2002

Physical and perceived noise levels within the neonatal intensive care unit of St. Louis Children's Hospital

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PHYSICAL AND PERCEIVED NOISE LEVELS WITHIN THE NEONATAL INTENSIVE CARE UNIT OF ST. LOUIS CHILDREN'S HOSPITAL

by

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An independent study submitted in partial fulfillment of
the requirements for the degree of

Master of Science in Speech and Hearing

Emphasis in Audiology

Washington University
Department of Speech and Hearing

May 24, 2002

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Abstract

Renovation of the Neonatal Intensive Care Unit at St. Louis Children's Hospital was undertaken to reduce noise levels and improve the work environment. Results of an 18-item questionnaire given post-renovation were compared with those from a pre-renovation study (Sachs & Hardin, 2000). Few statistically significant improvements were observed. Nurses reported a decrease in the occurrence of NIUC staff members having to raise their voice. In general, respondents of the B room, where seriously ill neonates are cared for, reported fewer auditory signals missed. Furthermore, change in the appearance of the NICU had a positive effect on mood from pre-renovation to post-renovation.

Perception of Noise within the Neonatal Intensive Care Unit at St. Louis Children's Hospital: A Pre- and Post-Renovation Comparison

A large body of research focuses upon physical noise levels within the NICU, as well as the effect of that noise upon infants living within the NICU. Graven (2000) reported recommendations formed by the Physical and Developmental Environment of the High-Risk Infant Center, Study Group on Neonatal Intensive Care Unit (NICU) Sound, as well as the Expert Review Panel. Recommendations for nursery sound limits include an hourly L_{eq} of 50 dB (A), an hourly L_{10} of 55 dB (A) and a 1-second L_{max} of 70 dB (A), all A-weighted, slow response scale (Graven 2000). "These recommended criteria apply to every bed space in occupied, newly constructed or renovated nurseries; they do not apply to existing nurseries," (Philbin et al., 1999).

The literature reveals the need for noise level recommendations. Wide ranges of decibel values are found within NICU's. For example: Philbin (2000) reported values ranging from 38 to 75 dB (A). Slevin et al. (2000) reported a pre-treatment NICU noise level of 58 dB(A). Thomas (1989) observed a sound level of 60 dB (A) in a "quiet" nursery. Horgan & Easton (1999) describe average noise levels within the NICU to be 68 dB (A) with values of 45 to 82 dB (A). Nzama et al. (1995) reported NICU decibel levels to be 64 to 66 dB (A) in the critical care area, and 50 to 60 dB (A) in the grower nursery.

The perception of noise within the NICU by staff members has been a little studied subject. Thomas and Martin (2000) note that, "...there are few studies of sound within the sound level typical of the NICU. Health care personnel and parents in the NICU have noted sound level and noise as stressors; however, there are no reported studies linking specific measures of the stress response and noise in caregivers....It is impossible to divide the effects of noise from the numerous stressors in the NICU environment." Additionally, "The response to noise is

subjective, determined by the physical characteristics, informational content, and predictability of the sound, as well as the individual's ability to control the sound, attitudes toward the noise source, activity, and the necessity of the sound" (Thomas & Martin, 2000). Kam, Kam, & Thompson (1994), in their article on noise in the anaesthetic and intensive care environment, note that "Exposure to moderate levels of noise can cause psychological stress. 'Annoyance' is a common psychological reaction to noise. It includes feelings of bother, interference with activity, and symptoms such as headaches, tiredness, and irritability." A study by DePaul & Chambers (1995) concurs, noting, "Fatigue, irritability, impaired judgment, and altered perceptions are among adult responses to environmental noise. These responses may make staff members more prone to errors in patient care. Staff may habituate to unit noise, resulting in a slower response to monitor alarms and a potential increase in the overall noise level."

Noise within the NICU also affects communication. "Failure to discriminate or distinguish several auditory signals, especially if the signal-to-noise ratio (difference in dB between the signal and the background noise level) is small, may lead to the phenomenon of 'masking', " (Kam et al., 1994). Previous research has shown, "deterioration in speech communication... at intensity levels of 70 to 75 dB (A). While these levels are not continuous in NICUs, ... [they] are reached during crisis situations and around some infants whose life support equipment sound production is augmented by unit equipment.... The quality of communication in such situations is clearly at risk" (Thomas & Martin, 2000). In addition, noise levels found in the NICU could cause the speaker to talk louder or shorten the distance to enhance reception (Thomas & Martin, 2000). This changes the nature of parent / caretaker exchanges from a neutral position to a more intimate or personal position. The change in the communication posture towards an intimate position affects the feelings of privacy within the family. This

invasion of privacy may, in turn, intensify the stress response of the family. The intent of the caretaker was to comfort and inform, but the close proximity of the nurse and the use of a loud voice may make the parent uncomfortable as well as impair comprehension of the message. "Closer posturing due to sound levels and the still noisy environment are thought to interfere with syntax and emphasis reception as well as other non-verbal cues critical to balancing the nature of the conversation" (Thomas & Martin, 2000).

The Neonatal Intensive Care Unit (NICU) at St. Louis Children's Hospital (SLCH) underwent construction from the fall of 1999 through the summer of 2001 to improve the environment for patients and staff. Prior to renovation, Sachs and Hardin (2000) surveyed the NICU staff and reported the results. The author surveyed the NICU staff post-renovation. The purpose of this study is to report the change in staff perception of interfering and bothersome noises within the NICU environment, as well as the effect of this noise upon communication within the unit.

Sound level measurements have yet to be recorded post-renovation. Therefore, it is unknown whether the St. Louis Children's Hospital's Neonatal Intensive Care Unit meets the recommended criteria (Graven, 2000) stated previously.

In a previous study at SLCH, Sachs & Hardin (2000) surveyed NICU staff members before renovation began with respect to noise level. In the pre-renovation survey, ninety-five questionnaires were distributed and 79 were returned (83% return rate). The majority of the respondents were nurses (N=62, 78%). The remainder of the respondents were respiratory therapists (N=5, 6%), physicians (N=4, 5%), secretaries (N=4, 5%), patient care associates (N=3, 4%), and phlebotomists (N=1, 1%). The average length of employment at SLCH NICU was seven years, three months. Of the ninety-three respondents, thirty-five had worked in another

NICU with the average length of employment being five and a half years. The majority of the respondents worked in a single room in the NICU (83%), while the remainder worked in multiple rooms within the NICU (17%). Of those working in a single area, the majority of the respondents were evenly divided between A room (37%) and B room (38%) with only 8% working in C room. The critically ill infants were cared for in A room. Infants that were seriously ill were cared for in B room. C room held "feeder-grower" infants and those infants who were going home.

Results from the pre-renovation study indicated that alarms were the loudest sound sources, the most bothersome sound sources, and interfered with work the most. Sachs and Hardin (2000) attributed this result to the nurses being "too busy attending to the needs of the infant to turn the alarms off immediately." When asked about the loudness of the alarms, 74 of the respondents (94%) replied that the alarms were either too loud or somewhat loud.

Additionally, the majority of the respondents (83%) reported missing important auditory signals. When staff members were asked if they could hear the alarms for each infant, fewer than half gave a negative response, or stated that they could occasionally or rarely hear the alarms for each infant (42%). It appears that although the majority of respondents reported the alarms as being loud, bothersome, and interfering: most staff members (58%) could hear the alarms for each infant.

METHODS

SUBJECTS

One hundred and four questionnaires were distributed to NICU staff members in the post-renovation survey. Ninety-five staff members (90%) completed the survey. The majority of the respondents were nurses (N=70, 67%). The remainder of the respondents were physicians (N=7,

7%), patient care associates (N=5, 5%), secretaries (N=4, 4%), respiratory therapists (N=3, 3%), nurse practitioners (N=2, 2%), medical students (N=1, 1%), environmental services technicians (N=1, 1%), and audiology technicians (N=1, 1%).

Results of the entire surveyed population reveal the average length of employment at SLCH NICU to be seven years, three months. For all nurses surveyed, the average length of employment at SLCH NICU was eight years, two months. When asked if they had worked in another NICU, the surveyed population as a whole, as well as just the nurses (62%), had not worked in another NICU.

Respondents were evenly divided between working in a single area and working in multiple areas within the NICU (N=47, and N=48 respectively). Of those working in a single area, the majority of respondents were from B room (N=16). The remainder of the respondents were from C room (N=13), A room (N=8), D room (N=6) and the front desk (N=4). Of the respondents who worked in multiple rooms, 21 worked in all four rooms. Post-renovation there are four rooms, rather than three in the pre-renovation NICU. The function of A and B room remained the same. The A room still holds the critically ill infants. Infants that are seriously ill are cared for in B room. C room is for the less ill infants and "feeder-grower" infants. D room is for overflow "feeder-grower" infants and those infants who are awaiting discharge.

PROCEDURE

A questionnaire developed by Popelka and Karzon in 1999 was used for assessment of the staff's auditory perceptions of their environment (Sachs & Hardin, 2000). The eighteen-item questionnaire was divided into four parts: demographics, auditory environment, general environment, and staff recommendations (see Appendix A).

The original questionnaire was revised for the current study in the four following ways. The introductory paragraph was revised to give relevant information about the current questionnaire and the current researcher. The wording of question 1 was revised from "years" to "month(s) / year(s)" as it was a point of confusion in the earlier questionnaire. The wording of question 4 was changed from "past 6 months" to "past 4 months" due to the completion of the construction four months prior to the survey. The questionnaire was re-numbered since the previous questionnaire was numbered incorrectly.

The revised questionnaires were distributed to and collected from staff members by the researcher on eight separate occasions between June 18th and August 21st of 2001. An effort was made to collect data during all NICU shifts as to not bias the data. Staff members were instructed to fill out the questionnaire at their earliest convenience and reminded that infant care took first priority. Staff members were given a $1.00 wooden nickel upon collection of the completed questionnaire. The wooden nickel could be redeemed at the St. Louis Children's Hospital gift shop or cafeteria.

RESULTS

Since nurses made up the majority of respondents, results were analyzed two ways. First, the author examined results for all respondents, and second, nurses were analyzed separately. Results for all respondents may be found in figures (1-14) and results for nurses may be found in figures (15-27) within Appendix C.

Several staff members (N=1 to 7 per question) for the post-renovation study either did not circle an answer at all or circled more than one answer. Responses with multiple answers circled were not included in data analysis as well as those who did not respond. This allowed for a more precise pre-renovation and post-renovation comparison.

As a result of the differing population numbers of the pre- and post-renovation surveys, percentages were used to compare between the two surveys. The author was unable to duplicate the reported percentages for question 11, thus recalculated percentages for each response from the raw data were used for data analysis. This affected the results. After recalculation, the percentages increased in the "too loud" and "somewhat loud" category by roughly 10%. In turn, this decreased the amount of change five to seven percent between pre-renovation versus post-renovation.

STATSITICAL ANALYSIS

For data analysis, a Fisher's Test was used with a 95% confidence interval. Data was grouped from four responses to two responses. The responses were divided in half with the first two choices grouped together (Group 1) and the last two paired as a group (Group 2). Statistical analysis for selected survey items can be found in Appendix D.

When comparing pre-renovation to post-renovation the number of respondents who answered "no" to the question of any important auditory signals missed (question #8), a slight increase was seen (from 32% to 39%). This increase was not statistically significant (p-value=0.188).

A statistically significant change was seen in the occurrence of NICU staff members having to raise their voice to communicate due to the renovation. An increase in the "occasionally" and "rarely" group was found (p-value of 0.037).

The renovation appears to have caused a positive effect on mood from the pre-renovation population to the post-renovation population. The "positively" and "somewhat positively" categories increased for both the nurses only (p=0.001) and the entire population (p=0.00024).

DISCUSSION

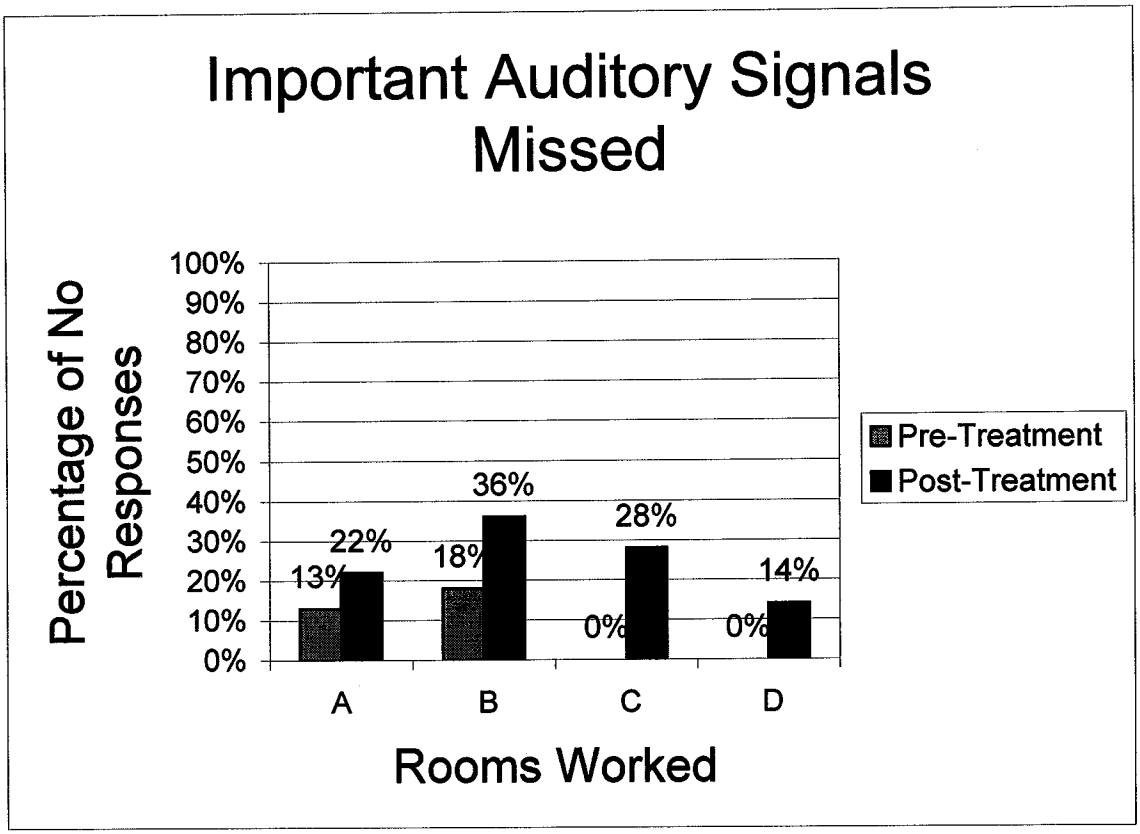
Although fifty nurses out of a total seventy-one nurses responding to the post-renovation questionnaire were working in SLCH NICU during the time period of the pre-renovation questionnaire, the responses pre-renovation to post-renovation did not change significantly as expected. With the large population that was present during the pre-renovation, it was hypothesized that more responses to post-renovation questions would have indicated statistically significant improvements to the nurse only group.

Phones were the loudest, most bothersome, and most interfering noise sources for both the entire study population and the nurses only for the post-renovation survey. However, alarms composed the majority of responses for the same questions in the pre-renovation survey. Phones may be a top response due to the change in the set-up of the NICU. The NICU changed from separate stations with a secretary for each room all secretarial staff at a front desk. This new arrangement leaves phones in each room, but without a designated person to answer it. As a result, one would assume that phones would become a significant source of noise due to the sporadic nature of telephone calls and the ensuing loss of control within one's environment when the phone rings and no one is available to answer it. It is also important to note that the rooms within the NICU received new monitor equipment and some alarms have been changed as a result of the renovation. It is unknown if the actual alarm levels were decreased as a result of the new monitors.

For the nurses in the post-renovation survey, talking was listed as the second loudest and second most bothersome noise source, whereas talking was in the top three of all questions for both the entire pre-renovation survey and nurses only. It appears as if the sources of noise in SLCH NICU have shifted from a mechanical source (e.g. alarms, ventilators) of noise towards a behavioral source (e.g. talking, nursing activities). This may indicate an overall reduction of

mechanical noise within the NICU. This is assuming that the behavioral source of noise was always present but previously masked by mechanical noise. This is consistent with Kam, Kam, & Thompson (1994) who state that "unnecessary conversation in the background interferes with performance to a greater extent than do other types of noise, as it is usually distracting or may lead to a masking effect." This masking may "eliminate" other speech-like signals or similar signals in a lower frequency range. Another possibility is habituation to the noise the equipment. "Nurses are quick to habituate to a unit's noise levels, 'turning off' stimuli and convincing themselves that noise is integral to intensive care," (Thomas, 1989). Philbin (2000) notes a study by Long et al. (1980), in which staff members were asked to identify noise sources in the nursery. "Noisy equipment was subsequently repaired, moved, or adapted to be more quiet.... Ultimately, there were no noise sources remaining other than the behaviors of staff themselves."

When comparing responses to the question if any important auditory signals were missed (question #8) across rooms pre-renovation versus post-renovation, more respondents in B room answered "no" than in any other room (18% and 32%). A key component to this change may be that the most critical babies were moved from an adjoining room as they were pre-renovation into a separate walled room. This would significantly decrease the noise levels within B room, thus allowing more staff members to not miss important auditory signals.



There is an ongoing need for research regarding staff perception of their auditory environment within the NICU. Areas of specific focus should include: communication breakdowns, perception of noise, noise related stress, physiological and behavioral effects of noise, mechanical versus behavioral causes of noise, and the effect of noise upon job performance. Future research at SLCH should focus upon the physical noise measurements compared to the staff perception of noise within the NICU.

In conclusion, the renovation shifted the perception of noise within the NICU from a mechanical source towards a behavioral source. Statistical analysis revealed significant improvements in the following areas: important auditory signals missed (question #8) within B and C room; having to raise their voice to communicate in the NICU (question #12); and appearance of the NICU affecting mood (question #17).

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Appendix A

NICU ENVIRONMENT STAFF QUESTIONNAIRE

We are graduate students from Washington University School of Medicine program in Occupational therapy. To fulfill the graduate requirement for our master's degree, we have selected to investigate the NICU Environment. This information will be forwarded to SLCH and the NICU managerial staff.

Please help us by filling out this short questionnaire. Disregard the impact of the construction because it is only temporary. After completion, please place the questionnaire in the collection box with the unit secretary. Thank you for your time.

Please fill in the blanks or circle where appropriate.

1. How long have you worked at SLCH NICU?_____ years

2. Have you ever worked in another NICU(s)? YES_____ NO_____

   If yes, how long? _____ years

3. What is your job title? (e.g. nurse, secretary, physician) _____

4. During the past 6 months, I have spent most of my time working in area:

   A B C D Other_____

Please list in descending order.

5. What do you believe are the loudest three sound sources in the NICU? (Please rank in descending order.)

   1._____ 2._____ 3._____

6. What do you believe are the three loudest sound sources that bother you the most? (Please rank in descending order.)

   1._____ 2._____ 3._____

7. What are the three sound sources that interfere with your work the most? (Please rank in descending order.)

   1._____ 2._____ 3._____

8. Are there important auditory signals in your work environment that you fail to notice because of competing sounds?

   Yes_____ No_____

   If yes, please specify: _____

Please circle the answer that best applies.

9. I can hear the alarms for each infant:

   Almost Always Frequently Occasionally Rarely

10. I can identify the location of each alarm as it sounds:

    Almost Always Frequently Occasionally Rarely

11. The alarms are:

    Too Loud Somewhat Loud Somewhat Soft Too Soft

12. I have to raise my voice to communicate with hospital employees or parents:

    Almost Always Frequently Occasionally Rarely

13. Extraneous noises / sounds interfere with my work:

    Almost Always Frequently Occasionally Rarely

14. The temperature is comfortable:

    Almost Always Frequently Occasionally Rarely

15. The size of my work space is:

    Too Large Somewhat Large Somewhat Small Too Small

16. My workspace is efficiently organized:

    Strongly Agree Somewhat Agree Somewhat Disagree Strongly Disagree

18. The appearance of the NICU usually affects my mood:

    Positively Somewhat Positively Somewhat Negatively Negatively

Please list in descending order.

19. What two improvements would you recommend for the NICU environment. (Please list in descending order.)

_____

_____

NICU ENVIRONMENT STAFF QUESTIONNAIRE

I am an Audiology graduate student from Washington University / Central Institute for the Deaf. To fulfill the graduation requirement for my master's degree, I will be investigating the NICU Environment. This information will be forwarded to SLCH and the NICU managerial staff.

Please help by filling out this short questionnaire. After completion, please place the questionnaire in the collection box with the unit secretary. Thank you for your time.

Please fill in the blanks or circle where appropriate.

1. How long have you worked at SLCH NICU?_____ month(s) / _____ year(s)

2. Have you ever worked in another NICU(s)? YES_____ NO_____

   If yes, how long? _____ month(s) / _____ year(s)

3. What is your job title? (e.g. nurse, secretary, physician) _____

4. During the past 4 months, I have spent most of my time working in area:

   A B C D Other_____

Please list in descending order.

5. What do you believe are the loudest three sound sources in the NICU?
   (Please rank in descending order.)

   1._____ 2._____ 3._____

6. What do you believe are the three loudest sound sources that bother you the most?
   (Please rank in descending order.)

   1._____ 2._____ 3._____

7. What are the three sound sources that interfere with your work the most?
   (Please rank in descending order.)

   1._____ 2._____ 3._____

8. Are there important auditory signals in your work environment that you fail to notice because of competing sounds?

   Yes_____ No_____

   If yes, please specify: _____

Please circle the answer that best applies.

9. I can hear the alarms for each infant:

   Almost Always Frequently Occasionally Rarely

10. I can identify the location of each alarm as it sounds:

    Almost Always Frequently Occasionally Rarely

11. The alarms are:

    Too Loud Somewhat Loud Somewhat Soft Too Soft

12. I have to raise my voice to communicate with hospital employees or parents:

    Almost Always Frequently Occasionally Rarely

13. Extraneous noises / sounds interfere with my work:

    Almost Always Frequently Occasionally Rarely

14. The temperature is comfortable:

    Almost Always Frequently Occasionally Rarely

15. The size of my work space is:

    Too Large Somewhat Large Somewhat Small Too Small

16. My workspace is efficiently organized:

    Strongly Agree Somewhat Agree Somewhat Disagree Strongly Disagree

17. The appearance of the NICU usually affects my mood:

    Positively Somewhat Positively Somewhat Negatively Negatively

Please list in descending order.

18. What two improvements would you recommend for the NICU environment. (Please list in descending order.)

_____

_____

Appendix B

Question #18

Improvements Listed in First Slot

Organized Monitors / Supplies @ Bed space
More work space for each infant
Fewer patients in one area
Change drawers around at bedside
Different supply & trash arrangement
Smaller, more spacious room with fewer babies. [A-Room was supposed to be 6 kids not 8 all the time. Would allow more space to work, Decrease the spread of nosocomial infections, and have fewer alarms sounding at once.]
Less use of phones in NICU by other hospital departments
Move tube system
Larger bed spaces (at least 120 sq. ft. / bed space)
More room at bedside for family and RN
Larger bed spaces
Bigger bed spaces
Larger work area
Approximately 10 bed spaces per room to decrease noise level. [For example "A" room is a big improvement on sound / noise levels.]
Change the bedside equipment / trash setup
Increase sq. footage / bed
More space
More room in library
Increase the size of the NICU Library
Larger spaces between patients to accommodate families & patients & vents
More square footage to make workable organized areas [Conducive to decreasing infections!!! & cross contamination & decreasing employee injuries (current & possible injuries)]
Scrub sink at entrance
More work space in "library"
Relocating trash & linen receptacles
Larger work environment
More rooms like A room - smaller rooms
Larger work space - less clutter
Larger bed spaces- work spaces too small & unorganized because of it
I don't like oscillator in isolettes - the sound is too loud & bounces off all sides of isolette -echoes on baby
Ergonomically designed trash containers
More space between beds
I've only been here for 1 week, hence I can't comment on this.
Larger workspace for doctors (arrange computers along one wall)

Decrease noise
More work space
Less piercing vent alarms
Better thermo regulation
More space at bedside - no room for chart & supplies
Decrease how loud ventilator alarms are
Keeping uniform pump times
Accessible trash bins
Move more trash bins / drawers from under writing surfaces
We are trying beepers to decrease noise pollution - this seems to be helping
Drawers, trash containers
Organization
Cupboard space
More room
Increasing bed space size
Different tones for alarms
Greater access to trash / linen cans
Quieter monitors
Better organization of workspace
More efficient workspace that adjusts as needed to the baby's severity & amount of equipment
Bigger work areas
Make bed spaces larger
More private parent / child areas
Remotes to silence alarms
Drawers [are] set up different at every bedside
Trash location
Greater separation of clean & dirty areas
A second secretary on nights
All room supplies located in same spaces
Larger work area
Keep visitor to a minimum
Immediate work space to be well organized & efficient [i.e. Not having to "crawl" behind isolettes, ect to get to important things like O2, suction, ect.]
Trash cans that can be reached
More space
Positive feedback
Closed off petitions to separate some more kids - doesn't need to be solid walls just maybe petitions of cloth
Friendlier attitudes
More stable air temperature, less breezes over infant's beds
Better trash receptacles
Trash receptacle
Improved setup of monitors, drawers, trash, linen, & sharps container

Someone who can answer phone calls during feeding times
Use A room as a 6-bed pod to see if more space is truly an asset
Larger bed spaces (at least 120 sq. ft. / bed space)
More bedside space
Decreased noise
Change trash / linen location!!!!
No comment
Smaller rooms for patients
Tone down isolation alarms
Supply drawers & trashcans at bedside hard to access!
Clutter of patient's belongings
More room
I think carpeting has helped with air vents
Bed spaces remain too crowded - adds to sensory overload in rooms
Better use of space
Different storage area for supplies, instead of little drawer
Change or decrease noise / light (environmental stimuli)

Question #18

Improvements listed in the second slot

Better Access to Trash & Linen
More Privacy for parents
Find other place for Trash Cans
More Bedside space for families
Smaller rooms
Easier access to supplies
More linen receptacles
More Privacy for parents
Place monitor so as to view while caring for child (opposite side of bed)
Increase storage space @ bedside
More windows / sun!
Blinds on office window
No phones in rooms
More organized library
Redesign wall units
Enlarged workspace
Quieter alarms
Better placement of monitors so you can see them as you face your patient
The unit is much quieter since the renovation
More beds (spread apart more)
Smaller rooms
More rolling chairs
Strict visitor restrictions
Restricted visiting
Less noise
Increase work space
Using pagers more often instead of phones
Increase staffing
Encourage people to use softer voices - especially near patient bedside.
Each nurse being responsible for their infants alarms!
Appearance
Trash / linen containers
Darker
Use sound absorbing machine
Supply drawer on top or moved somewhere else
Space for chart out of way - i.e. Wallaroo
More space
Less visitors at once

Larger workspace with more isolation rooms
Stricter parent visitation during report time
Organize bed space better
Set bedsides up exactly the same
Trash - hard to hit
Drawers organized and same at each bed
Trash & sharps containers are not in safe places and are difficult to access
More linen and pillows for the parents
Back supply room organized more efficiently
More windows
Rounds away from baby
Bedside drawers are nicely organized but always have to move slide out tray for chart to get to drawer, which contain most necessary items.
Linen cans conveniently located at each bedside
Re-education of staff on lighting options/choices
Kindness toward one another
Can't think of anything else
Better location for trash - difficult to "fit" receptacle under pull out drawer for writing
More windows
Linen receptacle
Someone to help answer monitors during feeding times
Curtains for every bed side should be mandatory
Different system for bedside supplies & trash / linen
Monitors which were easier to adjust up away from bedside space
Set temperature
Make pods bigger
More efficient work area (i.e. Charting area)
More linen cans
Alarms answered faster
A room seems really loud when get 2 HFO's ventilators in there. Not as noticeable with B or C
...I have felt for some time that manufacturers need to agree on particular alarm sounds for each device, meaning that all IV pumps would have the same alarm tones regardless of manufacturer, vents would all hav too many similar alarm sounds makes it easy to overlook an alarm.
Better access to O2, suction outlet
Bigger work spaces
Stable temperature

Question #18

Improvements listed in the third slot

Remove all visual obstacles that impede alarm light on ceiling above each child bed (i.e. Balloons, computer
Decrease number of infants per room
More IV pole space
Put trash cans and drawers differently
Larger bed spaces. Trash cans? Linens?
Better temperature control
IV poles and placing pumps appropriately are always a challenge
Monitors that you don't hit your head on
Have central location for extra chairs
Loud with brief times of vacuuming the unit. Drawback with carpet.
Better access to trash bin, more phones

Appendix C

Figure 1

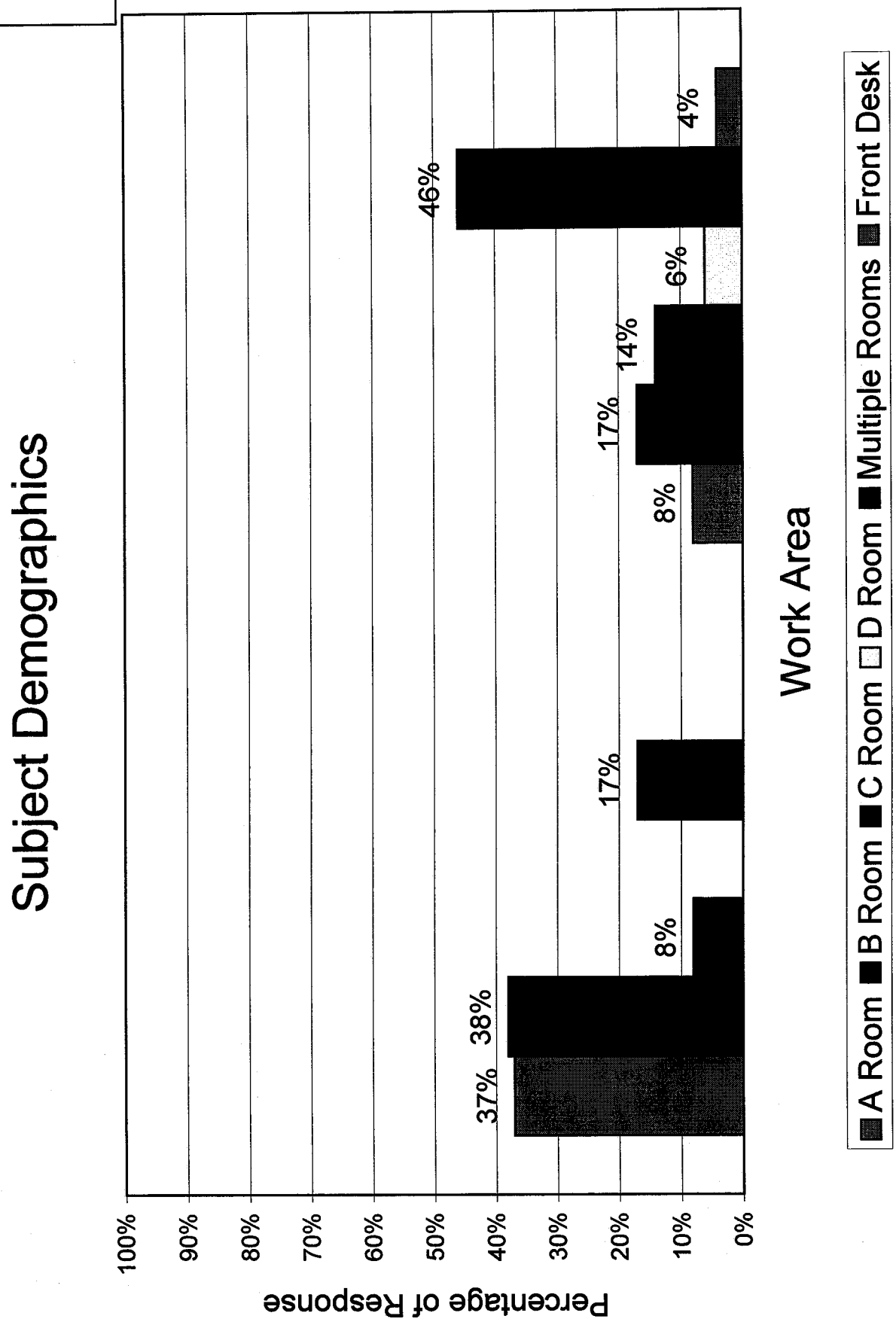

Subject Demographics
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
37%
38%
8%
17%
8%
46%
17%
14%
6%
4%
Work Area
A Room
B Room
C Room
D Room
Multiple Rooms
Front Desk

Figure 2

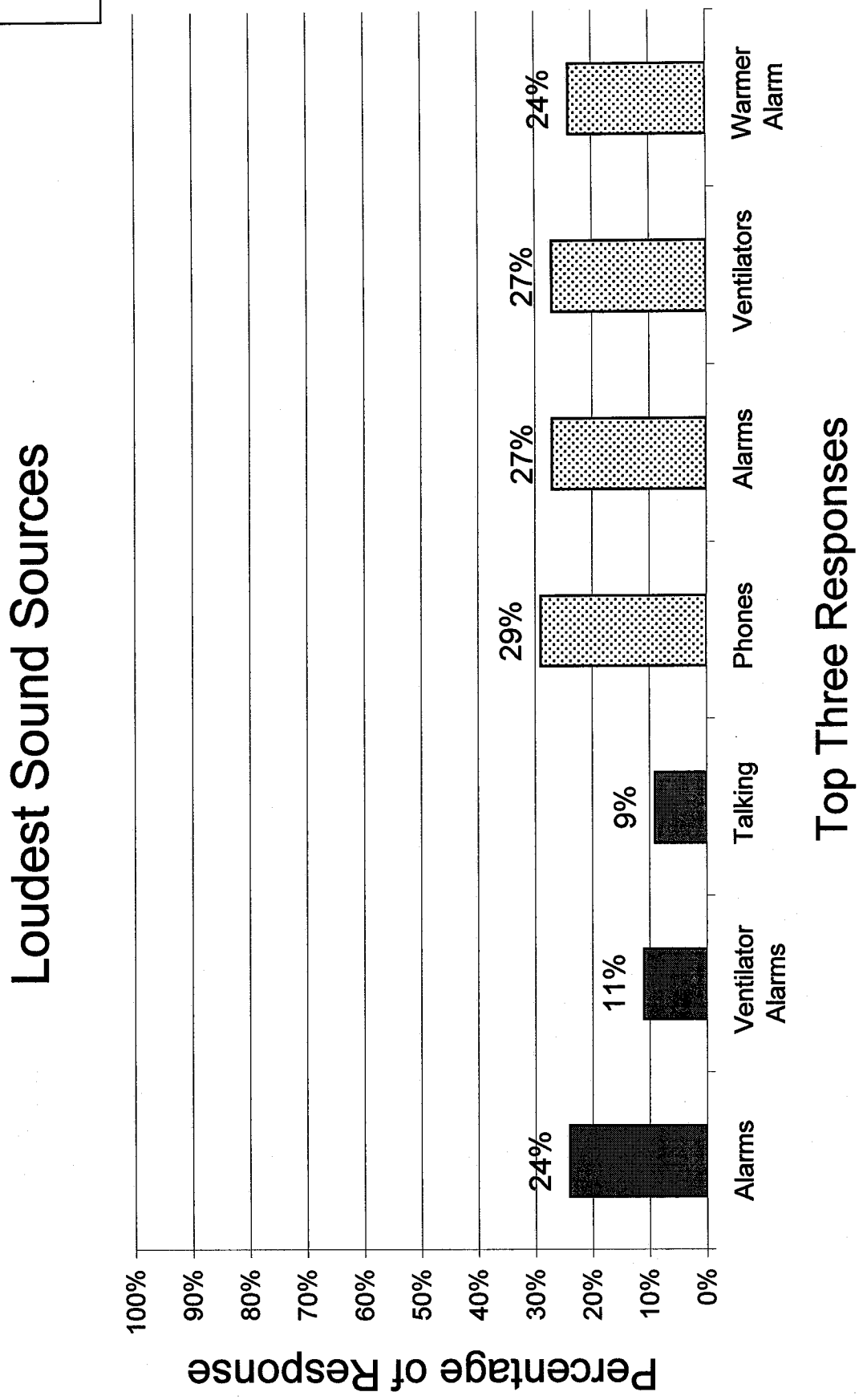

Loudest Sound Sources
Top Three Responses
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
24%
11%
9%
29%
27%
27%
24%
Alarms
Ventilator Alarms
Talking
Phones
Alarms
Ventilators
Warmer Alarm

Figure 3

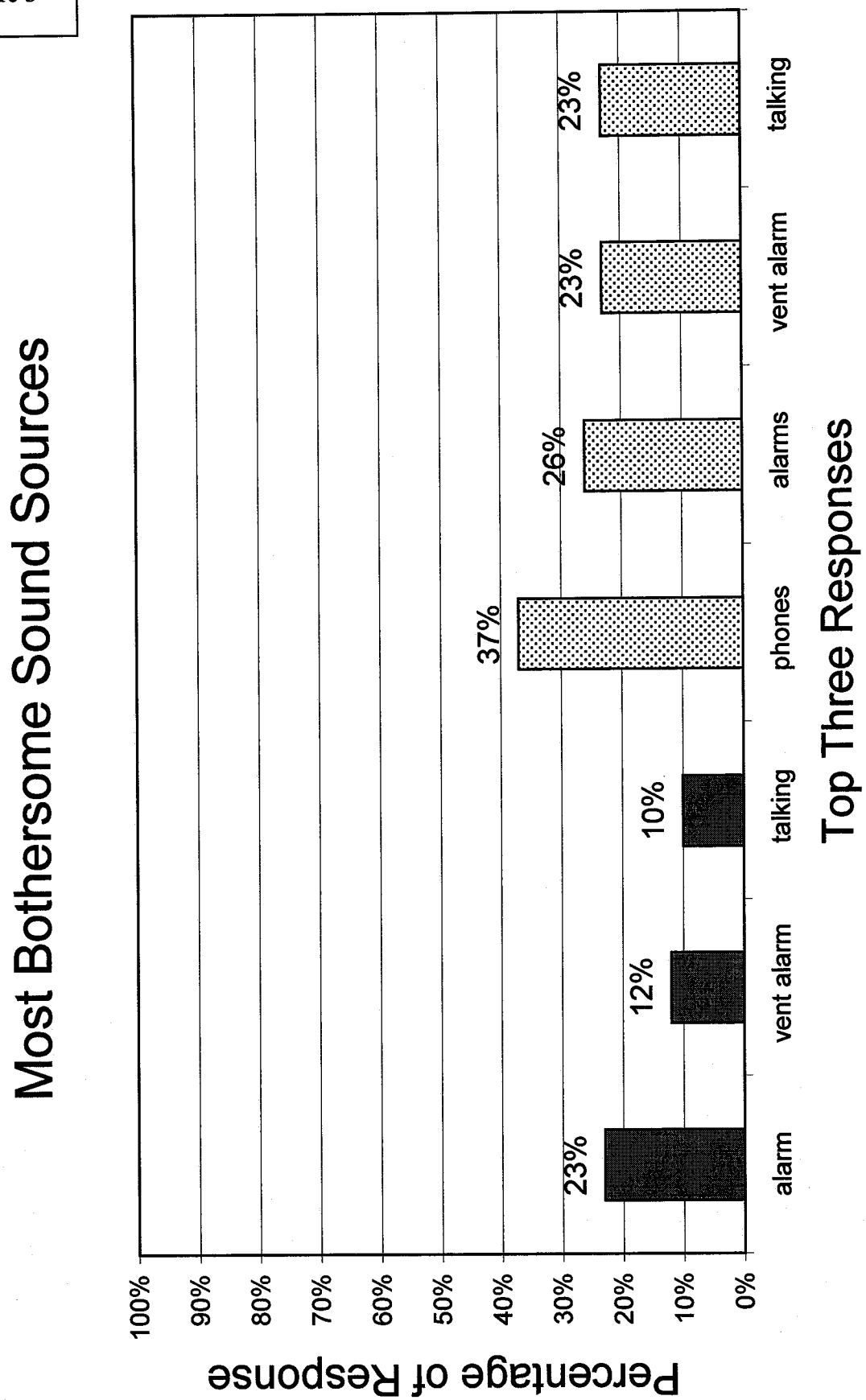

Most Bothersome Sound Sources
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
23%
12%
10%
37%
26%
23%
23%
alarm
vent alarm
talking
phones
alarms
vent alarm
talking
Top Three Responses

Figure 4

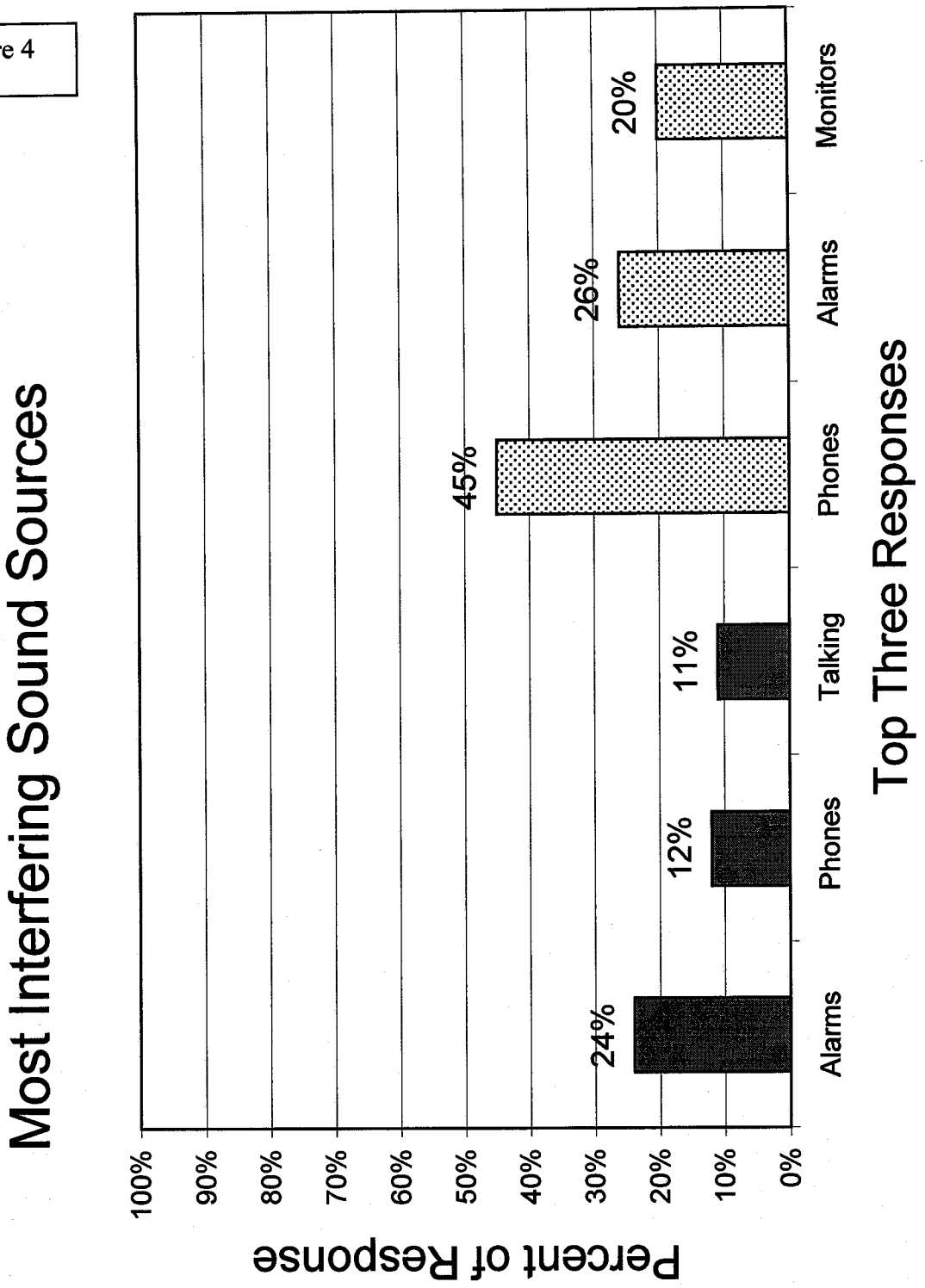

Most Interfering Sound Sources
Percent of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
24%
12%
11%
45%
26%
20%
Alarms
Phones
Talking
Phones
Alarms
Monitors
Top Three Responses

Figure 5

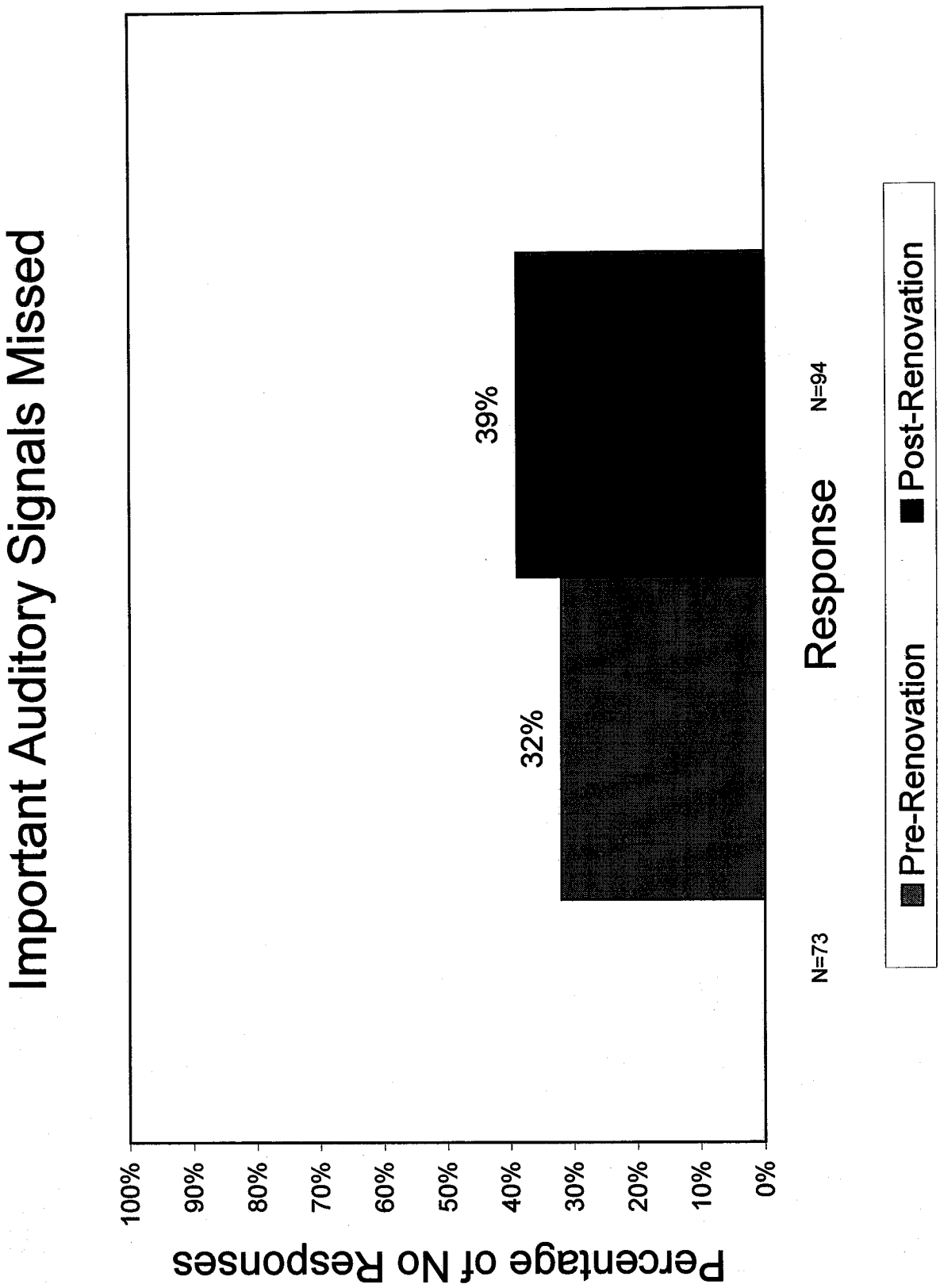

Important Auditory Signals Missed
Percentage of No Responses
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
39%
32%
N=73
N=94
Response
Pre-Renovation
Post-Renovation

Figure 6

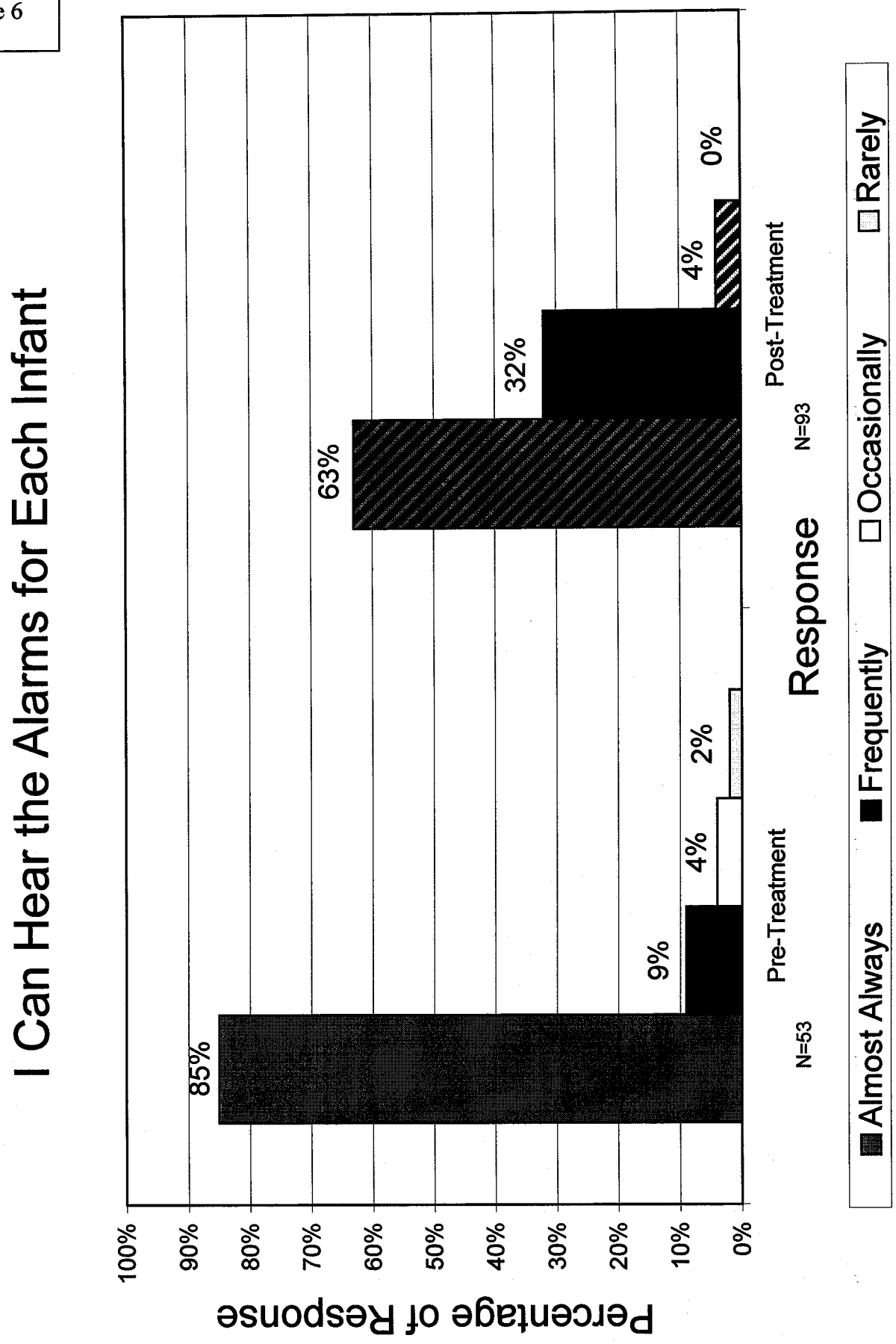

I Can Hear the Alarms for Each Infant
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
85%
9%
4%
2%
63%
32%
4%
0%
Pre-Treatment
N=53
Post-Treatment
N=93
Response
Almost Always
Frequently
Occasionally
Rarely

Figure 7

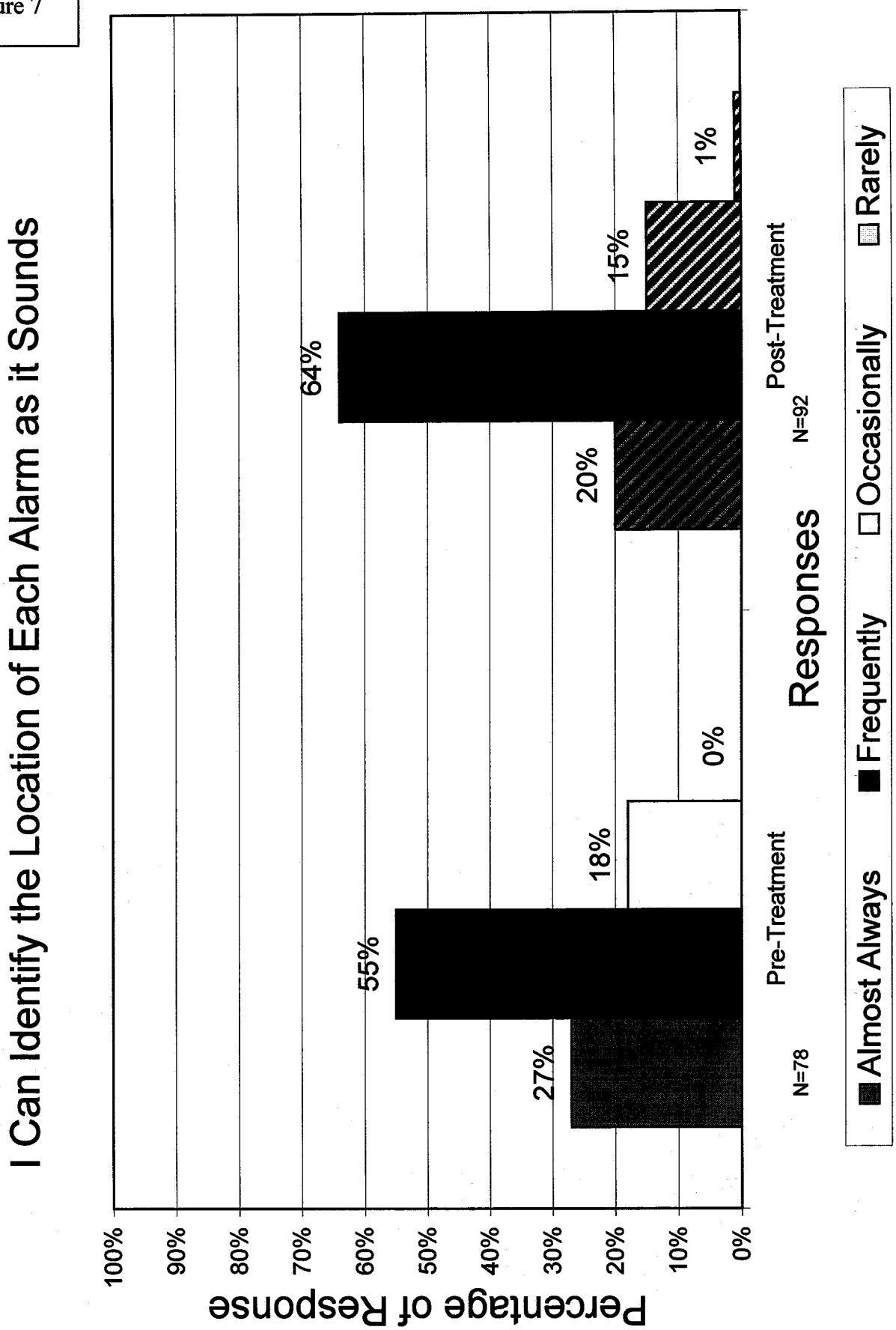

I Can Identify the Location of Each Alarm as it Sounds
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
27%
55%
18%
0%
64%
20%
15%
1%
Pre-Treatment
N=78
Post-Treatment
N=92
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 8

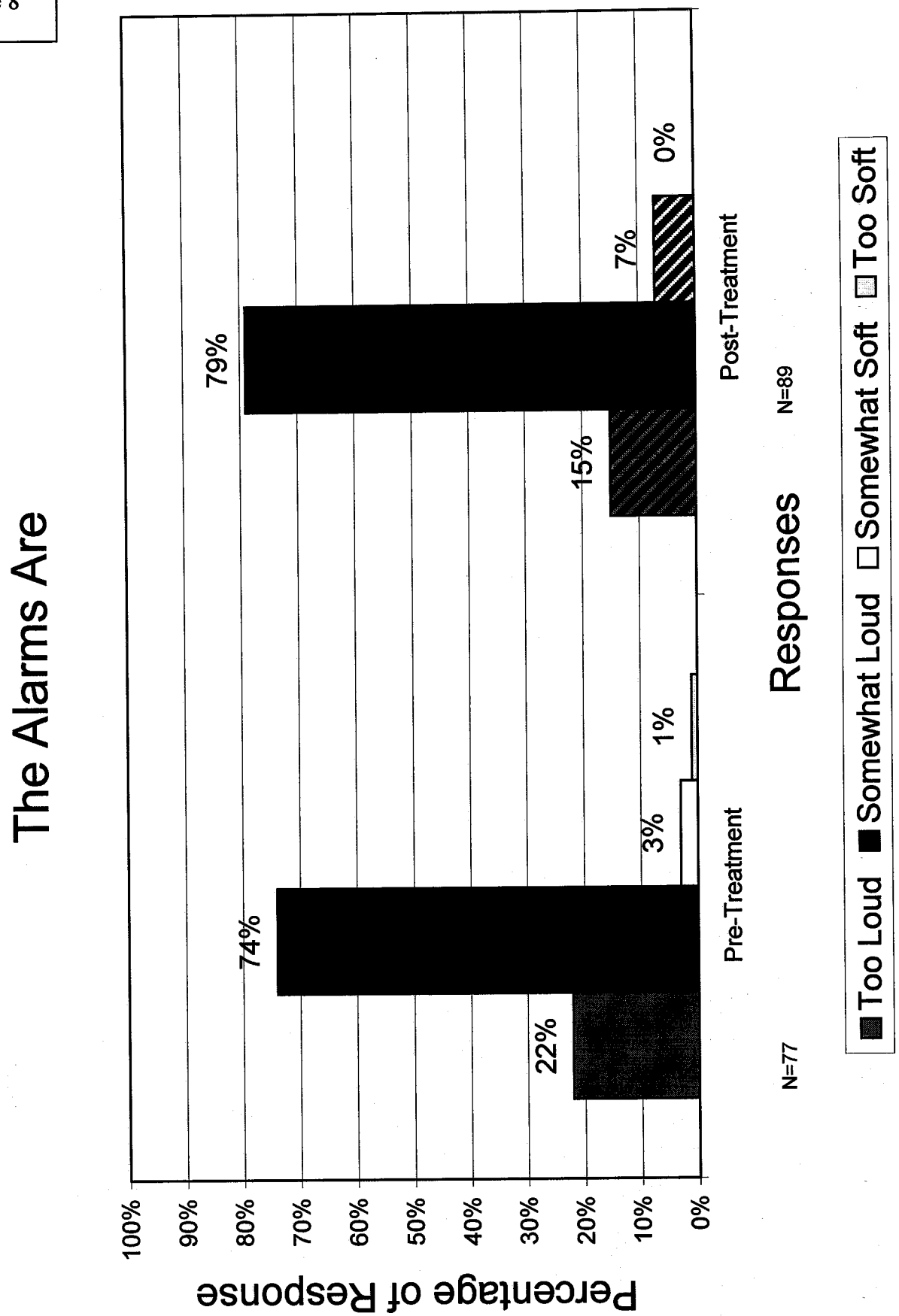

The Alarms Are
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
74%
22%
3%
1%
79%
15%
7%
0%
Pre-Treatment
Post-Treatment
Responses
N=77
N=89
Too Loud
Somewhat Loud
Somewhat Soft
Too Soft

Figure 9

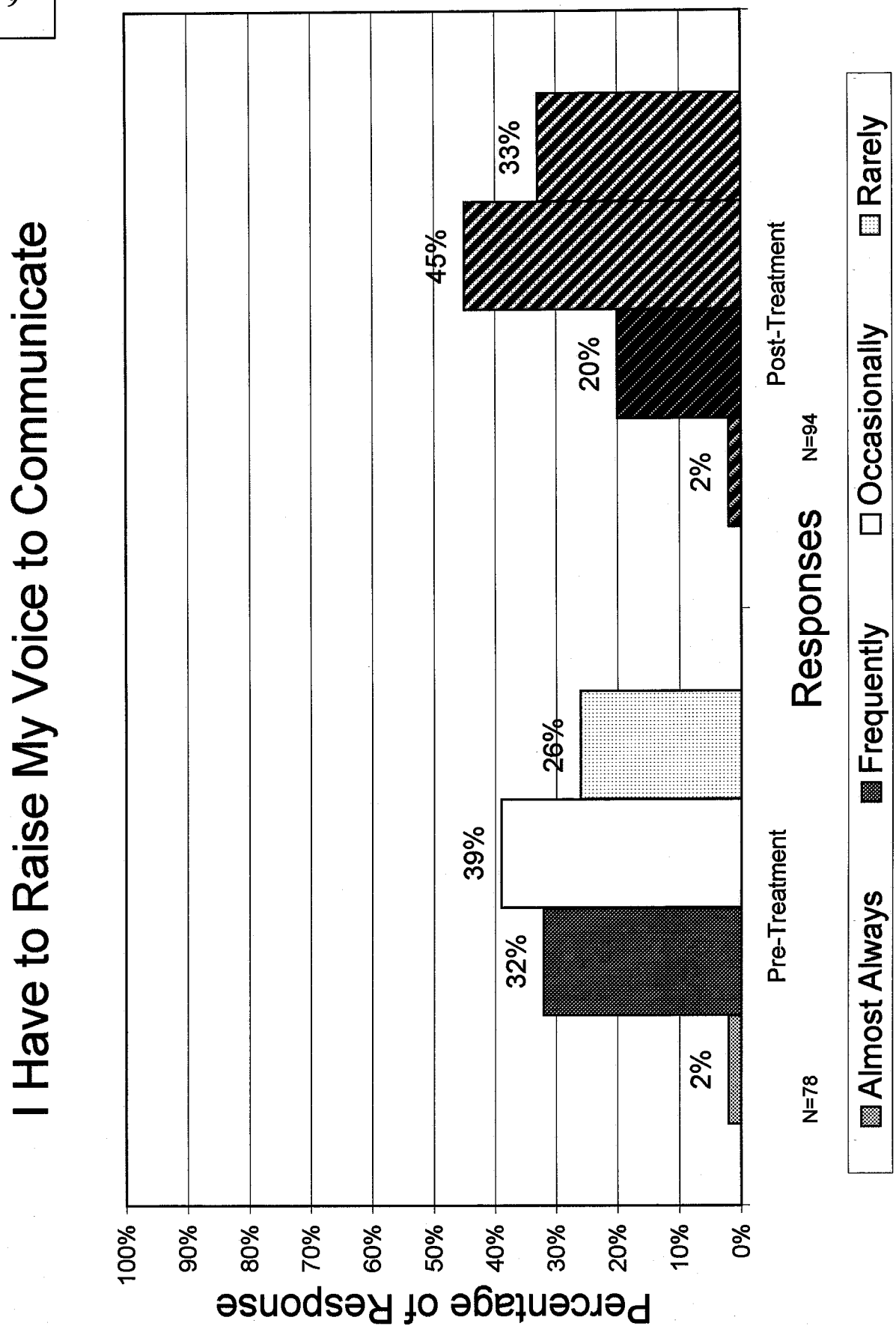

I Have to Raise My Voice to Communicate
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2%
32%
39%
26%
2%
20%
45%
33%
Pre-Treatment
Post-Treatment
Responses
N=78
N=94
Almost Always
Frequently
Occasionally
Rarely

Figure 10

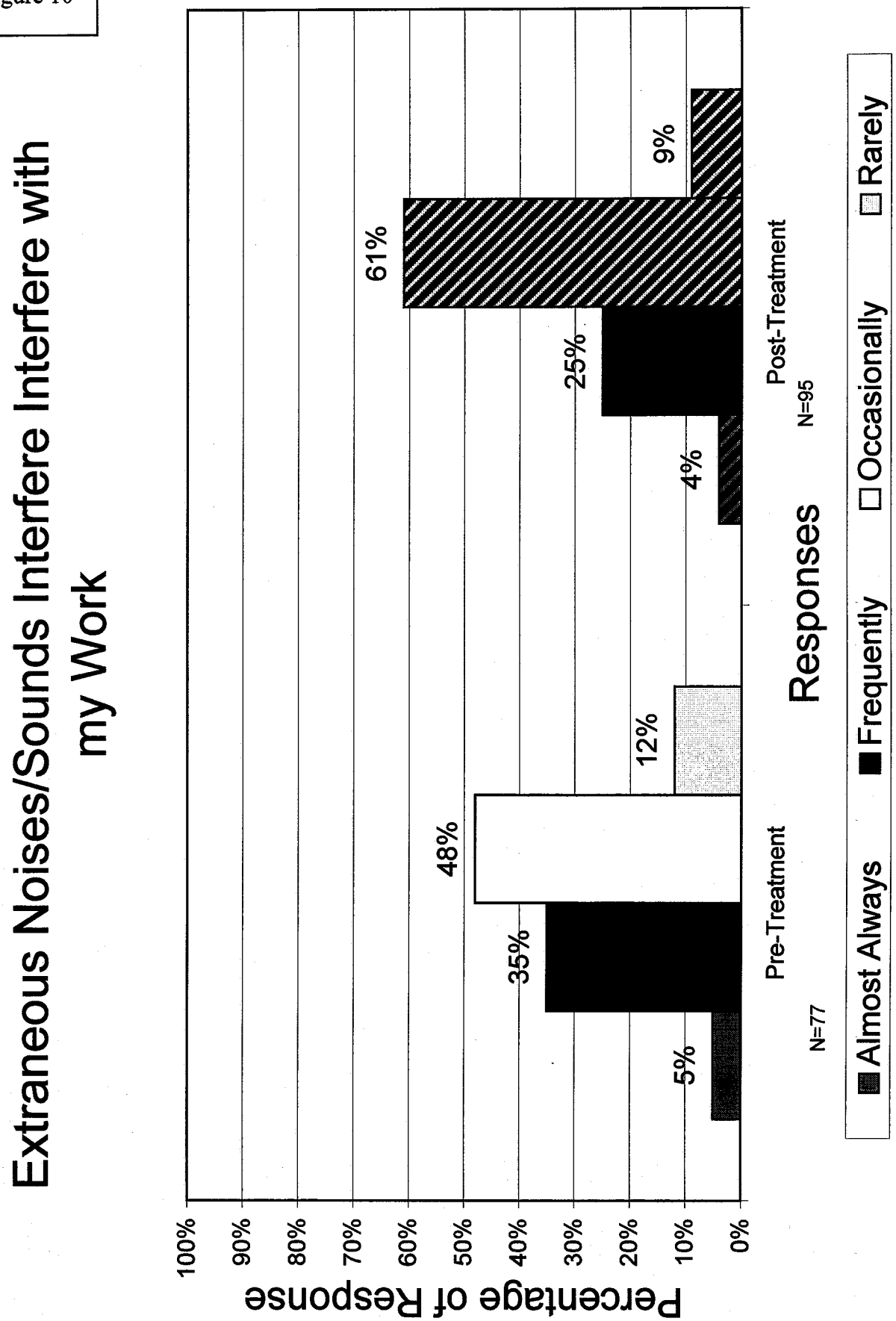

Extraneous Noises/Sounds Interfere Interfere with my Work
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5%
35%
48%
12%
25%
61%
4%
9%
Pre-Treatment
N=77
Post-Treatment
N=95
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 11

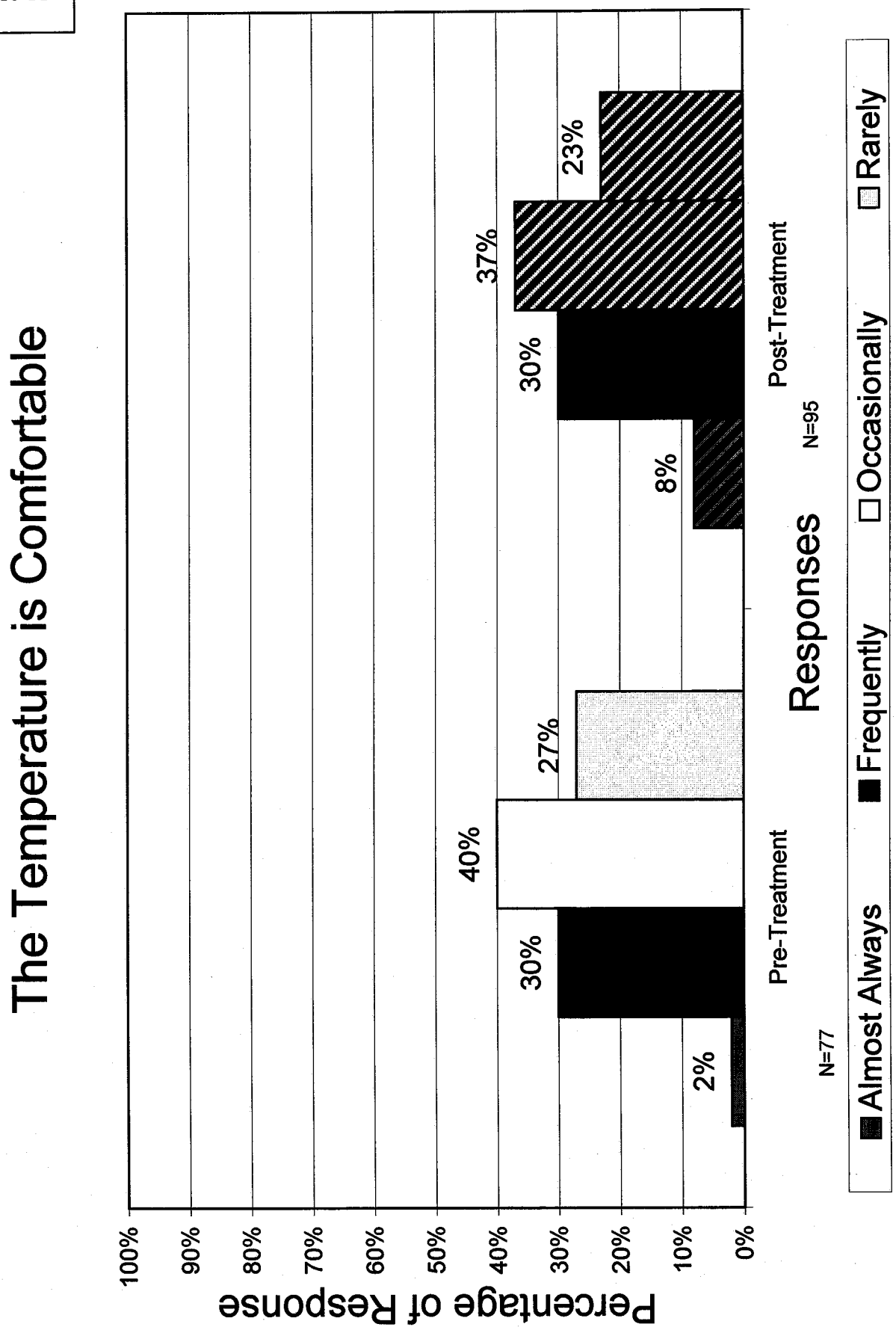

The Temperature is Comfortable
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2%
30%
40%
27%
37%
30%
8%
23%
Pre-Treatment
Post-Treatment
Responses
N=77
N=95
Almost Always
Frequently
Occasionally
Rarely

Figure 12

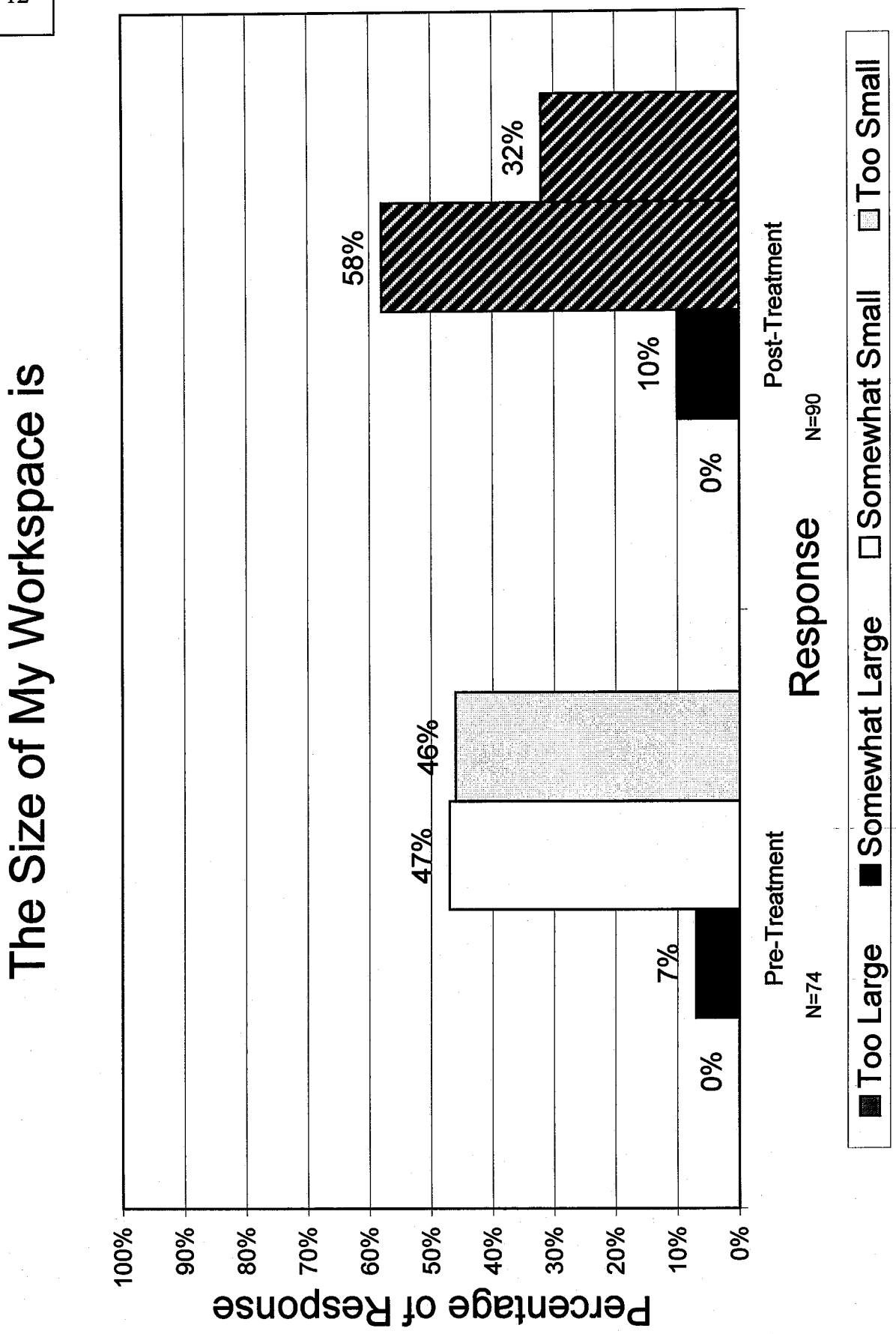

The Size of My Workspace is
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
7%
47%
46%
10%
0%
58%
32%
Pre-Treatment
N=74
Post-Treatment
N=90
Response
Too Large
Somewhat Large
Somewhat Small
Too Small

Figure 13

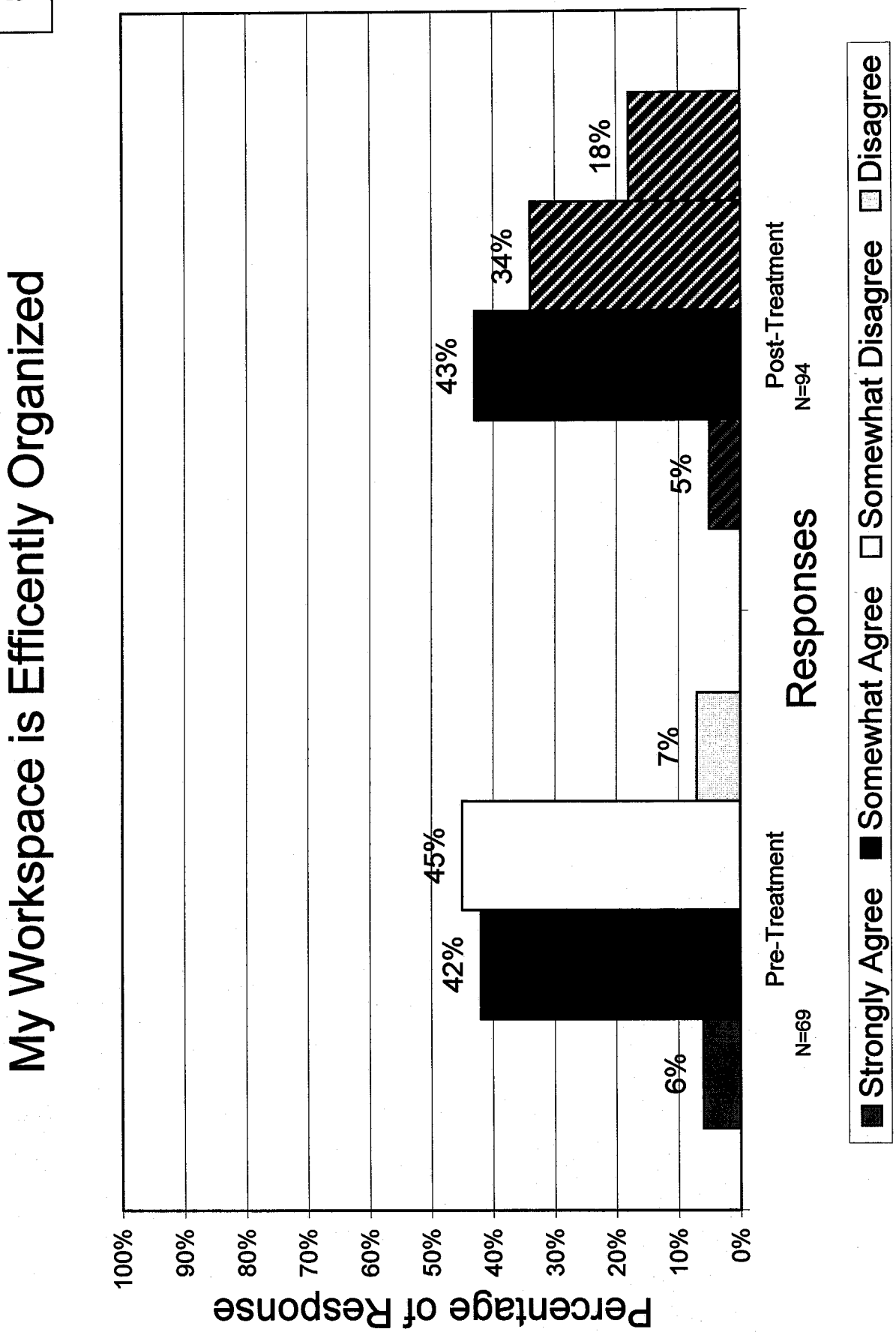

My Workspace is Efficently Organized
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
6%
42%
45%
7%
43%
34%
18%
5%
Pre-Treatment
N=69
Post-Treatment
N=94
Responses
Strongly Agree
Somewhat Agree
Somewhat Disagree
Disagree

Figure 14

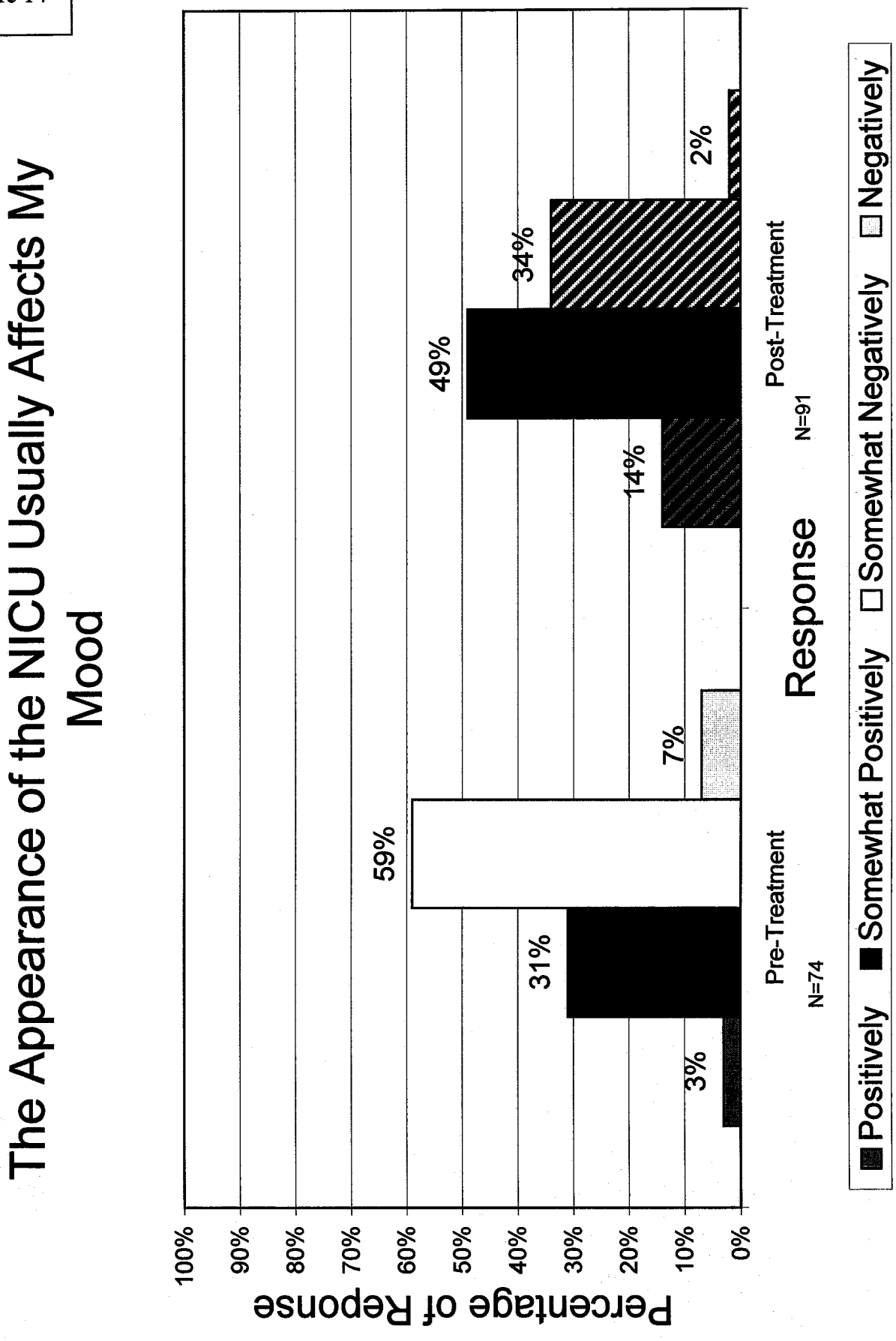

The Appearance of the NICU Usually Affects My Mood
Percentage of Reponse
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
59%
31%
3%
7%
14%
49%
34%
2%
Pre-Treatment
N=74
Post-Treatment
N=91
Response
Positively
Somewhat Positively
Somewhat Negatively
Negatively

Figure 15

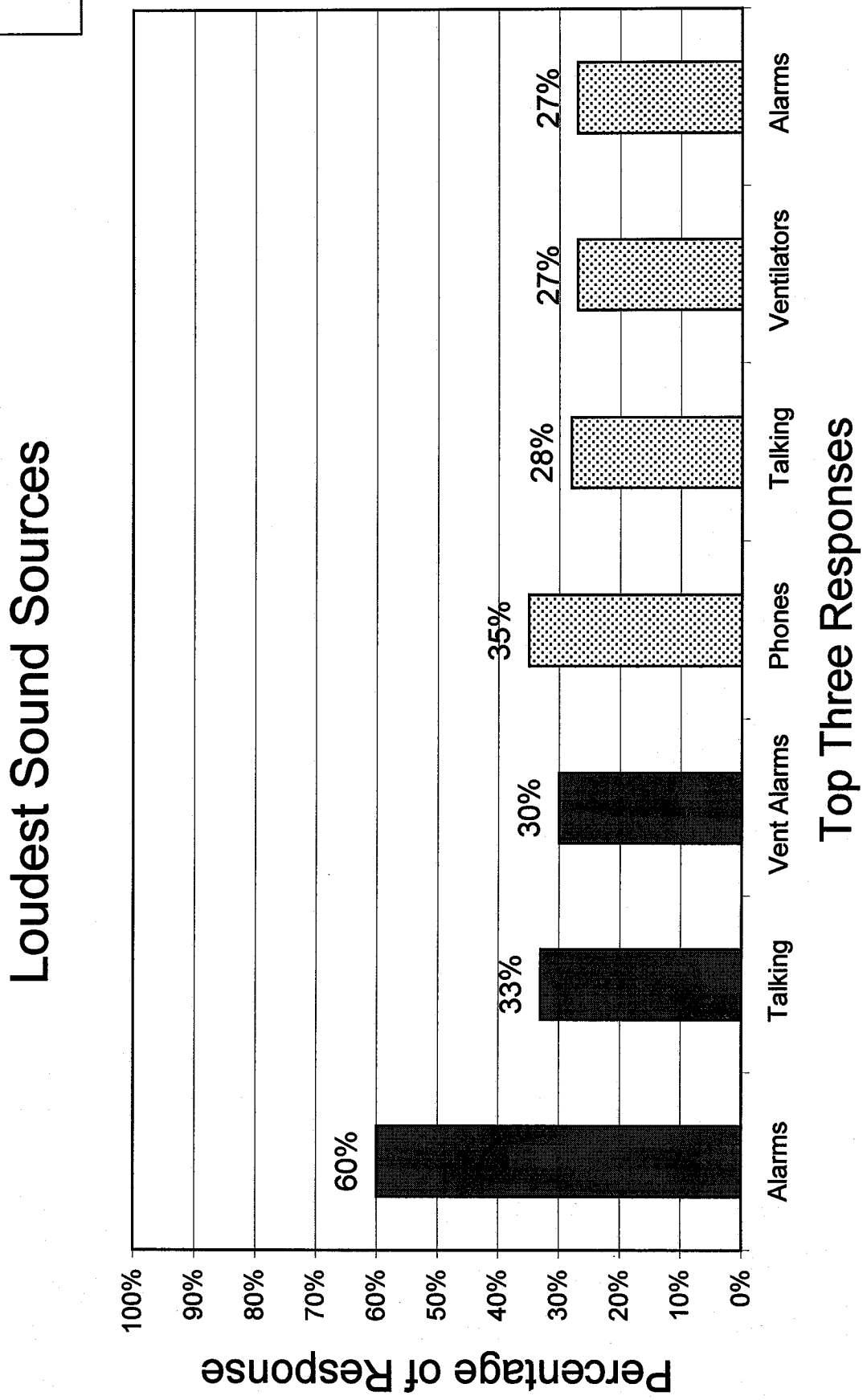

Loudest Sound Sources
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
60%
33%
30%
35%
28%
27%
27%
Alarms
Talking
Vent Alarms
Phones
Talking
Ventilators
Alarms
Top Three Responses

Figure 16

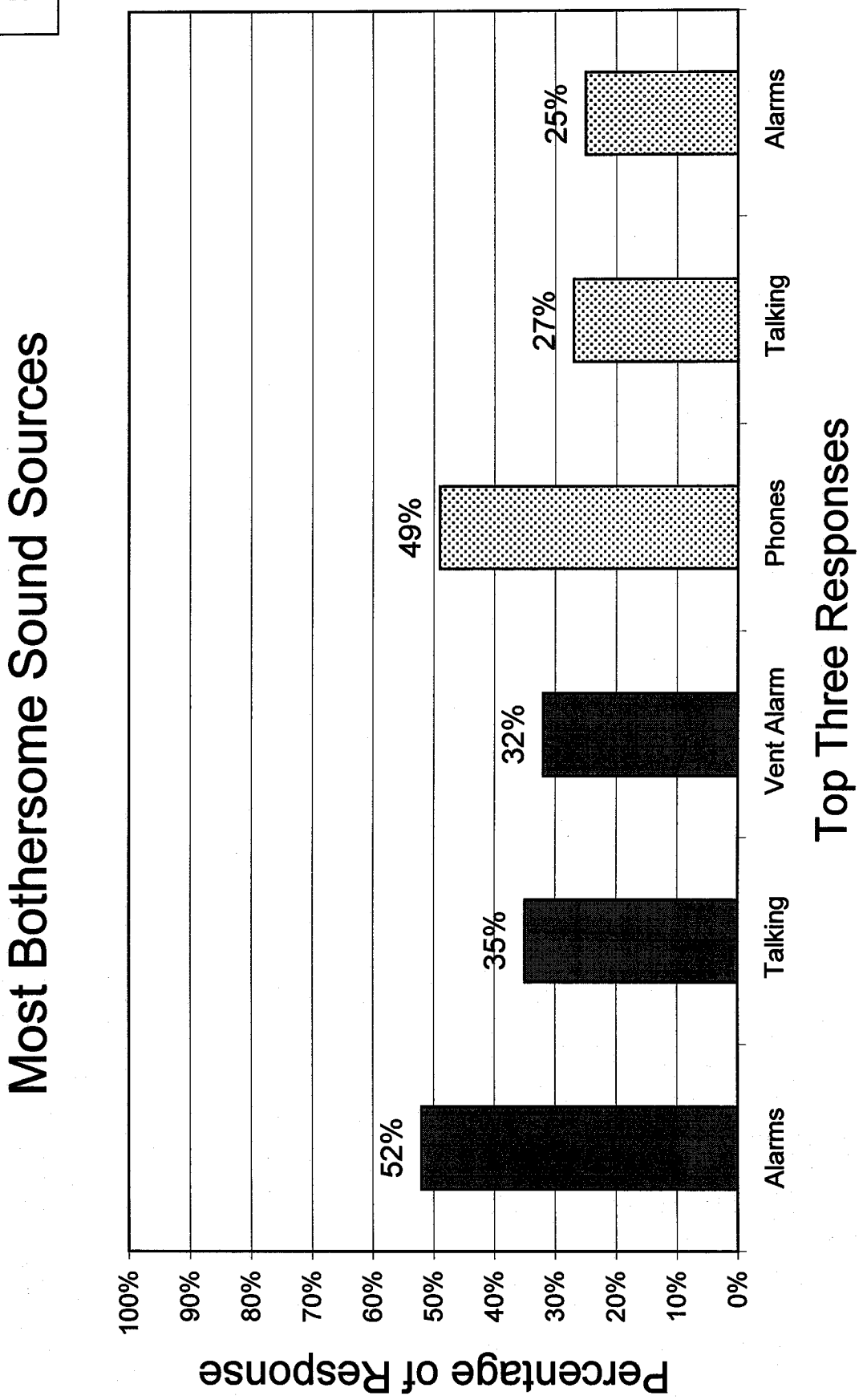

Most Bothersome Sound Sources
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
52%
35%
32%
49%
27%
25%
Alarms
Talking
Vent Alarm
Phones
Talking
Alarms
Top Three Responses

Figure 17

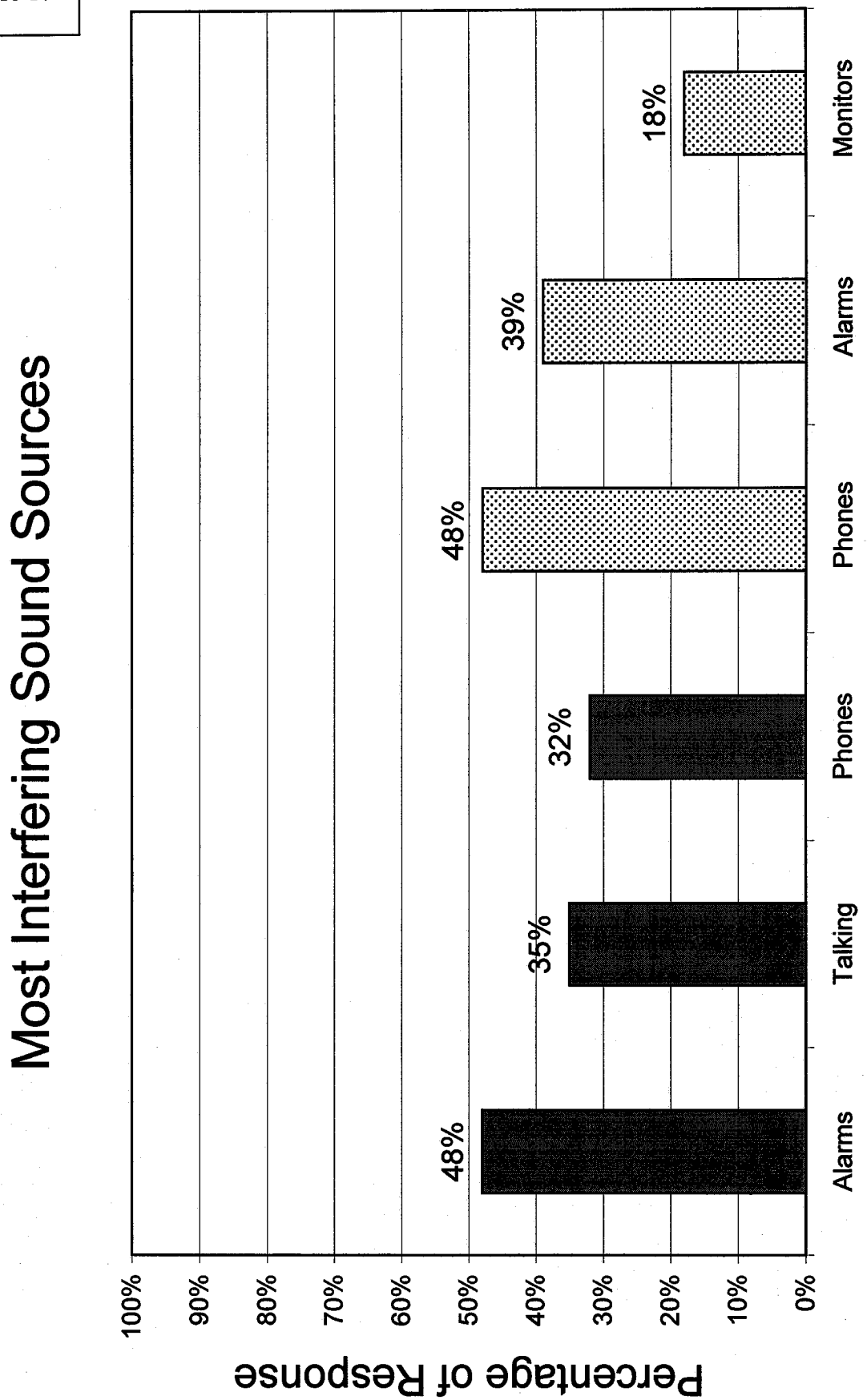

Most Interfering Sound Sources
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
48%
35%
32%
48%
39%
18%
Alarms
Talking
Phones
Phones
Alarms
Monitors
Top Three Responses

Figure 18

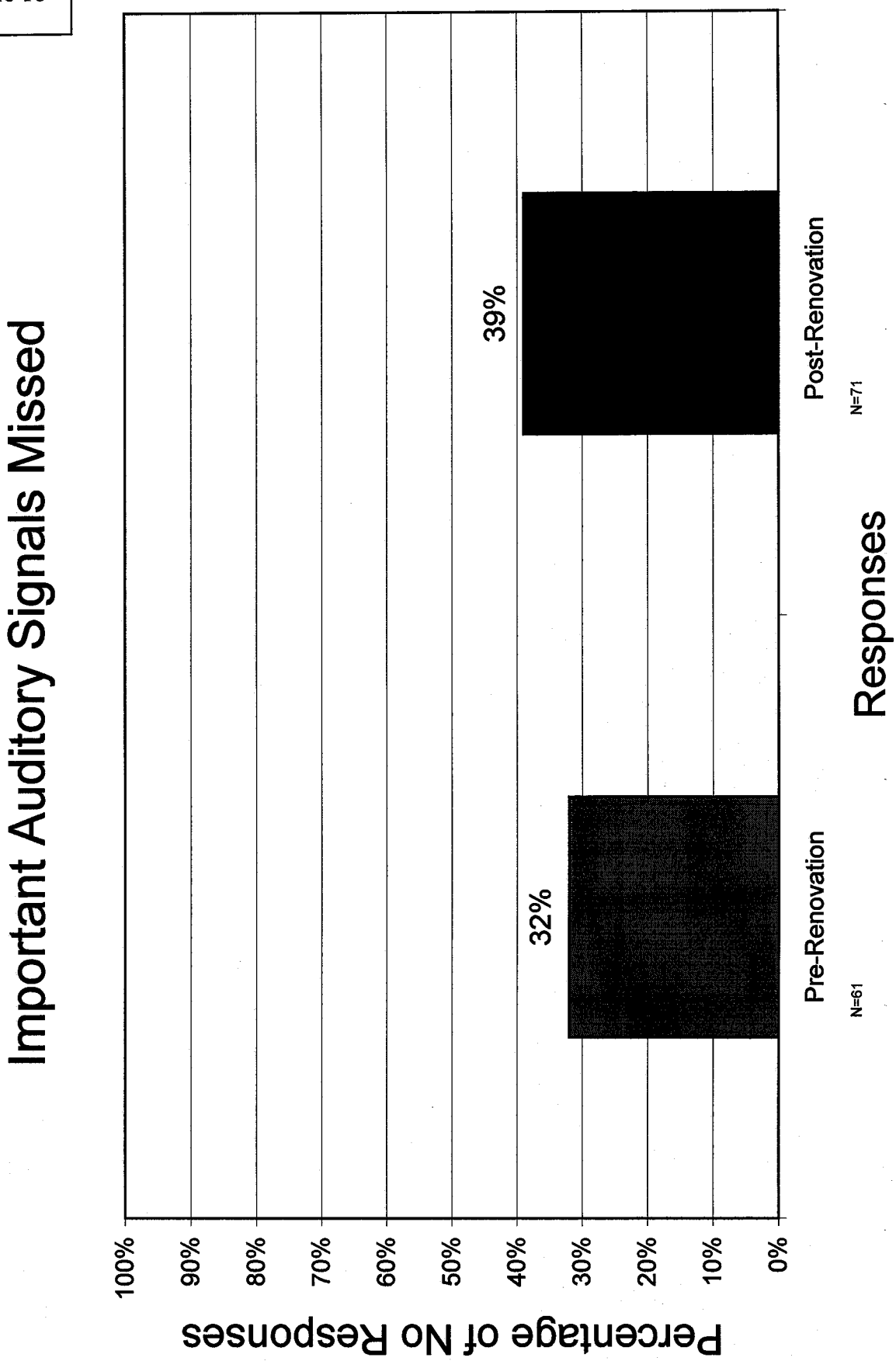

Important Auditory Signals Missed
Percentage of No Responses
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
32%
39%
Pre-Renovation
N=61
Post-Renovation
N=71
Responses

Figure 19

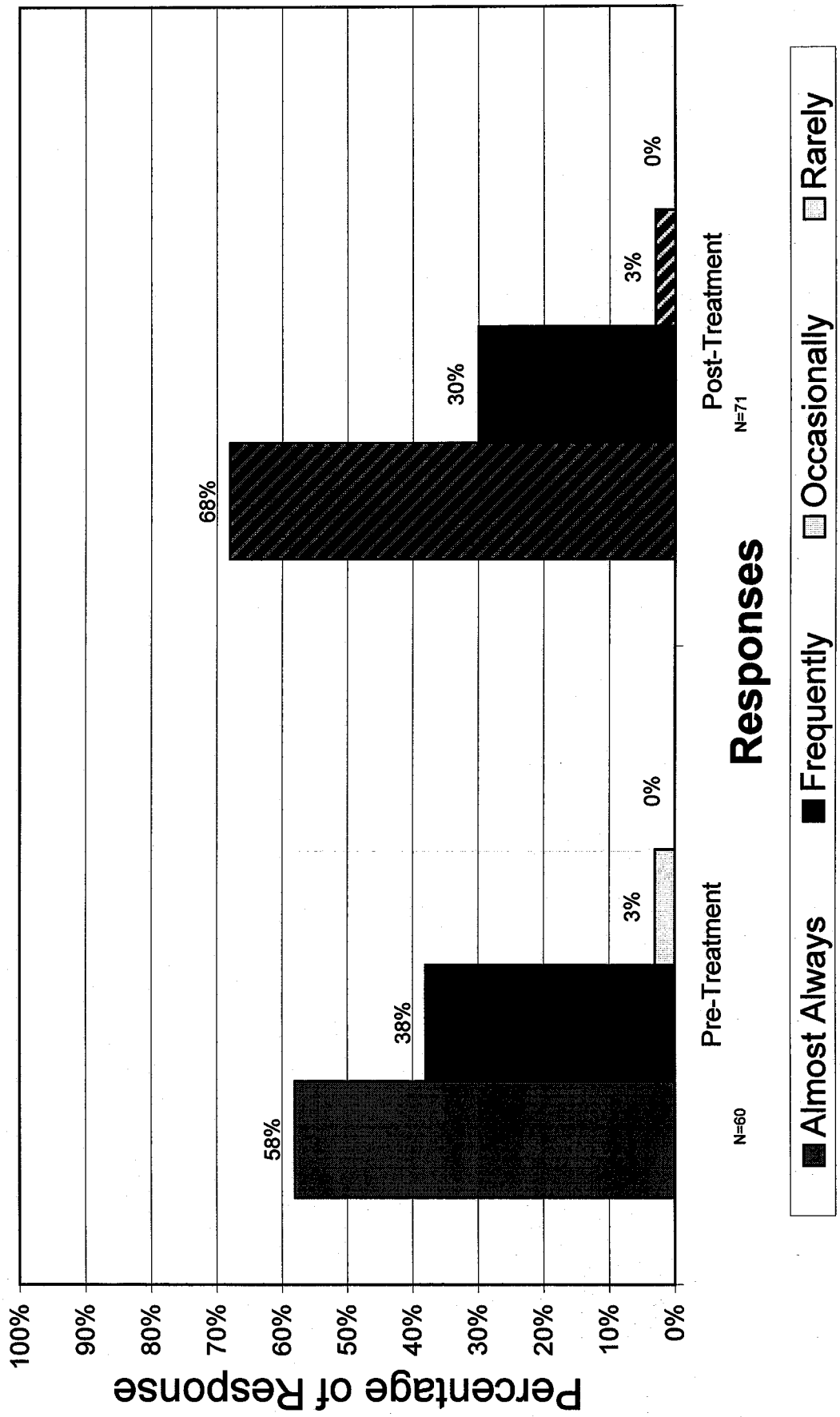

I Can Hear the Alarms for Each Infant
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
58%
38%
3%
0%
68%
30%
3%
0%
Pre-Treatment
N=60
Post-Treatment
N=71
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 20

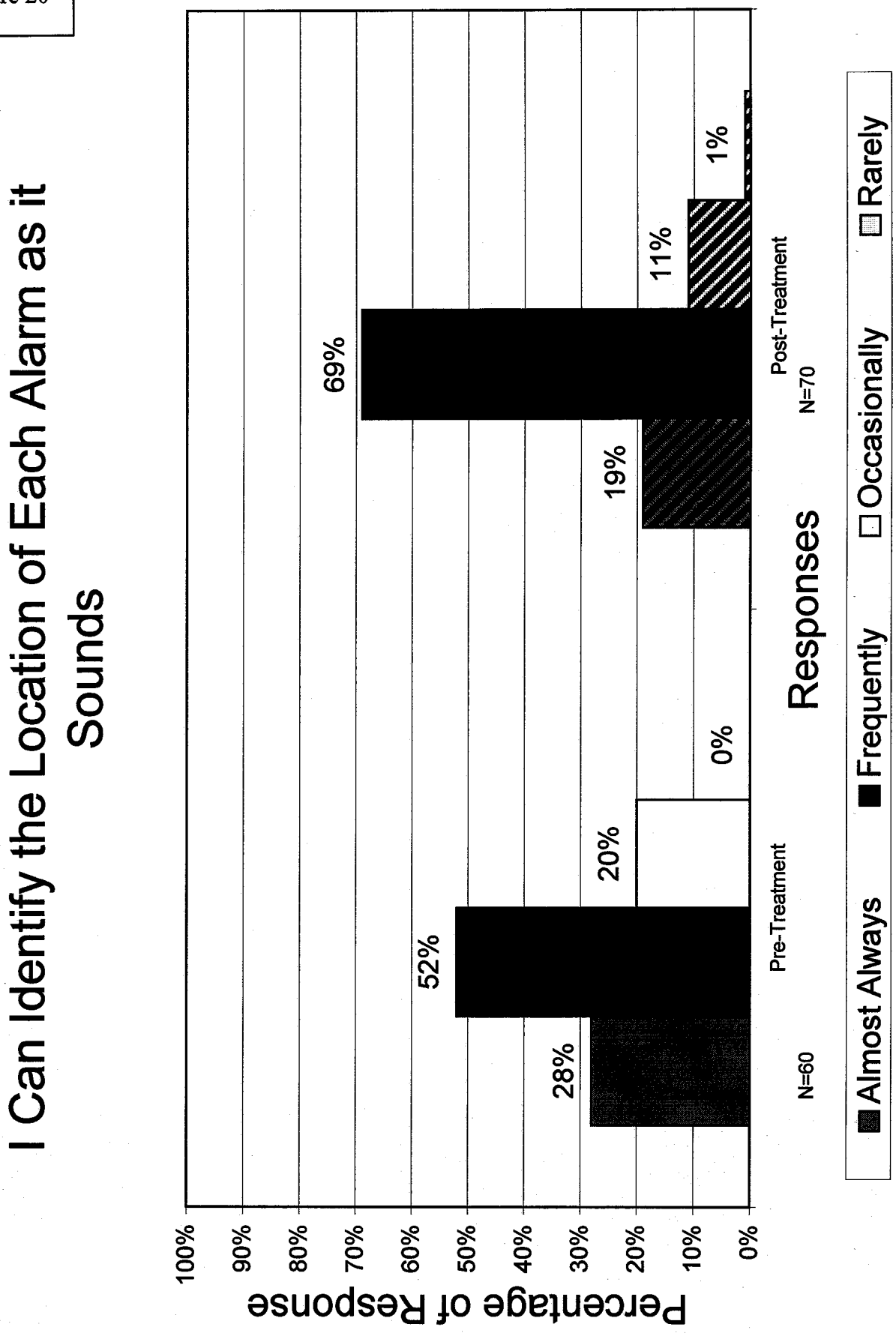

I Can Identify the Location of Each Alarm as it Sounds
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
28%
52%
20%
0%
69%
19%
11%
1%
Pre-Treatment
N=60
Post-Treatment
N=70
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 21

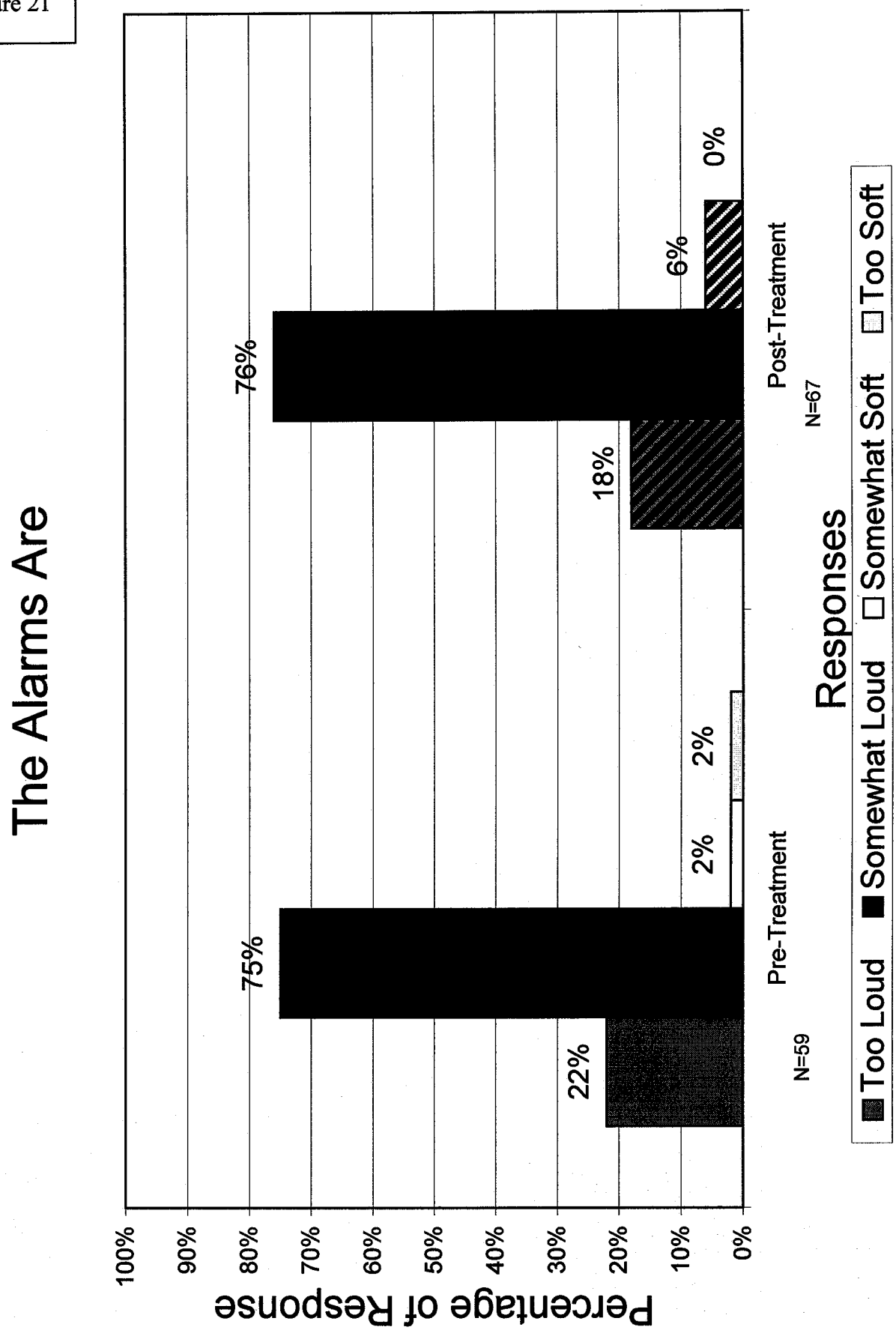

The Alarms Are
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
75%
22%
2%
2%
76%
18%
6%
0%
Pre-Treatment
N=59
Post-Treatment
N=67
Responses
Too Loud
Somewhat Loud
Somewhat Soft
Too Soft

Figure 22

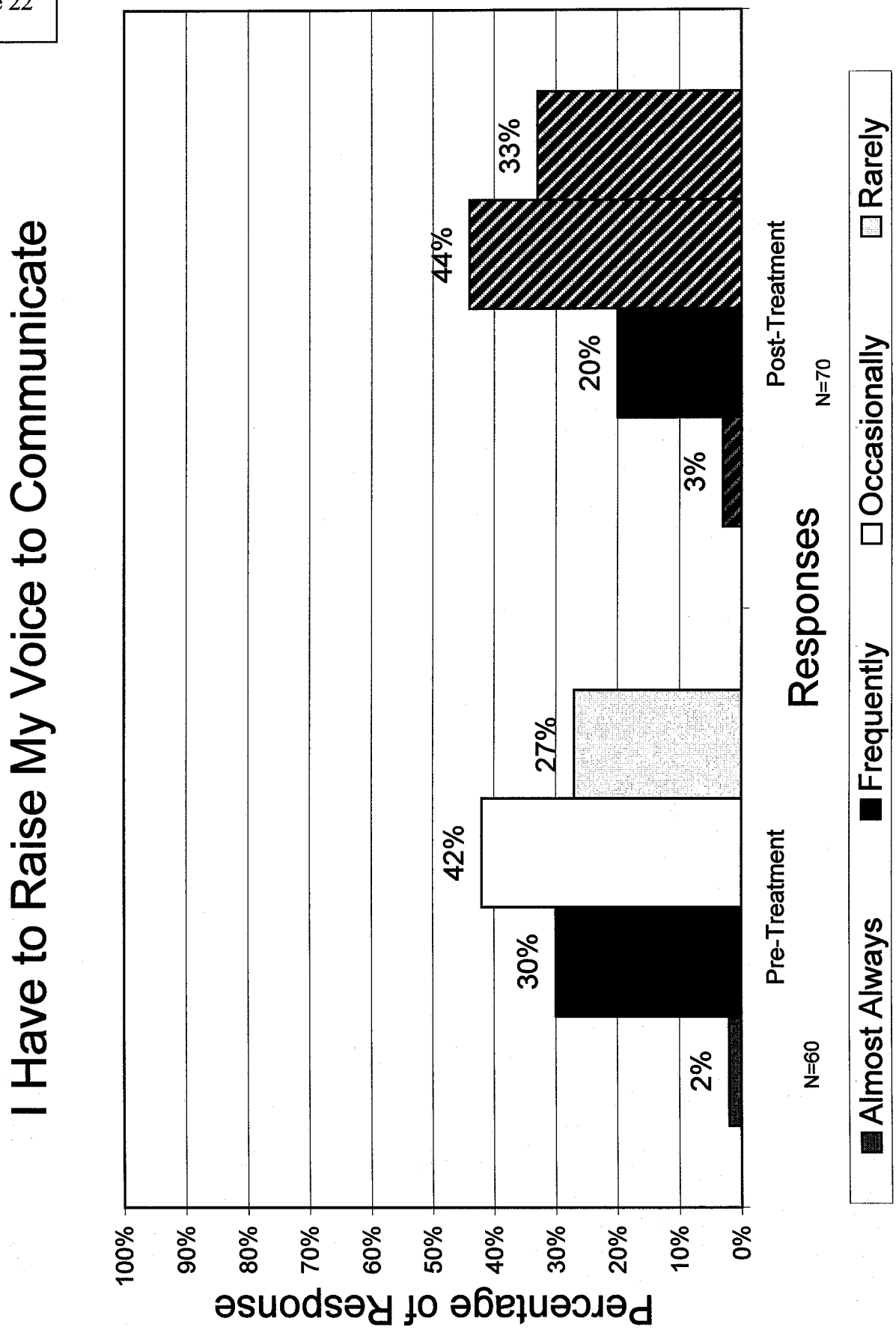

I Have to Raise My Voice to Communicate
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2%
30%
42%
27%
3%
20%
44%
33%
Pre-Treatment
Post-Treatment
N=60
N=70
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 23

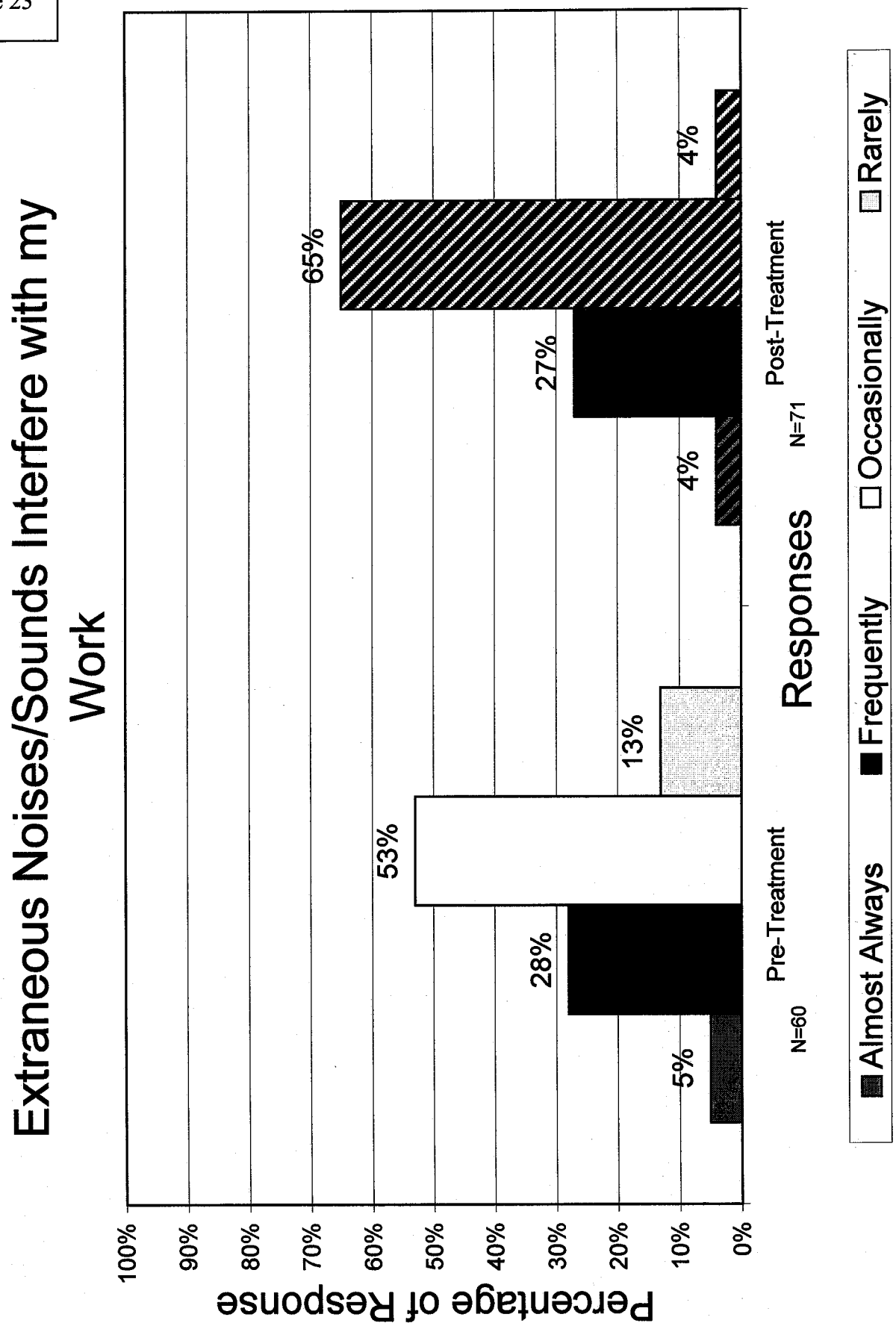

Extraneous Noises/Sounds Interfere with my Work
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5%
28%
53%
13%
4%
27%
65%
4%
Pre-Treatment
N=60
Post-Treatment
N=71
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 24

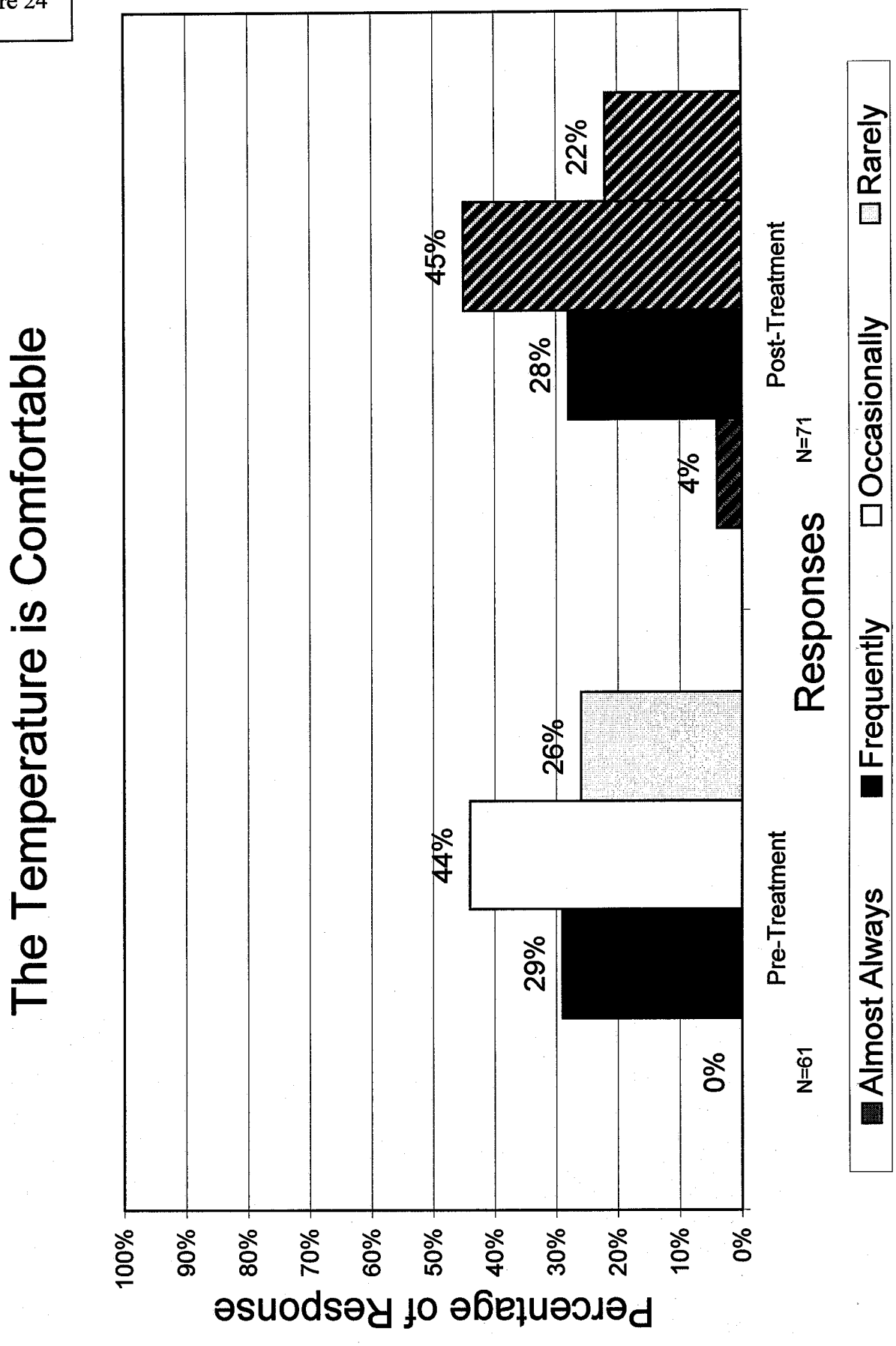

The Temperature is Comfortable
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
44%
29%
26%
0%
45%
28%
22%
4%
Pre-Treatment
N=61
Post-Treatment
N=71
Responses
Almost Always
Frequently
Occasionally
Rarely

Figure 25

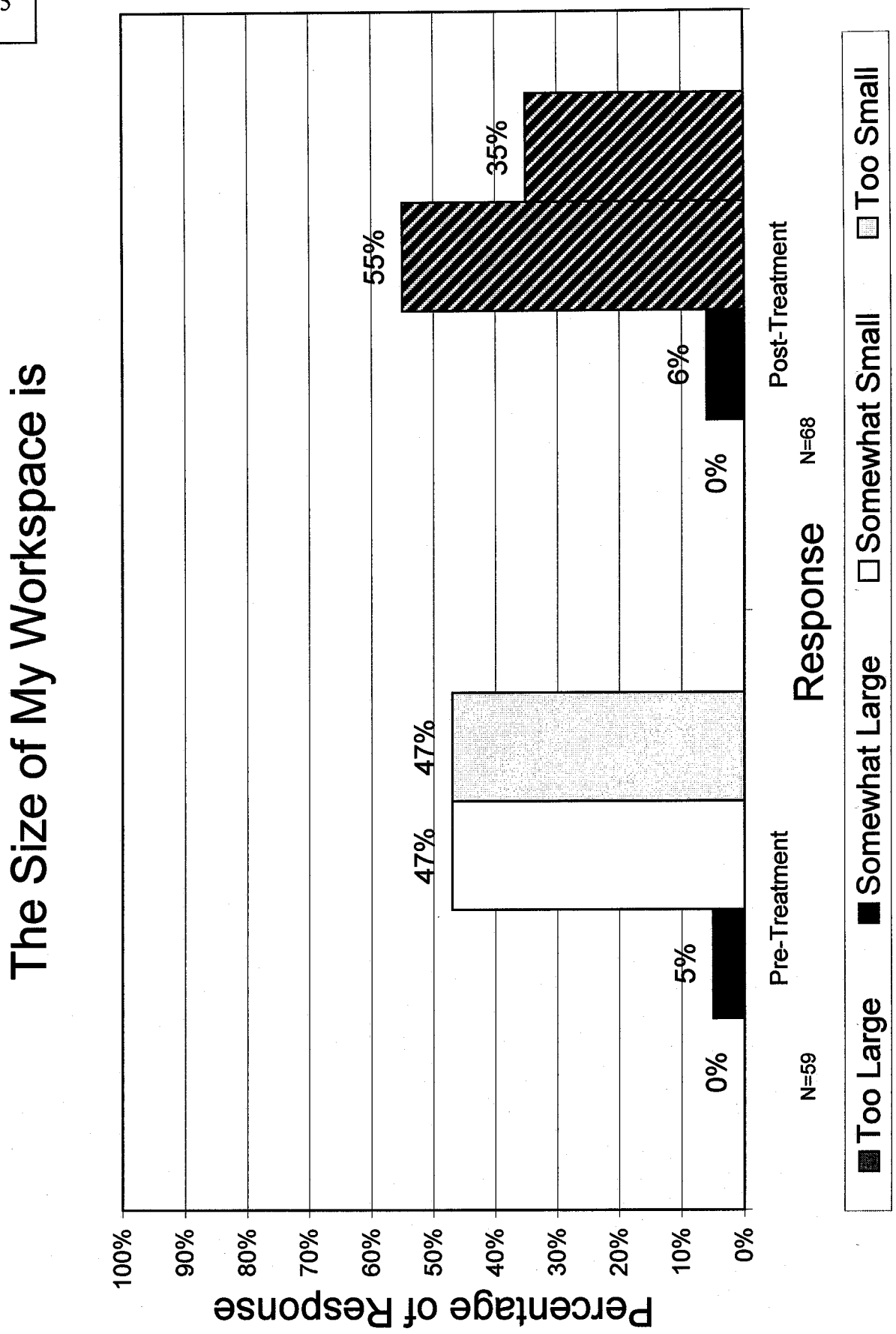

The Size of My Workspace is
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
47%
47%
5%
0%
55%
35%
6%
0%
Pre-Treatment
N=59
Post-Treatment
N=68
Response
Too Large
Somewhat Large
Somewhat Small
Too Small

Figure 26

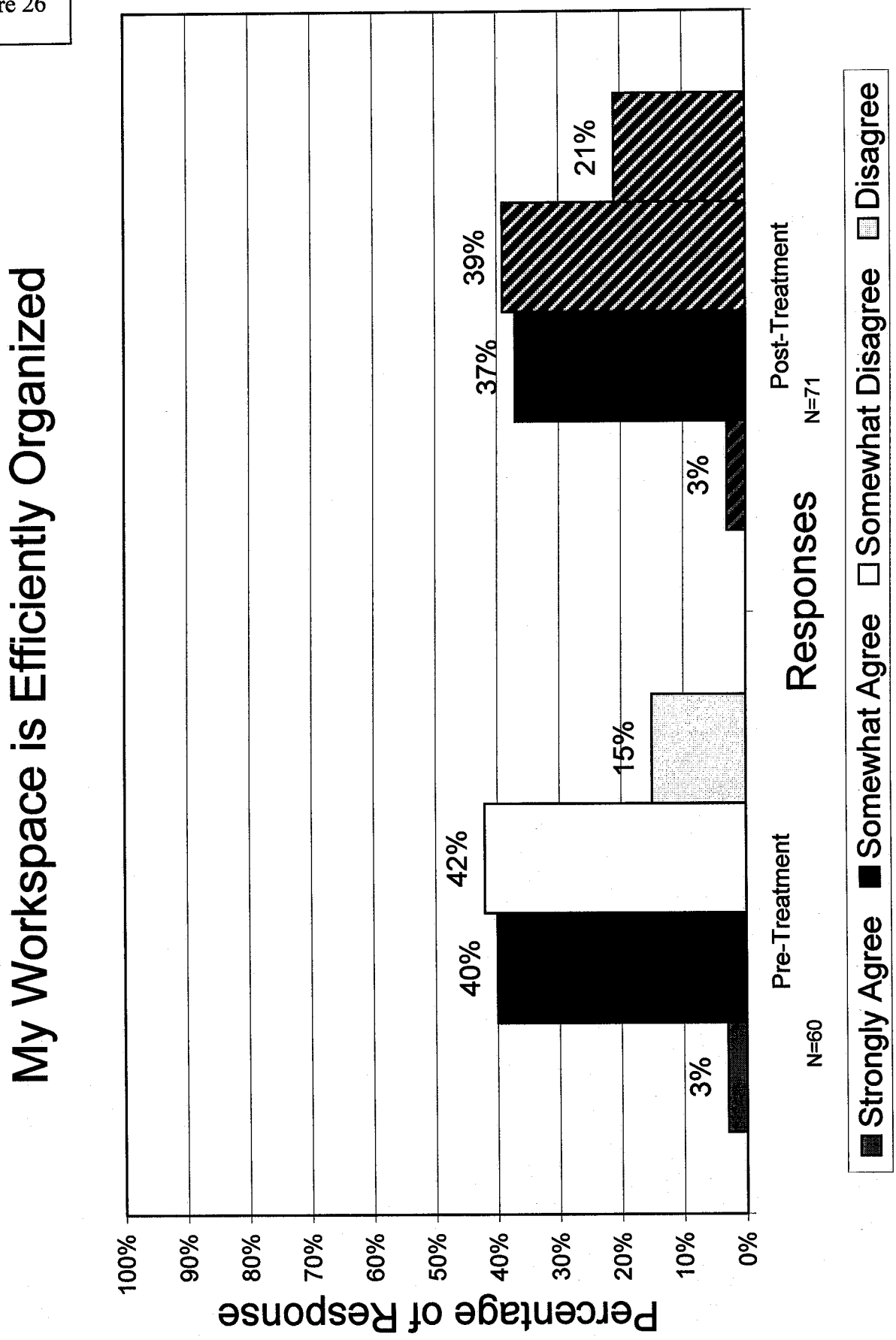
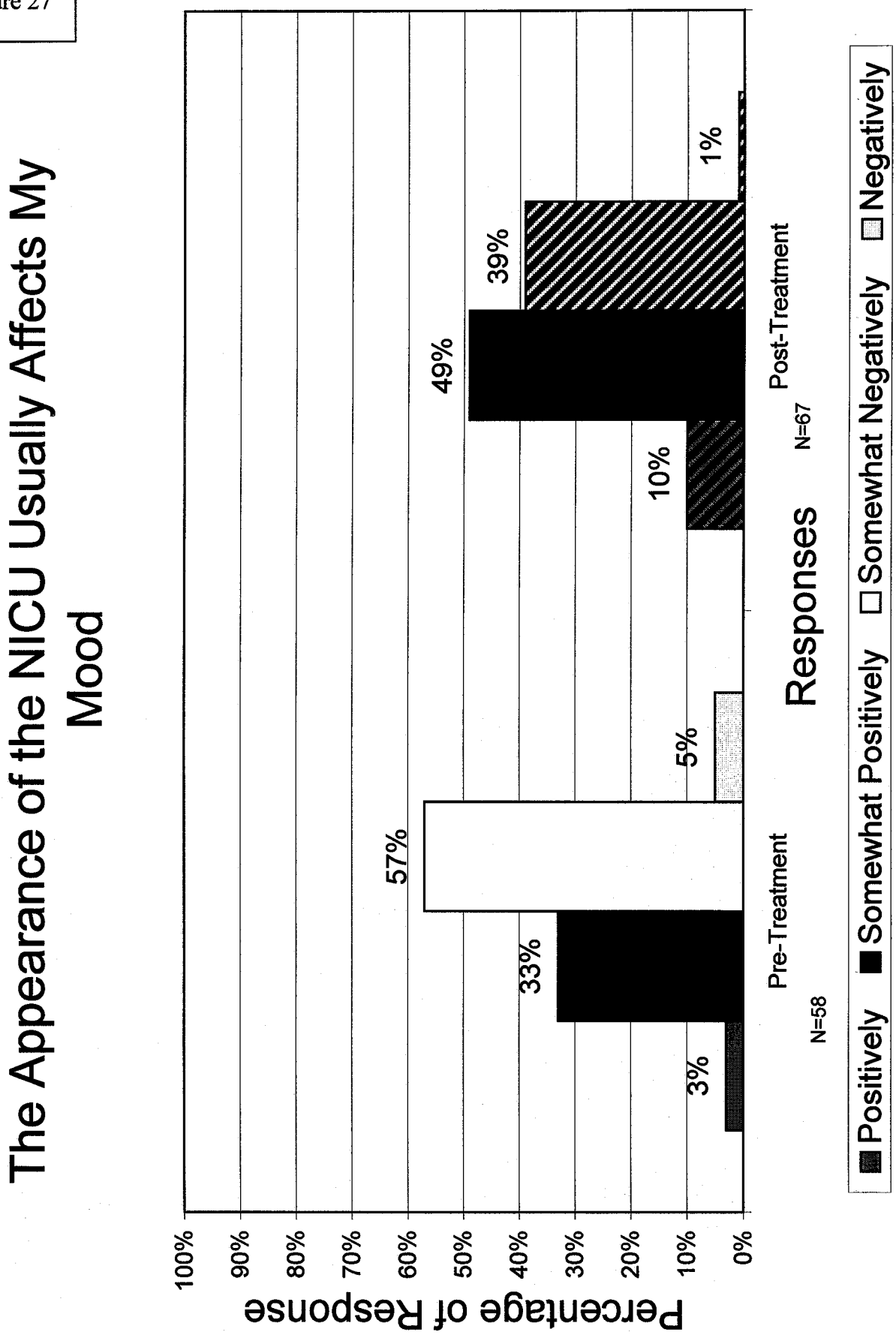

My Workspace is Efficiently Organized
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
3%
40%
42%
15%
3%
37%
39%
21%
Pre-Treatment
N=60
Responses
Post-Treatment
N=71
Strongly Agree
Somewhat Agree
Somewhat Disagree
Disagree

Figure 27


The Appearance of the NICU Usually Affects My Mood
Percentage of Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
57%
33%
3%
5%
49%
39%
10%
1%
Pre-Treatment
N=58
Post-Treatment
N=67
Responses
Positively
Somewhat Positively
Somewhat Negatively
Negatively

Appendix D

Statistical Grouping Across Surveys

	Entire Population					Nurses Only				
	Pre-Renovation		Post Renovation			Pre-Renovation		Post-Renovation		
	Group 1	Group 2	Group 1	Group 2	P-Value	Group 1	Group 2	Group 1	Group 2	P-Value
#9	94%†	6%	95%†	4%	0.380	96%†	3%	98%†	3%	0.649
#10	82%†	18%	84%†	16%	0.425	80%†	20%	88%†	12%	0.088
#11	96%†	4%	94%†	7%	0.890	97%†	4%	92%†	6%	0.847
#12	34%	65%†	22%	78%†	0.037*	32%	69%†	23%†	77%	0.111
#13	40%	60%†	29%	70%†	0.075	33%	66%†	31%	69%†	0.421
#14	32%†	67%	38%†	60%	0.213	29%†	70%	32%	67%†	0.379
#15	7%†	93%	10%†	90%	0.307	5%†	94%	6%†	90%	0.479
#16	48%†	52%	48%†	52%	0.556	43%†	57%	40%†	60%	0.717
#17	34%†	66%	63%†	36%	0.00024*	36%†	62%	59%†	40%	0.001*

*Indicates Statistical Significance with a 95% Confidence Interval

†Indicates Group with Predicted Change