EQUIPMENT NOISE IN THREE TYPES OF HOUSING

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Disruptive or unwanted sound is an environmental characteristic of contemporary society. While the physiological and/or psychological damage resultant from excessive sound depends on the length and type of exposure, research has revealed direct relationships between noise and cardiovascular dysfunctions, gastro-intestinal disorders, allergies, endocrine and metabolic problems, increased cholesterol levels, and muscular tension (Berrien, 1946; Farr, 1967). Because prolonged or excessive sound has been demonstrated to adversely affect such factors as emotional behavior, motivation, productivity, and safety, individuals and groups concerned with enhancement of the quality of life must strengthen their confrontation of the issues related to sound abatement. A particularly significant issue warranting immediate attention is that of the auditory environment of the home (Westman, 1972).

Many factors compound the potential for noise pollution in family housing. Urbanization, population growth, technology, and prosperity have added new sources of noise to the family's near environment (Farr, 1967; Fath, 1972). Concurrently, factors of cost and style have influenced families and builders to design and construct housing based on "open planning design" and to utilize thin interior walls which frequently fail to provide a sound-absorbent space band. In addition, modern finishing and decorating materials such as stone, brick, glass, and paneling have hard surfaces which reflect and amplify sound. Westman (1972) warns that as a result the auditory home environment constitutes a major public health and ecological problem.

One way of minimizing household noise is through adherence to stringent acoustic criteria in designing or selecting family shelter. A second alternative is the effective selection and placement of household equipment, a major source of annoyance in the household environment (Baade, 1971; Epp and Konz, 1975). The latter alternative is the more realistic possibility for the majority of families. Yet, decisions related to household equipment appear to focus primarily on cost, warranty, and maintenance considerations. Sound emission is rarely a major concern (Bender, 1972).

Recognizing the need to define the harmful potential of home noise disturbances, this study was designed to compare the equipment noise in the household environment of single dwelling units, mobile homes, and apartments. For each type of housing, investigation focused on sound levels produced by six types of equipment: commode,[1] dishwasher, dryer, garbage disposer, range hood, and washer. A second research endeavor was to appraise the relationship between selected characteristics of families residing in each type of housing and their concern for sound abatement in their selection of housing and equipment.

Design of the Study

The research samples consisted of 20

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[1]Commode #1 denotes that in the master bathroom or that in the general bathroom when dwelling had no master bathroom. Commode #2 denotes that in the general bathroom when dwelling had both a master bathroom and a general bathroom.

TABLE 1
CHARACTERISTICS OF THREE TYPES OF HOUSING STUDIED

Characteristic	Apartments	Mobile Homes	Single Dwelling
	Type of Housing		
Mean Total Floor Space	1,008.30	1,043.40	1,631.70
Mean Total Number of Rooms	5.40	5.80	8.25

Distribution of Types of Floor Covering	Cushioned			Cushioned			Cushioned		
	Hard	Firm	Carpet	Hard	Firm	Carpet	Hard	Firm	Carpet
Kitchen	95%	5%	0%	60%	5%	35%	55%	25%	20%
Dining Room	35%	15%	50%	55%	5%	40%	40%	0%	60%
Living Room	0%	0%	100%	10%	0%	90%	0%	0%	100%
General Bathroom	85%	5%	10%	45%	5%	50%	40%	20%	40
Master Bathroom	80%	0%	20%	22%	0%	78%	44%	19%	38%
Master Bedroom	0%	0%	100%	5%	0%	95%	0%	0%	100%
Second Bedroom	0%	0%	100%	25%	0%	75%	6%	6%	88%
Third Bedroom	0%	0%	100%	15%	0%	85%	0%	0%	100%

apartments, 20 mobile homes, 20 single dwelling units, and the residents of each. In order to avoid confounding the research design by introducing significant variation in floor space, single dwelling units were limited to 1,900 square feet, and comparable size apartments and mobile homes were studied. Table 1 shows some characteristics of the three types of housing studied. Table 2 presents quantitative data concerning the specific types of equipment and rooms investigated in each type of housing.

Noise emitted by the six types of equipment was measured by use of a Bruel and Kjar sound level meter. The sound level meter was set to ascertain decibel readings on the "B" curve. This particular setting is recommended for measuring sound falling within a range of 55-85 dB, as opposed to the "A" curve which is recommended for studying sounds of 55 dB or below (Tremine, 1973).

Sound levels were measured at a distance of three feet from each item of equipment studied, and also discerned in the kitchen, dining room, living room, bathrooms,[2] and bedrooms.[3] Sound measurements in the various rooms were taken with interior doors open and, again, with doors closed. Analysis of variance (AOV) was used to assess the significance of the differences in equipment noise for each type of housing. Essentially, AOV facilitated identification of specific equipment sound levels which differed significantly among various rooms in the three types of housing studied. Treating total floor space in dwelling, type of floor covering, and room location as covariates, analysis of convariance (ACOV) was employed to identify differences in equipment sound levels, while controlling for differences in

[2]Because both master and general bathrooms were studied, master bath denotes that adjacent to the master bedroom. General bath denotes that nearest to the master bedroom when no master bath was present or a second bathroom when dwelling included a master bath.

[3]Master, second, and third bedrooms were studied.

TABLE 2

ROOMS AND EQUIPMENT TESTED IN THREE TYPES OF HOUSING

Rooms and Equipment Tested	Type of Housing		
	Apartments f	Mobile Homes f	Single Dwelling Units f
Type of Rooms			
Kitchen	20	20	20
Dining Room	20	20	20
Living Room	20	20	20
General Bathroom	20	20	20
Master Bathroom	5	11	17
Master Bedroom	20	20	20
Second Bedroom	12	20	20
Third Bedroom	3	5	16
Type of Equipment			
Commode #1	20	20	20
Commode #2	5	11	17
Dishwasher	14	10	16
Dryer	2	19	18
Garbage Disposer	19	5	14
Range Hood	20	7	16
Washer	2	18	20

total floor space, type of floor covering, and room location.

The behavior of airborne sound is affected, however, by factors such as ceiling and wall treatments, upholstered furniture, and structural discontinuities. As these intervening variables were not controlled, the finding of the study may be biased to the extent to which these factors may have differed among the three types of housing.

Consideration for noise pollution in selecting present and future housing and household equipment was ascertained by asking respondents three questions: (1) was interior noise a consideration in selecting present housing, (2) was interior noise a consideration in selecting and purchasing most presently owned household equipment, (3) would noise pollution be an important consideration in selecting future housing/equipment? The Pearson product-moment correlation coefficient was employed to determine the significance of the relationships between these considerations and the size of family, ages of family members, and tenure status (rental versus ownership).

Summary of Findings

In acoustical research, a difference of two decibels is detectable while a difference of four decibels is noticeable (Sudnik, 1973). Therefore, with respect to mean sound emission at a distance of three feet from each type of equipment investigated, the study revealed several observable differences between apartments, mobile homes, and single dwelling units.

As shown in Table 3, commodes #1 and #2 appear to emit comparable levels of noise in apartments and single dwelling units. The former are detectably louder and the latter are noticeably louder than those in mobile homes. Dishwashers and dryers are fairly comparable in apartments and single dwelling units. However, those in single dwelling units are detectably louder than those in mobile homes. Garbage disposers in apartments produce noticeably greater noise while those in single dwelling units are detectably

TABLE 3

MEAN EQUIPMENT SOUND EMISSION AT THREE FEET[1]

Item of Equipment	Type of Housing		
	Apartments dB (B)	Mobile Homes dB (B)	Single Dwelling Units dB (B)
Commode #1	64.45	61.23	64.35
Commode #2	66.70	60.90	65.29
Dishwasher	71.11	69.65	72.86
Dryer	67.00	66.29	68.50
Garbage Disposer	72.02	65.40	67.50
Range Hood	66.75	55.79	66.50
Washer	69.00	70.33	72.60

[1]In acoustical research, a difference of 2 dB results in a detectable difference while 4 dB result in a noticeable difference Sudnik, 1973).

TABLE 4
VARIATION IN HOUSHOLD NOISE
ACCORDING TO TYPE OF EQUIPMENT

Type of Equipment	Frequency of Significant Variation[1]	Location of Noise Variation Doors Open/Doors Closed		Mode Dwelling Type With Most Intense Noise[2] Doors Open/Doors Closed		Mode Dwelling Type With Least Intense Noise[2] Doors Open/Doors Closed	
Garbage Disposer	11	Dining Room Living Room Master Bathroom General Bathroom Bedroom #2 Bedroom #3	Master Bathroom General Bathroom MasterBedroom Bedroom #2 Bedroom #3	A	MH	SDU	SDU
Dryer	8	Kitchen Dining Room General Bathroom Master Bedroom	Living Room General Bathroom Master Bathroom Bedroom #3	A or MH	MH	SDU	SDU
Commode #1	7	Living Room Master Bathroom General Bathroom Bedroom #2	Living Room General Bathroom Bedroom #2	A or MH	MH	SDU	SDU
Range Hood	6	Kitchen Dining Room Living Room Master Bedroom Bedroom #2	Master Bedroom	A	MH	MH	SDU
Dishwasher	5	Bedroom #2	Master Bathroom General Bathroom Master Bedroom Bedroom #2	MH	MH	SDU	SDU
Washer	5	Dining Room Master Bedroom Bedroom #2	Living Room Master Bedroom	MH	MH	SDU	SDU
Commode #2	5	Master Bathroom General BAthroom	Living Room Master Bathroom Bathroom #2	A	MH	SDU or MH	SDU

[1]Computation denotes total number of rooms studied for which a particular type of equipment noise differs significantly among types of dwellings (based on AOV) and for which total floor space in dwelling was not the major factor underlying transmission of equipment noise (based on ACOV).
[2]Type of dwelling in which the most intense equipment noise was most frequently observed.

A - Apartments
MH - Mobile Home
SDU - Single Dwelling Unit

TABLE 5
VARIATION IN HOUSEHOLD NOISE
ACCORDING TO TYPE OF ROOM

Type of Room	Frequency of Significant Variation[1]	Source of Noise Variation Doors Open/Doors Closed		Mode Dwelling Type With Most Intense Noise[2] Doors Open/Doors Closed		Mode Dwelling Type With Least Intense Noise[2] Doors Open/Doors Closed	
Bedroom #2	9	Commode #1 Dishwasher Garbage Disposer Range Hood Washer	Commode #1 Commode #2 Dishwasher Garbage Disposer	A	MH	SDU	SDU
Master Bedroom	8	Dryer Range Hood Washer	Dishwasher Dryer Range Hood Washer	MH	MH	SDU	SDU
General Bathroom	8	Commode #1 Commode #2 Dryer Garbage Disposer	Commode #1 Dishwasher Dryer Garbage Disposer	A	A or MH	SDU	SDU
Living Room	7	Commode #1 Garbage Disposer Range Hood	Commode #1 Commode #2 Dryer Washer	A	MH	SDU	SDU
Master Bathroom	6	Commode #1 Commode #2 Garbage Disposer	Commode #2 Dishwasher Garbage Disposer	MH	MH	SDU	SDU
Dining Room	4	Dryer Garbage Disposer Range Hood Washer		A	-[3]	SDU orMH	-[3]
Bedroom #3	3	Garbage Disposer	Dryer	A	MH	SDU	SDU
Kitchen	2	Dryer Range Hood		A or SDU	-[3]	MH	-[3]

[1]Computation reflects the number of observations for which equipment noise transmitted to a given room differs significantly among types of dwellings (based on AOV) and for which total floor space in dwelling did not appear to be the major factor underlying transmission of equipment noise to room (based on ACOV).
[2]Type of dwelling in which the most intense equipment noise was most frequently observed.
[3]Rooms did not have immediate interior doors to permit closing off remainder of dwelling, thereby prohibiting measurement of sound with doors closed.

A - Apartment
MH - Mobile Home
SDU - Single Dwelling Unit

louder than those in mobile homes. Range hoods appear to be comparable in apartments and single dwelling units and, in both instances, are noticeably louder than those in mobile homes. Washers are detectably louder in single dwelling units than in the other two types of housing studied.

These initial findings suggest that household equipment in mobile homes tends to have the least potential for noise pollution while equipment in apartments tend to have the greatest potential. As previously cited, however, noise pollution throughout the home environment is dependent on several factors in addition to the actual sound levels emitted by given items of equipment (i.e., floor and wall surfaces, spatial factors, etc). Because all facets of family life rarely occur within three feet of a given item of equipment, the research study focused next on analysis of equipment sounds discernible throughout the various rooms in a dwelling. Analysis of variance reveals that sound produced by garbage disposers, range hoods, and dryers differs most frequently among the types of housing studied. Single dwelling units tend to have the least noise pollution of this nature and apartments have the most. Variations in total floor space, however, were found to be primarily responsible for certain noise problems in four different areas of a dwelling. Analysis of covariance revealed that floor space, when treated as a covariate, is responsible for variations in: (1) commode #2 noise discernible in living rooms; (2) range hood and washer noise transmitted to general bathrooms; (3) range hood, washer, and dryer noise heard in second bedrooms; and (4) commode #2, dishwasher, range hood, and washer noise heard in third bedrooms.

Integration of findings in conjunction with both AOV and ACOV, as shown in Table 4, suggests that variation in equipment noise as a result of type of residence is most noticeable among garbage disposers, range hoods, dryers and commodes #1 when interior doors are open. With interior doors closed, variation is most noticeable among garbage disposers, dishwashers, dryers, and commodes #1 and #2. Single dwelling units tend to reflect the least degree of noise pollution from these types of equipment, and mobile homes reflect the most significant degree.

Variations among equipment sound transmitted to different rooms throughout dwellings are summarized in Table 5. These findings indicate that bedrooms #2, general bathrooms, and dining rooms differ most frequently when interior doors are open. When doors are closed, differences occur most frequently among master bedrooms, bedrooms #2, general bathrooms, and living rooms. Both AOV and ACOV, treating total floor space as a covariate, substantiated that equipment noise transmitted throughout housing tends to be least discernible in those rooms located in mobile homes.

Room location as a result of overall floor plan, and the type of floor covering did not differ significantly among types of dwellings. Therefore, no main effects of this nature regarding noise abatement were measurable.

Analysis of relationships between family characteristics and concern for noise in selecting housing and household equipment revealed that for residents of single dwelling units and of mobile homes, significant positive relationships were observed between size of family and concern for noise pollution as a criterion for selecting future housing and household equipment. Ownership of a single dwelling unit was found to be directly related to concern for noise in selecting present housing and household equipment. Age of apartment dwellers was found to be negatively related to concern for noise in selecting present housing.

Conclusions

Despite the fact that household equipment installed in mobile homes appears to operate generally at quieter levels than that in apartments or single dwelling units, equipment noise as a pollutant of personal home environment is a far

more serious problem in mobile homes than in single dwelling units or apartments. In mobile homes, particular attention needs to be directed toward sound abatement in bedrooms and bathrooms. The equipment that contributes the most to disruptive sound levels in these areas include dishwashers, dryers, garbage disposers, and commodes.

Because an increasing segment of the population is turning to mobile home living, designers and manufactureers need to be advised of this information and encouraged to improve the quality of their products accordingly. Housing educators can contribute to the solution of the problem by helping to stimulate awareness of the harmful potential of noise and emphasize effective utilization of sound absorptive textiles, surface materials, doors and furnishings in designing mobile home interiors. Perhaps housing professionals should assert the need for legislation establishing acoustical standards in the design and production of mobile homes.

Ownership of a single dwelling unit was found to be directly related to concern for noise in selecting present housing and household equipment. Single dwelling units also had less equipment noise pollution. The question remains as to how resident-owners of mobile homes and apartment dwellers can be motivated to consider potential noise problems when involved in housing and equipment purchasing decisions. This is a particularly important issue since industry attitudes toward noise control are largely a function of market place pressure.

While apartments tend to fare better than mobile homes with regard to potential noise pollution from household equipment, caution is advised in interpreting the overall noise problem in this type of family dwelling. External sources of sound in conjunction with interior equipment sound may well bring the total noise to a harmful level, while the noise emitted by interior equipment alone may not appear to pose so great a problem. Further research is needed on the combined effects of internal and external noise of different structure types.

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