noise based on whether it is perceived as a nuisance or an annoyance? (Y/N)
11) Does the ordinance specify activities deemed as violations? (Y/N)

12) Does the ordinance allow for waivers or permits? (Y/N)

13) Does the ordinance define penalties for violations? (Y/N)

14) Does the ordinance delegate the power of enforcement? (Y/N)

15) Does the ordinance include certain exemptions? (Y/N)

16) Does the ordinance include a severability clause? (Y/N)

17) Does the ordinance have a list of definitions for terms used? (Y/N)

18) Does the ordinance restrict noise from animals? (Y/N)

19) Does the ordinance utilize quiet zones? (Y/N)

20) Who is enforcing the law? (Q)

21) What types of sound sources are mentioned? (Q)

22) What is banned? (Q)

To make sure that coding was done well, ten jurisdictions were randomly selected to see if there would be any variance in coding. No differences were found in coding after review.

We then generated a sample of 40 communities, randomized based on zip code. We included the 10 highest populated cities in the United States to increase the sample of ordinances from large jurisdictions. Although noise might be listed in other parts of a community's ordinance, we only looked at ordinances that had noise in its title. Jurisdictions were classified by population as small (<50,000 people), medium (50,000–500,000 people), and large (>500,000 people) (National Association of County & City Health Officials, 2016).

Geospatial Mapping Analysis

The Geospatial Research, Analysis, and Services Program (GRASP) at CDC helped conduct the geospatial mapping analysis. Coded data were cross-referenced with the 2017-vintage TIGER/Line boundary files from the U.S. Census Bureau in ArcMap 10.5.1 from ESRI

to produce maps. We built three maps. The first map identified communities as small, medium, and large in terms of population. The second map identified communities based on whether or not they used zoning, quiet zones, decibel levels, time of day restrictions, and plainly audible noise control measures in their ordinances. These communities were grouped into three categories: those that had up to three of the aforementioned noise control measures, those that had four, and those that had five or more. The third map identified communities in one of four categories: yes penalty/yes enforcement, no penalty/no enforcement, yes penalty/no enforcement, and no penalty/yes enforcement.

Best Practices for Noise Ordinances

We hope this study to assist public health practitioners and stakeholders in producing policies aimed at reducing community noise levels. Recommendations were drawn from articles in the literature search, developmental frameworks, and comprehensive noise ordinances. We also included recommendations from other countries to contrast with U.S. regulations.

Results

Literature Review

Of the original 1,984 articles collected from the literature search, we reviewed the 32 papers we considered most relevant. Among those 32 articles were four that discussed U.S. policy as their main theme. Another seven articles focused on policy outside of the United States. Seven articles focused on health effects resulting from noise exposure. Five of the articles discussed geospatial mapping or modeling as methods for assessing noise exposure.

Descriptive Data

Table 1. Population data for 60 U.S. communities with noise ordinances.

Measure	No. (N = 60)	%
Small	32	53
Medium	16	27
Large	12	20
Total jurisdictions	60	
Average population	512,557.5	

Table 1 shows population data for the 60 jurisdictions analyzed in this project. The mean population of the communities was 512,557.5. Of the jurisdictions coded, 32 (53%) were small, 16 (27%) were medium, and 12 (20%) were large.

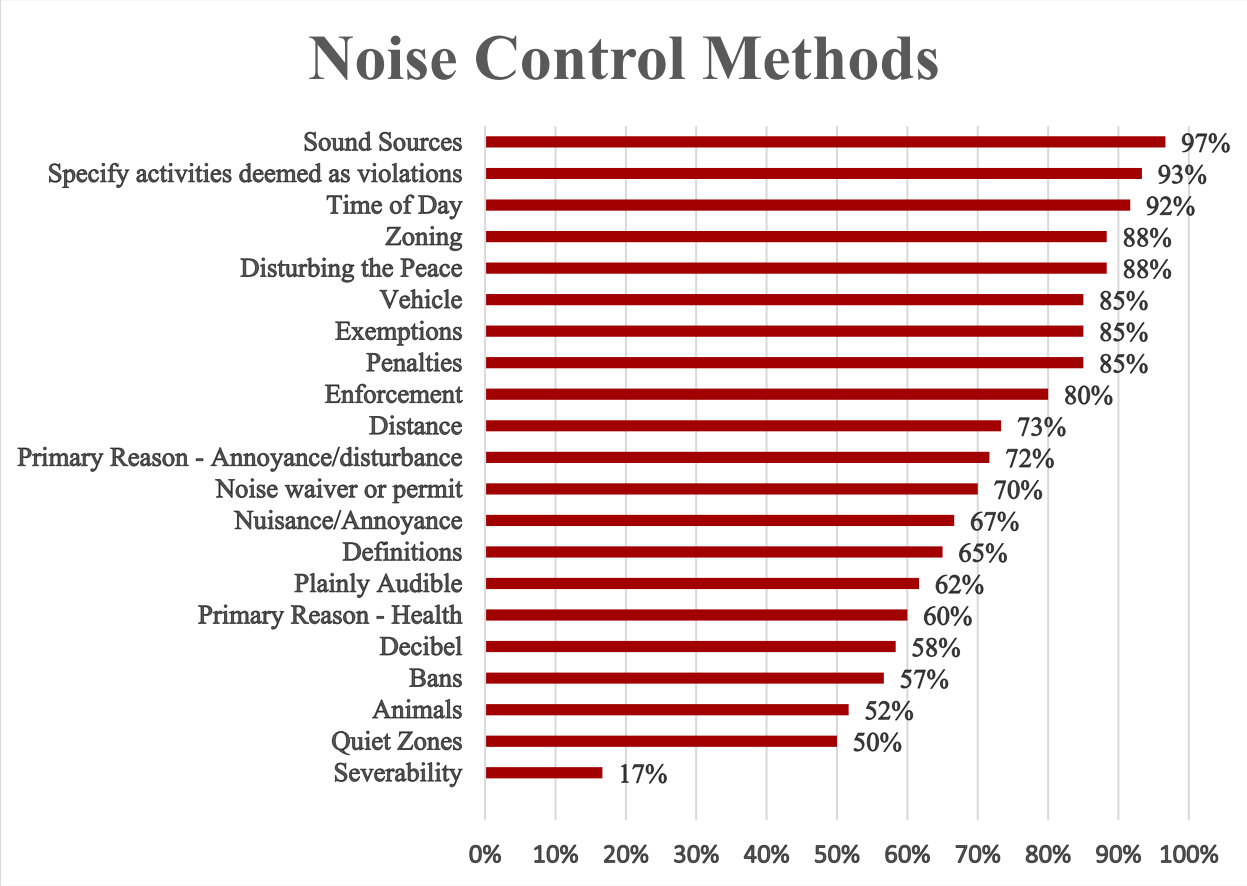
Legal Mapping

Noise control methods

Figure 1 shows the 22 different codes for methods we evaluated. Sound sources that were controlled by law were specified in 58 (97%) of the ordinances. Activities deemed to be noise disturbances were specified in 56 (93%) ordinances. Time of day restrictions were found in 55 (92%) of the ordinances. Zoning restrictions were used in 53 (88%) of the ordinances. Disturbing the peace and exemptions were mentioned in 53 (88%) of the noise codes. Restrictions on

Figure. 1. Prevalence of various noise control methods used in community noise ordinances.

vehicles were found in 51 (85%) of the ordinances.



Authority

Table 2 identifies the authorities in charge of enforcement and implementation of noise ordinances. In 31 (52%) of the ordinances, the police or sheriff departments had authority. In 14 (23%) of the noise codes, the authority for enforcement or implementation of regulations was unclear. Departments of codes, inspections, or ordinances had authority in 11 (18%) of the ordinances. The Departments of Health and its officers were listed as having authority in 10 (17%) of the noise ordinances.

Table 2. Agency assigned authority to enforcement noise ordinance.

Authority	No. (N = 60)	%
Police/Sheriff department	31	52
Department of codes/inspections/ordinances/regulation	11	18
Department of health	10	17
City/Town manager	7	12
Department of buildings	4	7
Department of public safety	3	5
Noise control administrator	3	5
Fire department	3	5
Department of planning and development	2	3
City council	2	3
Animal control	2	3
Air pollution control commission	1	2
Department of housing	1	2
Department of business affairs and consumer protection	1	2
Department of streets and sanitation	1	2
Department of transportation	1	2
Department of finance	1	2
Housing court	1	2
Unclear	14	23

Penalties

Table 3 lists the various penalties imposed by jurisdictions in their noise ordinances. Among the 60 communities, 44 (73%) included fines in their ordinances. Civil penalties or infractions were found in 24 (40%) of the ordinances. Charges of misdemeanor are listed as penalties in 20 (33%) of the ordinances. In 12 (20%) of the noise codes, violation could result in imprisonment. There was no penalty specified in 20 (17%) of the noise ordinances.

Table 3. Types of penalties included in community noise ordinance.

Penalty	**No. (*N* = 60)**	**%**
Fines	44	73
Civil penalty/infraction	24	40
Misdemeanor	20	33
Imprisonment	12	20
Abatement order	8	13
Notice	5	8
Warning	4	7
Injunction order	4	7
Hearing/Summons	4	7
Seizure	3	5
Impoundment	3	5
Criminal violation	3	5
Citation	3	5
Restraining order	2	3
Towing	2	3
Compliance order	2	3
License revocation/modification	2	3
Mandamus	1	2
Community service	1	2
Education	1	2
Cease and desist	1	2
Subpoena	1	2
Disconnect burglar alarm	1	2
Stop work order	1	2
Seal device	1	2
Not specified in noise ordinance	10	17

Law enforcement agencies

Table 4 lists the people or agencies responsible for enforcing the noise code. In 42 (70%) of the noise codes, the police or sheriff's department are responsible for enforcement. In 12 (20%) of the ordinances, departments of codes, inspections, or ordinances are responsible for enforcement. The Department of Health or its officials are tasked with enforcement in nine

(15%) of the ordinances. In 12 (20%) of the noise ordinances, enforcement responsibilities were unclear.

Table 4. Agency assigned to enforce community noise ordinance.

Enforcement	**No.**	**%**
Police/sheriff department	42	70
Department of Codes/Inspections/Ordinances	12	20
Department of health	9	15
Noise control administrator	5	8
City manager	4	7
Fire department	3	5
Animal control	2	3
Director of public safety	1	2
Department of housing	1	2
Department of business affairs and consumer protection	1	2
Department of streets and sanitation	1	2
Department of transportation	1	2
Department of finance	1	2
Air pollution control commission	1	2
Housing court	1	2
Citizen complaint	1	2
Court	1	2
Unclear	12	20

Geospatial Mapping Analysis

Figure 3 shows the 60 communities included in this study, according to population size. The National Association of County & City Health Officials (NACCHO) (2016) classifies local health departments based on the sizes of their jurisdiction: small (<50,000 people), medium

(50,000-500,000 people), and large (>500,000 people). We used these parameters to define our populations.

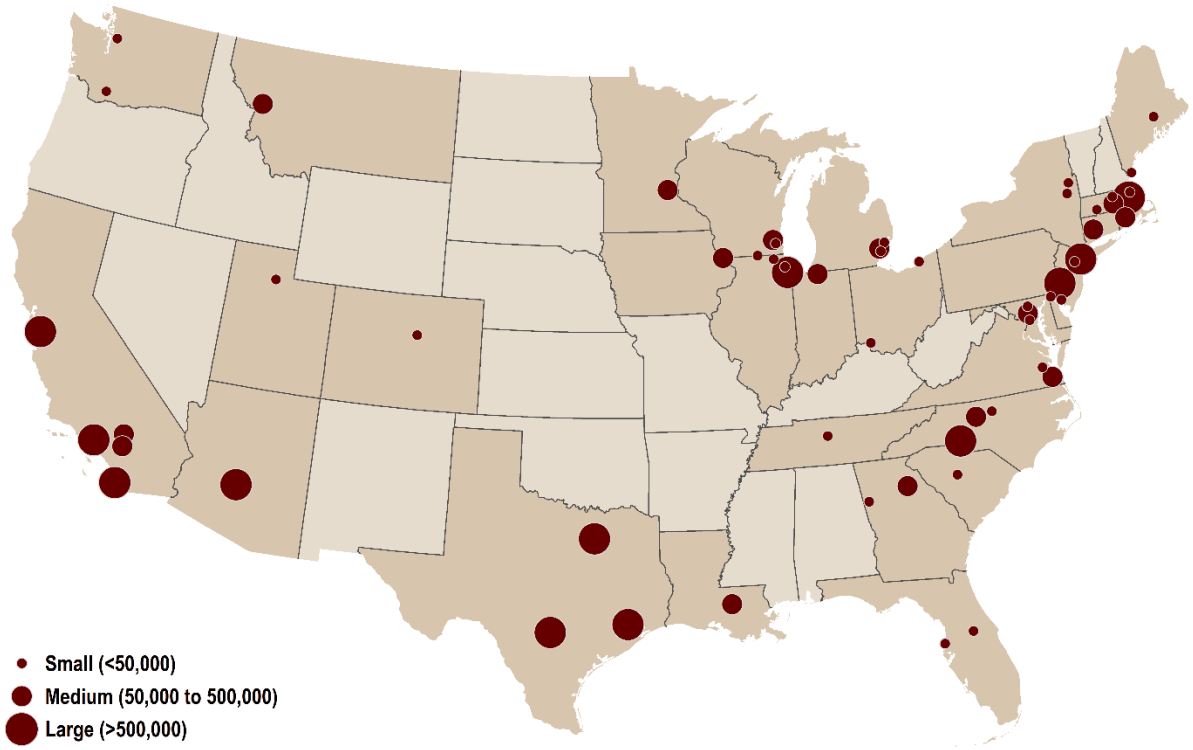


Figure. 2. Map of communities in noise ordinance study, based on population size. Size classified according to National Association of County & City Health Officials definitions.

In Figure 4, we classified communities based on the number of key noise control categories in their ordinances. The five categories we listed as key noise control measures were zoning, quiet zones, decibel levels, time of day restrictions, and plainly audible. The pink dots represent the 29 communities that have no more than three of these categories. The red dots represent the 17 communities that have four of these categories. The maroon dots represent the 14 communities that have five of these categories in their noise ordinances. Most of the maroon dots are in the Northeast, California, Texas, and the Midwest. The red dots are found mostly in states on the East Coast. The pink dots are found more in states that are not on either coast of the United States.

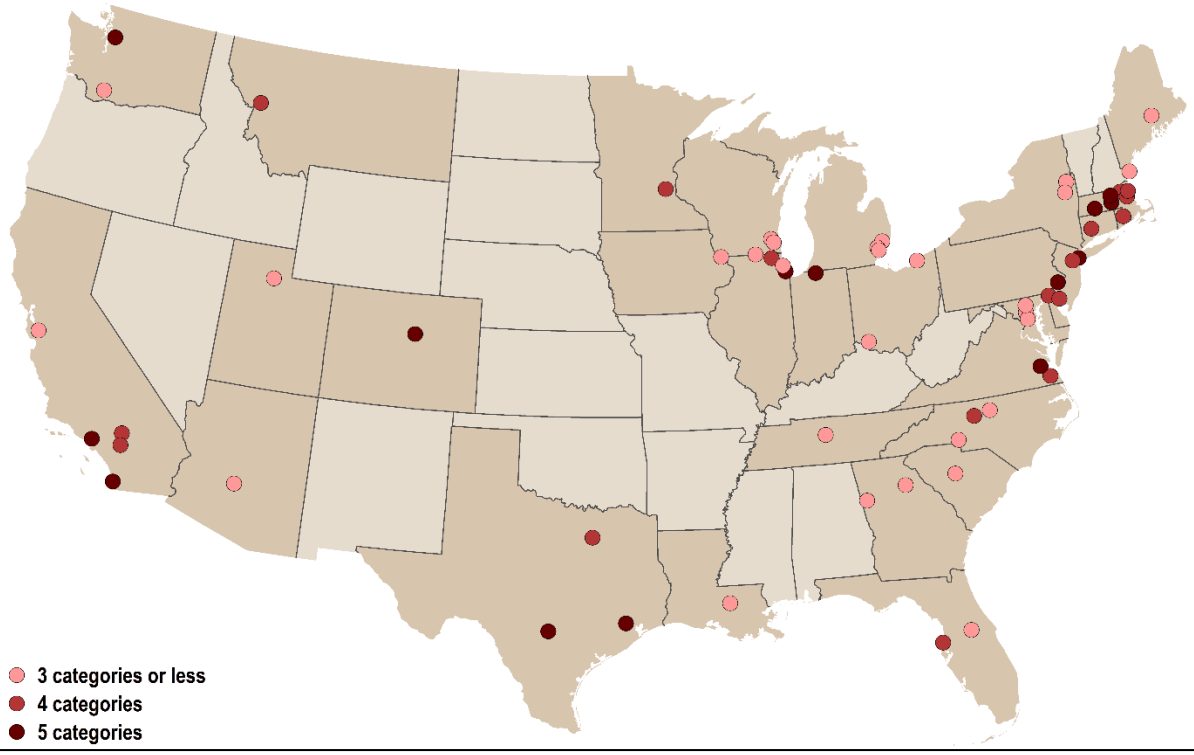


Figure. 3. Portion of five noise control categories found in noise ordinances of 60 communities (pink ≤ 3, red = 4, and maroon = 5). Noise control categories = plainly audible, time of day, decibel levels, zoning, and quiet zones.

Figure 4 shows how the 60 communities enforce their noise ordinances and the penalties those include. We color-coded the different communities as follows: red is no penalties/no enforcement, purple is no penalties/yes enforcement, green is yes penalties/no enforcement, and blue is yes penalties/yes enforcement. The seven red dots represent communities that have no penalty and no enforcement clauses in their noise codes. The two purple dots represent communities that have enforcement, but no penalties written into their ordinances. The five green dots represent communities that have penalties, but no enforcement written into their ordinances. The 46 blue dots represent communities that have enforcement and penalties written into their noise ordinances. A majority of the blue dots are on the East Coast and West Coast.

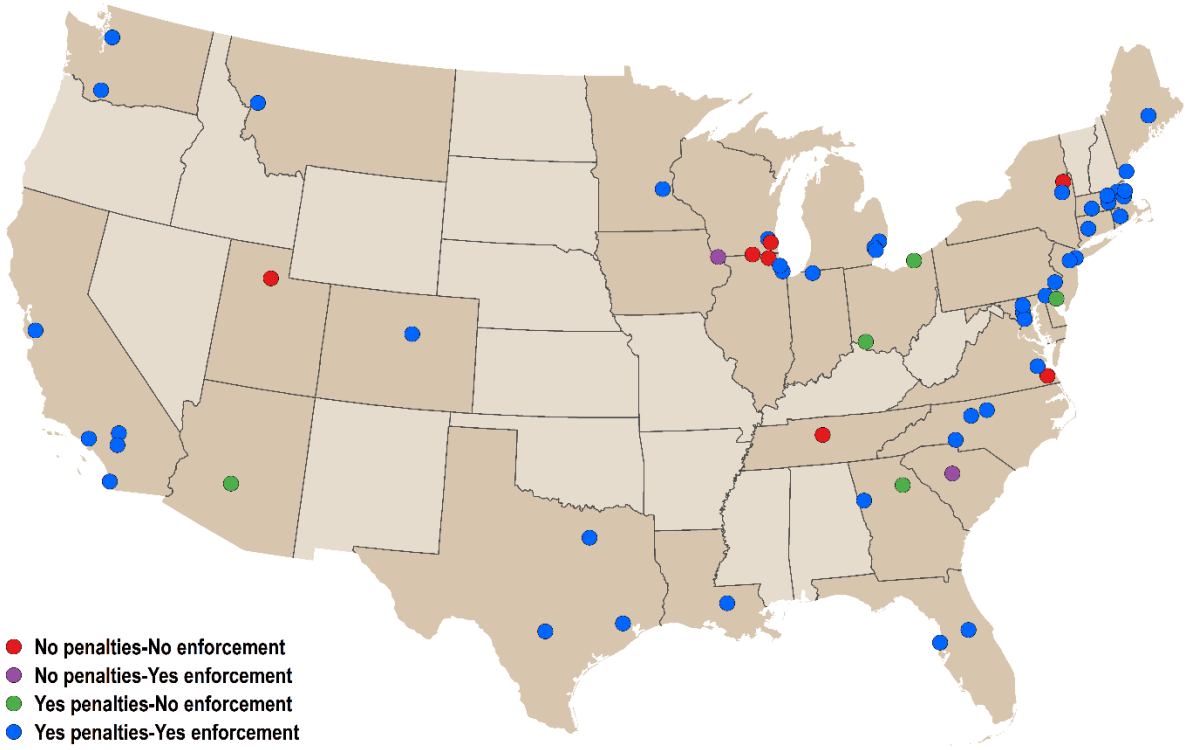


Figure 4. Enforcement and penalties written into community noise ordinances. Red dots = no penalties/no enforcement, purple dots = no penalties/yes enforcement, green dots = yes penalties/no enforcement, and blue dots = yes penalties/yes enforcement.

Discussion

Legal Mapping Assessment

While 43 jurisdictions had annoyance, nuisance, or disturbance as a primary purpose for the noise control ordinance, only 36 mentioned health as a primary purpose for an ordinance. However, even as a nuisance, annoyance, or disturbance, noise regulations can have health implications. Noise has been linked to anxiety and sleeplessness, and when people have less sleep, stress hormones are released in their bodies (Hammer MS, Swinburn TK, Neitzel RL. 2014).

To help offset the harmful effects noise can have on health, ordinances can incorporate quiet zones into communities. Quiet zones, or noise sensitive zones, can be designated in areas that should have a lower threshold for noise, such as areas that have hospitals or elderly care homes. Issues such as sleep disturbance and cardiovascular disease affect the elderly and persons with chronic illness (Kim & Berg, 2010). Schools and day care centers should also be in quiet zones so that even moderate traffic noise does not detract from children's development in speech and writing (Wilensky & Winter, 2001).

In 55 of the 60 jurisdictions we studied, noise ordinances included time of day restrictions. This shows that the communities understand that excessive noise at certain hours can be more problematic. It also provides a pragmatic approach to noise regulation because it is less stringent than bans and reduces the overall time of noise exposure.

For enforcement, 70% of jurisdictions listed the police or sheriff's department. Only five communities had a noise control administrator or another similar position. As a result, noise regulation becomes the responsibility of police departments that may not prioritize noise violations. Another concern is that 20% of noise ordinances did not have an enforcement agency listed in the noise ordinance. This might mean, however, that a general enforcement statute is listed elsewhere in the local code.

A majority of noise ordinances (73%) included fines as a penalty for violating the law. Misdemeanors accounted for 33% of the penalties and imprisonment was listed in 20% of ordinances. Only 40% of local ordinances specified that breaking the noise law can constitute a civil violation.

This study also did not account for noise regulations included in disturbing the peace ordinances, land use or zoning ordinances, and in other parts of the local code. These regulations

are not always cross-referenced in the noise ordinance. Enforcement officials also might be more apt to follow whichever ordinance is easier to implement. Equipment might not be available for noise monitoring or enforcement officials might not have the necessary training to use noise monitoring equipment. In such cases, enforcement officers might be more likely to go with a more subjective but easier to implement ordinance, such as a disturbing the peace ordinance.

Geospatial Mapping

Most of the large communities we analyzed are located on the East Coast, West Coast, and in Texas (Figure 3). The proportion of small communities to medium and large communities increased with the distance from the coastal regions.

Figure 4 shows variations in the number of methods used for abatement. We divided noise control methods into five categories: zoning, quiet zones, plainly audible, decibel, and time of day restrictions. Among the 60 ordinances evaluated, 14 included all five categories, 17 had four of the categories, and 29 had three categories or less. Ordinances that had three or fewer categories were more common further inland. Ordinances that had four or five of the categories were found more in the large cities and coastal regions. Although analyzing the number of categories in a jurisdiction reveals the variety of methods used, it is not necessarily a measure of the effectiveness of the ordinance. A community might use five of the categories and have an effective ordinance because the different methods meet its needs. Conversely, a community might include the five of the categories, but find it ineffective because the ordinance is confusing and difficult to enforce. The effectiveness of an ordinance is not necessarily linked to the number of noise control methods it includes.

Figure 4 shows that most of the communities had enforcement and penalties written into their noise ordinances. These communities were found mostly in the South and on the coasts.

The communities that had neither or only one of the two included in their ordinances were mostly farther from the coasts. A community noise ordinance might not have penalties or enforcement if a superseding chapter for penalties and enforcement affects multiple ordinances in the code. Some ordinances reference a superseding chapter, others do not. Because we were only looking at the ordinances with noise in the title, we marked that penalties and enforcement were not clearly included if they were not cross-referenced. If a community has a noise ordinance and a disturbing the peace ordinance, it might be easier for police officers to enforce the disturbing the peace ordinance because it is more subjective and might have less stringent requirements.

United States Policy and Noise Control

Noise is not always in the forefront of people's minds when they think of environmental protection. During the 1970s, when the Noise Control Act was passed, the public had become more concerned about environmental issues. Because noise comes from many sources, it is difficult to target a single source to generate enough public interest and pressure for reform (Shapiro, 1991). Yet, with the increase in use of personal listening devices, the growing trend of urbanization, and the ongoing rise in motor vehicle ownership, noise is receiving more attention.

The Noise Control Act is still federal law, enabling the United States to enforce regulations to reduce the public's exposure to noise. Regulation of noise emission sources and providing people with information on the harmful effects of loud noise are cheap and effective ways to help protect hearing. Clear and understandable labeling of products that make noise can help guide consumers on safe use to protect their hearing and health. Although not covered by the Noise Control Act, geospatial noise mapping is a technology that can be used to monitor noise throughout the country. For example, the U.S. Department of Transportation has produced

noise maps from highways across the nation, but more comprehensive mapping is needed (Hammer MS, Swinburn TK, Neitzel RL 2014).

Hearing loss is an issue that affects people's health and productivity. Noise-induced hearing loss is preventable, but noise is the cause of approximately 25% of the cases of hearing loss. A 10% to 20% decrease in the percentage of people with hearing loss would result in an estimated earnings increase of $61 billion to $122 billion (Neitzel, 2017). Better productivity leads to wage growth. When people are earning more, they boost the economy, and the nation fares better as a result.

One study looked specifically at the local ordinances of Hillsborough County and Winter Springs, Florida (MacDonald, 2015). The study found that an Leq approach, which takes into account the average sound pressure over time, would be more beneficial than using Lmax, which looks at the maximum sound pressure at any given time. Ordinances in central Florida were using the Lmax approach, which is more subjective because an enforcer can just wait until the sound pressure exceeds the limit at one point, even though the level might not be sustained. The ordinances also did not address annoying low frequency sounds, such as vibratory sources that can come from heating and air conditioning systems and amplified music. The author suggests addressing this with use of a C-weighted frequency metric (versus A-weighted) which includes less audible low frequency sounds in the measurement.. Another approach was creation of a central Florida complaints database, which allowed to find out what noise levels correlated with complaints in the community (MacDonald, 2015).

Policy and Noise Control Outside of the United States

After WHO Europe's Parma Declaration on Environment and Health in 2010, various European countries have expressed the need to reduce noise exposure. The European Union's

Environmental Noise Directive (END) was passed in 2002 and is implemented by the European Environment Agency (EEA). The goal of the directive was to bring Europe's noise levels down to the 1999 WHO-recommended levels by 2020. The WHO guidelines state that annoyance and nuisance are typically not found below 50-55 dBA and that speech is clearer when ambient noise levels are 35-45 dBA. The guidelines state that protection from hearing loss is found when Leq is less than 70 dBA over the course of a day or 85 dBA over the course of an hour (Jarosinska et. al, 2018; WHO, 1999; Carroll et. al, 2017).

EEA gathers noise data via the Noise Observation and Information Service for Europe (NOISE). This database compiles data on the number of people affected by noise and various noise sources, such as high-traffic roadways, major airports, railways, and urban clusters. For END, however, data are collected on noise above 55 dB, which might not capture the full effects of noise. Countries also vary in the extent to which they report findings to the database. Eastern European countries, so far, have not been reporting to the same extent as the rest of the continent (Jarosinska et. al, 2018).

In 2009, WHO issued night noise guidelines for Europe as an update to the 1999 guidelines. The guidelines correlate Lmax levels to sleep disturbance and Lnight levels (average sound pressure level over the course of a night) to cardiovascular issues. The night noise guidelines recommend an Lnight less than 30-40 dbA. Average levels higher than 55 dBA at night are considered a major public health concern (Kim & Berg, 2010). Stakeholders and policymakers in the United States can use the European Union's Environmental Noise Directive and the WHO night noise guidelines as frameworks for noise levels, noise monitoring, and action plans.

Hammer MS, Swinburn TK, Neitzel RL (2014) came up with an original framework in which to evaluate noise pollution policies called I-ACT. The "I" stands for information, the "A" stands for awareness, the "C" stands for coordination and leadership, and the T" stands for evidence-based tools. Policymakers can use I-ACT to clarify roles and identify strategies to create a more holistic environmental noise policy. .

Limitations

This study is subject to several limitations. Legal mapping assessments are not meant to evaluate how policy is enforced throughout the nation (Burris, 2018). As such, this study does not have data on noise enforcement. A community might have the most comprehensive and detailed noise ordinance, but it is useless if it is not enforced (Blomberg, 2016). Problems can arise if an agency does not have the budget, equipment, or training to carry out the enforcement of an ordinance. With a federal agency as a major source of guidance, state and local legislatures might feel more confident in passing new, effective noise ordinances and passing budgets that will support thorough enforcement. Local jurisdictions might lack the guidance, monitoring, training programs, or ability to buy noise monitoring equipment needed to properly enforce their noise laws. Another constraint is that the Noise Control Act does not specify minimum noise protection levels (Shapiro, 1991).

After our initial 10-state policy analysis and review of 40 randomly selected communities, we realized that our sample did not include many large jurisdictions. To address that, we also analyzed the ordinances of the 10 most populated cities in the United States. Out of all of these communities, only 35 can be classified as large using the NACCHO classifications (have a population ≥500,000) (U.S. Census Bureau, 2017). There are approximately 42,000 postal codes in the United States, with only a small fraction being a large jurisdiction (U.S.

Postal Service, 2018). The chances of us getting a large jurisdiction using our randomization was quite slim, so we had to oversample to make sure there was representation of large jurisdictions.

According to the 2012 Census of Governments, there are 3,031 county governments, 19,519 municipal governments, 16,360 townships, and 38,266 special districts in the United States (U.S. Census Bureau, 2012). Some of these communities might not have noise ordinances, but our limited sample cannot account for all of the different ordinances enacted in the United States. Over the course of this study, and outside the 60 ordinances analyzed, we could not find ordinances for 14 communities. Our random selection process also resulted in 18 states not being represented in this analysis of community noise ordinances.

We limited our review to ordinances with the word noise in its title because that was the part of the code where we expected to find the most regulations for noise. Laws governing noise could be in other parts of the code, also, but were not always cross-referenced. This can be confusing because to know the complete set of noise regulations, researchers would have to search throughout a jurisdiction's code. To avoid this confusion, lawmakers can make sure that all of the noise laws are cross-referenced. We did not review ordinances on zoning, disturbing the peace, occupational noise or land use ordinances.

Conclusion

Because local jurisdictions do not have up-to-date federal noise guidelines to follow, local noise ordinances reviewed in this article are varied in terms of their noise control strategies, enforcement, and penalties. With up-to-date guidelines that take into account the health implications of noise and recent noise monitoring technology, local governments might be better informed and could follow a set of common standards. Some first steps for improving noise regulation in the United States could be to use the European Union's Environmental Noise

Directive as an example of a framework for noise monitoring and action plans, incorporate source control methods, promote noise education, and create noise complaint databases. Another successful US model code that incorporates noise, is the Model Aquatic Health Code (MAHC) MAHC is an example of a science-based resource that addresses the design, construction, operation, maintenance, policies, and management of public aquatic facilities. MAHC guidance brings together the latest science and best practices to help the state and local authorities, and the aquatic sector to make swimming and other water activities healthier, and safer and helps prevent injury and illness. MAHC is notable because it provides the specific acoustic design requirements that shall apply to an indoor aquatic facility.

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