UBC SCHOOL OF ENVIRONMENTAL HEALTH & UBC SCHOOL OF NURSING

Acoustical Environments in VCH Facilities, Phase 1: Measurements Tools and Pilot Studies

Research supported by an
Innovation at Work grant from WorkSafeBC and the Workers' Compensation Board of Nova Scotia

Authors: Hind Sbihi M.Sc., Murray Hodgson PhD, George Astrakianakis PhD, Pamela Ratner PhD, RN

--- December 2010 ---

Report to: Dr. Ed McCloskey, Director, Research Secretariat
Policy and Research Division
PO Box 5350 Stn Terminal
Vancouver BC V6D 5L5
Grant number: RS2008-IG24 (WorkSafeBC); F08-03855 (UBC)

Executive summary; Main research findings

We originally proposed to conduct the first phase of an intervention study of the effects of the acoustical environment on relevant outcomes in Vancouver Coastal Health (VCH) health-care facilities. However, when the promised stakeholder funding for the intervention was withdrawn, the design of the research project shifted from an intervention study to an ecological study, with the following similar objectives: (1) to select facilities to study in addition to the long-term care (LTC) facility (i.e., Minoru Residence) in which previous research had been conducted, and (2) to consolidate all the tools necessary to perform exposure assessments and investigate the relevant study outcomes (i.e., comfort/productivity, verbal communication/privacy, stress, violence). Following are the main research findings:

- Four sites from three healthcare sectors (i.e., acute, community and residential care) were evaluated. A major finding of this pilot research project was the identification of residential care (LTC) as the work environment with the poorest acoustical conditions compared to those encountered in acute and residential care among those sites that were surveyed. As a result, the second phase of the project (the ecological study) will examine the impact of acoustics in a sample of LTC sites in the lower mainland of British Columbia.

- A new set of acoustical descriptors was developed and found to correlate with negative effects of poor acoustics. These descriptors include: the Occurrence Rate of peak sound levels above given thresholds, the Peakiness, and the Occurrence Rate of sound levels using different level weightings.

- In assessing the feasibility of the sampling, we concluded that biological markers (i.e., salivary cortisol and heart-rate variability) can be collected during an employee's scheduled working hours with minimal disruption to both the staff's activity and residents' routines.

- Monitoring of cortisol using the medication event monitoring system (MEMS) is an effective way to ensure compliance and therefore the reliability of the measurements.

- The motivation and incentives strategy put in place ensured 100% participation for the biological monitoring with high adherence to the protocol; we achieved 100% participation for the study questionnaire and 99% participation for completing the daily diaries.

- We recommend that dosimetry (i.e., personal noise measurements) be conducted while the biological markers are sampled.

- We developed a scale to assess healthcare workers' perceptions of noise in the workplace and related health effects. The tool will enable managers and researchers to identify: potential acoustical issues (e.g., loudness, interference with the proper conduct of work routines); their sources; and their effects on healthcare workers (the scale's items were found to measure three main components: (i) disturbance, (ii) impaired communication, (iii) mental fatigue). The newly-developed scale offers a cost-effective way to recognize and diagnose a hazardous work environment in healthcare settings, and lessens the need to take direct acoustical measurements. However, the latter need to be performed for a more in-depth understanding of facilities' soundscapes to suggest appropriate controls.

- A more effective research protocol is recommended for Phase II, following the study performed at the Minoru Residence: monitoring of heart-rate variability – a marker of sympathetic stress – and salivary cortisol measurement need only to be conducted during workdays.

Table of Contents

Executive summary, main research findings ii

Table of Contents iii

List of Figures v

List of Tables vi

Acknowledgments vii

1 Research problem and context 1

2 Methodology 2

2.1 Exposure assessment 2

2.1.1 Exposure measurement 2

2.1.2 Self-reported exposure 5

2.2 Outcomes 6

2.2.1 Physiological measurements 6

2.2.2 Self-reported measurements 7

2.2.3 Confounders and effect modifiers 8

2.3 Motivation and incentives 10

2.4 Summary of data collected – Phase I 11

3 Research findings 12

3.1 Exposure-assessment results 12

3.1.1 Long-Term Care vs. Community care vs. Acute care 12

3.1.2 Noise-Perception Scale: comparison across RC, AC, and CC. 17

3.1.3 Participant- vs. researcher-assessed exposure: are perceived and observed exposures correlated? 18

3.2 Results of pilot study #2: LTC_MR 19

3.2.1 Acoustical descriptors 19
3.2.2 Noise-Perception Scale 19
3.2.3 Stress assessment 20
3.2.4 Validated scale results: DDHNS and MBI 22
4 Implications for future research and knowledge transfer. 26
4.1 What have we learned? 26
4.1.1 Feasibility 26
4.1.2 Qualitative sense from the field work 26
4.1.3 Preliminary results 27
4.2 How to do this research? 27
4.3 Knowledge transfer 27
5 Bibliographical references 28
APPENDIX 1: STUDY QUESTIONNAIRE 31
APPENDIX 2: GUIDELINES FOR ACOUSTICAL PARAMETERS IN HEALTHCARE FACILITIES 50
APPENDIX 3: NOISE-PERCEPTION SCALE 63
APPENDIX 4: MONITORING INSTRUCTIONS 67

List of Figures

Figure 1. a) Floor plan of AC_UC indicating where reverberation time was measured; b) Floor plan of LTC_PP indicating where reverberation time was measured 4

Figure 2. Measured time variation of sound levels in UBC Hospital: a) LC_PP, and b) AC_UC 13

Figure 3. Time and space variability of sound levels in residential care. 14

Figure 4. Comparison of the Noise-Perception-Scale results across acute-care (AC), residential-care (LTC) and community-care (CHC) units: perceived satisfaction and possible causes. 17

Figure 5. Perceived psychological and physical effects of the acoustics in the workplace, with 0 = no effect at all, 3 = neutral, 6 = very strong effect..... 18

Figure 6. Perceived psychological and physical effects due to the acoustics in the workplace, with 0 = no effect at all, 3 = neutral, 6 = very strong effect 20

List of Tables

Table 1. Summary of data collection by type and setting 11

Table 2. Acoustical descriptors in two types of healthcare-delivery units at UBC Hospital..... 12

Table 3. Comparison of the active time periods in acute-care (AC) and residential-care (LTC) units at UBC Hospital..... 13

Table 4. Comparison of sound levels in residential care units across time period. 14

Table 5. Speech intelligibility scores for different source-receiver positions..... 15

Table 6. Verbal communication quality in community care..... 16

Table 7. Dosimetry results across the three types of healthcare-delivery units..... 17

Table 8. Comparison of NPS results in LTC_MR and in the LTC_PP..... 17

Table 9. Sound levels and Peakiness in LTC_MR during morning, evening and night shifts..... 19

Table 10. Socio-demographics and situational factors of the study population in LTC_MR..... 21

Table 11. Noise-induced stress, sensitivity and burnout scores. 22

Table 12. Sensitivity of biological markers 23

Table 13. Spearman correlation coefficients between acoustical metrics and perceived effects of acoustics. 24

Table 14. Univariate analysis for cortisol parameters and acoustical descriptors..... 25

Table 15. Univariate analysis of time- and frequency-domain heart-rate variability and acoustical descriptors 25

Acknowledgments

This research was supported with funds from WorkSafeBC (Workers' Compensation Board of British Columbia), and the Workers' Compensation Board of Nova Scotia.

We would like to acknowledge the great support and commitment of all the study participants from UBC Hospital, the North Shore Community Health Centre and the Minoru Residence, without whom this study would not have been possible. Our thanks are extended to the managers of these facilities for their assistance.

1 RESEARCH PROBLEM AND CONTEXT

Auditory environments in healthcare facilities are becoming increasingly poor across all different types of healthcare-delivery units (e.g., intensive-care, emergency, neonatal units). Measured noise levels have increased from 57 dB(A)[1] in 1960 to 72 dB(A) in 2004 for day-time exposures, and 42 dB(A) in 1960 to 60 dB(A) in 2004 for night-time exposure (Busch-Vishniac et al. 2005).

Noise is potentially hazardous not only for hearing, but also for normal physiological and psychological functioning (Babisch 1998; Westman and Walters 1981). With the increasing magnitude of the exposure, and the demonstrated effects of noise exposure, noise pollution in hospitals is attracting increasing scrutiny. While the bulk of the research has been devoted to effects of noise pollution on patients, more investigation of the effects on staff is warranted in light of preliminary findings that showed that the complex hospital soundscape contributes to stress and burnout in staff, a known risk factor for job dissatisfaction, absenteeism and turnover (Topf and Dillon 1988). For a sector that is already suffering from personnel shortages, it is of utmost importance to better understand the impact of environmental stressors such as noise. For those remaining in the nursing profession, long-term, chronic noise exposure has been shown to increase the risk of cardiovascular disease (Babisch 1998).

Concerns regarding the acoustical environments in Vancouver Coastal Health (VCH) facilities have been raised by staff and administrators. The problems stem from the open design and multi-functional use of the interior spaces and the lack of sound-absorbing materials on the room surfaces of many facilities. Staff members believe that the poor acoustics have a negative effect on staff and patients. This belief is supported by a recent evaluation of the VCH Minoru Residence long-term-care facility (Steininger and Hodgson 2007). High levels of ambient noise, excessive reverberation and poor speech intelligibility result in interference with concentration and clear communication between caregivers, leading to increased vocal effort and strain on staff, resulting in loss of privacy for the residents. High ambient noise levels increase the agitation and aggressive behaviour of residents, which poses a serious risk of physical/psychological harm to the staff.

Our research questions were motivated by the facts that: **(a) simultaneous stressors (work stress, noise-induced stress, threats of violence) exhaust coping resources and lead to burnout, which is one of the main risk factors for staff turnover, and (b) physiological changes induced by stress, when repeated chronically, become risk factors for adverse cardiovascular effects.** We proposed to identify VCH healthcare facilities in addition to Minoru Residence, characterize their acoustical environments through pilot measurements, and perform a pilot study of biological monitoring of the stress experienced by the staff. Initially, the proposed research was to do Phase 1 of an intervention study – Phase 2 – of the effects of the acoustical environment on relevant study outcomes in several VCH healthcare facilities. However, the design of this research shifted to an ecological study of the effects of acoustics on stress and violence in long-term-care settings.

[1] Sound-level measurements are reported on a logarithmic scale of decibels (dB) and using a weighted frequency scale. The A-weighting is the most commonly-used frequency weighting, as it mimics the human ear by giving more weight to mid-range (1-6 kHz) sounds. The C-weighting is also commonly used and only affects very low and high frequencies.

2 METHODOLOGY

2.1 Exposure Assessment

A series of meetings with Vancouver Coastal Health staff helped to identify pilot sites for each of the types of care facilities (i.e., acute, residential, community) that VCH either owns or manages. The choice of facilities, each delivering a different type of care, was dictated by the original goal of the project, to make a comprehensive assessment of the acoustical environments in VCH healthcare facilities. These were:

- For the acute-care facility: Urgent Care at the UBC Hospital (AC_UC)
- For the community-care facility: the North Shore Central Community Health Centre (CC_CHC)
- For the residential-care facilities (LTC) – two sites:
    - Purdy Pavilion (LTC_PP): this facility was first studied to consolidate the physical-acoustical measurement methods as well as the questionnaire developed for staff working in long-term-care facilities
    - Minoru Residence (LTC_MR): chosen as a pilot site for the biomarker monitoring since its acoustical characterization had already been conducted.

Next, ethics approval was sought from the University ethics boards and each of the relevant branches of the Vancouver Coastal Health Research Institute (VCHRI):

- For the pilot study aiming at the evaluation of the acoustical environment (for AC_UC, LTC_PP and CC_CHC), an ethics application was submitted to the Behavioural Research Ethics Board (BREB) of the University of BC.
- For the pilot study aimed at the development and testing of biomonitoring for stress markers, an ethics application was submitted to the Clinical Research Ethics Board (CREB) of the University of BC.
- For each of the facilities, ethics applications were submitted to different branches of the VCHRI: Vancouver Acute to seek consent for AC_UC, Vancouver Community to seek consent for LTC_PP, Richmond Health Services for LTC_MR, and Coastal Health Services Delivery Area for CC_CHC.

2.1.1 Exposure measurement

The sound environments in healthcare facilities are very diverse, comprising building noise (e.g., HVAC, elevators), equipment noise (e.g., medical equipment, carts, paging and communication systems), and human noise (e.g., staff activity, visitors, patients). Its assessment can be complex, as many acoustical descriptors need to be evaluated. Not only were both area and personal sound-level measurements made to assess staff exposures, but also additional physical-acoustical measures – quantifying reverberation and verbal-communication quality – were collected to evaluate and identify which acoustical descriptors are relevant to the study of the sound environments in the three existing types of healthcare facilities.

2.1.1.1 Area measurements

Sound monitoring

Stationary room-noise measurements were collected in all facilities at similar locations. The goal was to locate the microphone in an area where the staff spends considerable time, and where the activities were representative of the daily work of each healthcare facility, without impeding the routines. We chose to locate the microphone about 0.5 m below the ceiling and as close as possible to nursing stations.

UBC Hospital—Acute Care (AC_UC) and Residential Care (LTC_PP): Ambient noise levels were collected using a Rion NA-28 Sound Level Meter/Octave Band Analyzer for a full day of work (i.e., 10 and 22 hours, respectively). In both facilities, measurements were averaged in third-octave bands using SLOW response and A-weighting for the main signal and C-weighting for the sub-channel signal. Days for ambient-noise monitoring were selected randomly. During each monitoring day, several sound-pressure-level (SPL) measurements were recorded. These were averaged over 10 s with a sound level meter (Rion NA-29E) set on SLOW response and A-weighting (LAeq,10s). LAeq,10s data were collected in the occupied and unoccupied spaces, and in patient and staff areas such as the admissions area and the nursing station.

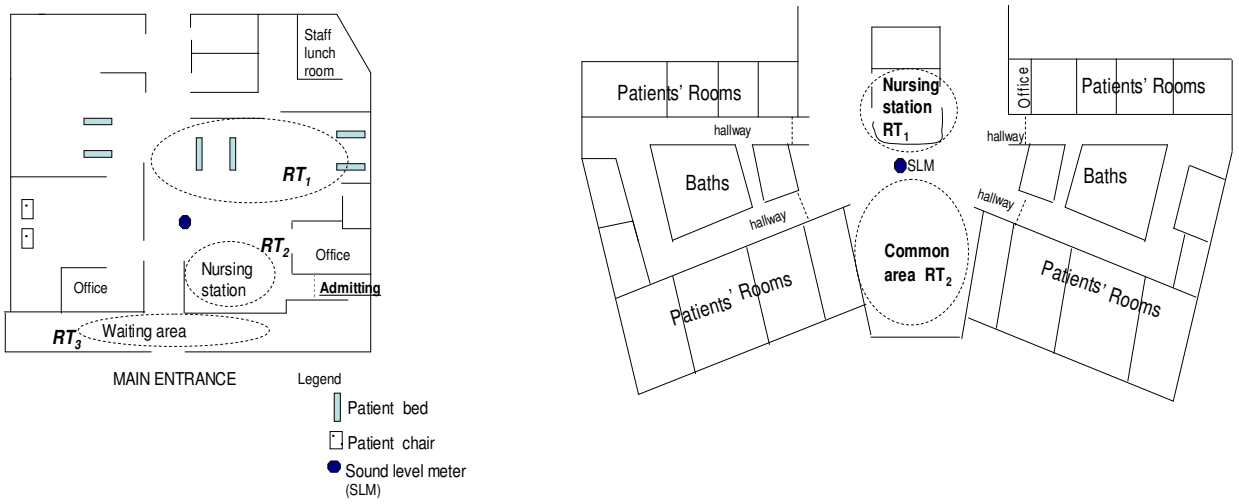
Community Care (CC_CHC): Two nursing units were monitored during their entire operating hours. These units have an open layout and no nursing station; therefore the microphone was placed 0.5 m below the ceiling and in the center of the open area. Monitoring was carried out using Larson Davis sound level meters/real-time analyzers (LD 870 and LD 2800) for the entire time the two floors were operational. Additional monitoring was performed on one unit to capture the temporal variability of the exposure.

Residential Care (LTC_MR): Given the layout symmetry among the residence's floors, the main floor was monitored in each of two wings over five full days to capture each shift (morning shift, 7 am to 3 pm; evening shift, 3 pm to 11 pm; and night shift, 11 pm to 7 am).

A number of acoustical measures were determined from the sound-monitoring results: unweighted, A-weighted and C-weighted 'average' levels (Leq, Leq,A, Leq,C); statistical levels (L10, L90); minimum, maximum and peak levels (Lmin, Lmax, Lpeak); 'Peakiness' (the difference between Lmax and Leq).

Reverberation Time

Reverberation Time (RT) was measured in the unoccupied spaces. Test signals were generated using an omnidirectional loudspeaker array or a speech source (a loudspeaker that radiates sound with the directional characteristics of a human talker). For AC_UC, measurements were performed when the unit was not open, as this particular emergency unit admitted patients until 10 pm and was typically empty between 11 pm and 8 am. For LTC_PP, measurements were performed after dinner in the common eating/activity area. Care was taken to isolate residents from the noise emitted during these measurements.



A **B**

Figure 1. A) Floor plan of AC_UC indicating where reverberation time was measured; B) Floor plan of LTC_PP indicating where reverberation time was measured.

Reverberation times were measured in three different spaces in the AC_UC (see Figure 1): in the area where healthcare was delivered, which had beds, radiography, and pharmacy dispensers (RT1); inside the nursing station (RT2); and in the waiting/admitting area (RT3).

In the long-term-care unit (see Figure 2), the reverberation was measured in two different spaces: in the nursing station and in the common area, as indicated. Despite the absence of a separating panel or door between these two spaces, the ceiling height was higher in the common area.

RT measurements were taken using the WinMLS software installed on a laptop computer equipped with an appropriate sound card. The software generates a signal that is amplified by a power amplifier and emitted from the loudspeaker. The received signal is acquired by the sound level meter, which transmits the signal back to the sound card, which in turn acquires and digitizes it. The resulting signal is processed by WinMLS to obtain the reverberation time from the rate of level decrease when the source is switched off. The reported values are the arithmetic averages of the values measured at several locations of the source (the loudspeaker) and the receiver (the sound level meter).

Verbal-communication quality

We measured the Speech Intelligibility Index (SII) to assess whether an environment was appropriate to clearly understand speech or if it provided the required speech privacy. The advantage of this measure is that it takes into account the background-noise level, the reverberation and the talker speech level. The listener was considered to be an average adult with normal hearing; the talker speaks clearly with some assumed voice level (e.g., casual, normal, raised, loud or shouting).

The Speech Intelligibility Index was measured with the technique described in ANSI (1997). SII is calculated at a listener position from octave-band values of the talker speech level, the continuous background-noise level,

and the reverberation time. A spreadsheet based on ANSI (1997) method was used to compute SII. The appropriately-oriented, calibrated speech source was used as the source, and a sound level meter (Rion NA-29E) as the receiver. The RTs and SPLs measured at different positions within a given area were averaged and used in the calculations.

2.1.1.2 Personal measurements: dosimetry

Although personal measurements have many limitations, they are the most proximal of exposure measures. Dosimetry measurements were collected from staff members in each of the three surveyed healthcare facilities, with the exception of LTC_MR, since such data had been previously collected from the same sample population. The CSA Standard Z107.56-94 measurement procedure was followed for all studies. All employees were met shortly before the start of their shift to fit the dosimeter—a Casella Cel-350 dBadge—on their lapels. All dosimeters were calibrated and their batteries checked before use. In addition, all the participants were asked to make note of the tasks performed throughout their shifts. Finally, they were met at the end of the shift to retrieve the equipment, and to obtain information about the places where they worked and their activities during the shift.

Acute and Residential Care (AC_UC and LTC_PP): Eight healthcare workers (including nurses, triage staff and admitting clerks) in AC_UC, and two care aides in LTC_PP were recruited to gain preliminary information about typical staff exposures. Ideally, a minimum of two measurements is recommended. However, since multiple nursing personnel were sampled over the week, only one full shift per person was monitored. The sampling days were randomly chosen.

Community Care (CC_CHC): Since the staff had different job titles on the two floors, participants were recruited and surveyed from each floor, and for a full-shift period. The inclusion criterion for the dosimetry survey was to work on site on the day of personal monitoring. Indeed, community-care health nurses and public-health officers are often required to visit a patient or inspect a home, a daycare facility, and so forth. Ten healthcare workers were recruited and wore the same dosimeters for the entire 8-hour shift.

2.1.2 Self-reported exposure

The methods described above allowed experimental assessments. To complement this information, we administered a questionnaire to obtain a perceived or subjective assessment that described the participants' opinions of the same sound environment. In so doing, we could examine whether the measurement scale correlated with the acoustical descriptors.

The Noise Perception Scale (NPS) that was used was a structured questionnaire adapted from: (1) literature on classroom acoustics, and (2) the Centre for the Built Environment Occupant Satisfaction Survey (Zagreus et al. 2004 – this survey has been used since 1996 to measure occupants' responses to indoor environmental factors. The scale used here was adapted from the acoustics module, to gather information about the subjective evaluation of the acoustical quality of the environment. In addition, items from the scale developed by Hetu et al. (1994) for the investigation of noise problems in educational settings were added to distinguish between noise sources (e.g., building, equipment, human) and types of noise (e.g., intermittent, continuous).

Furthermore, the work developed by Hodgson and colleagues with respect to classrooms acoustics was adapted and incorporated into the scale; in particular, the subjective assessment of the impact of the acoustical environment on the respondents' physical and psychological well-being (Hodgson et al. 1999; Kennedy et al. 2006).

The questionnaire was composed of satisfaction-scale items, with follow-up questions to diagnose the causes or noise sources leading to dissatisfaction, if indicated. The last part of the scale had specific questions about negative psychological and physical effects of the acoustical environment at work (e.g., annoyance, stress), specific questions about positive psychological and physical effects of the acoustical work environment (e.g., stimulating, relaxing) and questions about workers' perceptions of their patients' reactions to the acoustical quality of the environment. All items were assessed on 7-point scales with 0 = 'not at all' and 6 = 'very much'.

The participants completed the questionnaires during their work shifts, and each participated in a short individual debriefing to determine whether parts of the questionnaire were unclear, irrelevant or missed, as well as ways in which the questions could be enhanced. This structured questionnaire was included in the study questionnaire for the second pilot study (LTC_MR) after being pre-tested in all three types of healthcare settings at UBC Hospital and the North Shore CHC.

2.2 Outcomes

The outcomes were measured through a mix of methods: quantitative for the physiological outcome measurements and qualitative for personal self-reported information.

2.2.1 Physiological measurements

Stress affects many physiological processes in the human body. When a person is exposed to a stressor, the autonomic nervous (ANS) system is triggered through cortisol secretion: the parasympathetic nervous system is suppressed and the sympathetic nervous system is activated. This results in the secretion of hormones (i.e., epinephrine and norepinephrine) into the blood stream, which may lead to a chain of physiological changes such as increased blood pressure, increased muscle tension, a change in heart rate (HR), and a change in heart-rate variability (HRV); this is commonly known as the "flight or fight reaction" (Akselrod et al. 1981). Once the stressor is no longer present, a negative-feedback system stops cortisol production in the body. A sympathovagal balance is established through homeostasis between the parasympathetic (vagal) and sympathetic systems. To assess physiological stress, we conducted biological monitoring of HRV and cortisol.

2.2.1.1 Salivary cortisol

Salivary cortisol can be measured in the immunoassay of saliva samples. Compared to blood biomarkers, saliva analysis has the advantage of avoiding stress that might be caused by venipuncture itself. Salivary cortisol has proven to be a reliable marker of the hypothalamic-pituitary-adrenocorticol axis (McEwen 1998); it follows a distinct diurnal pattern that can be captured with at least four samples per day.

In our research protocol, diurnal cortisol, a marker of chronic stress, was collected four times a day over three continuous days to assess the workers' chronic stress responses. Day 1 (day off from work) was sampled to determine baseline profiles; Days 2-3 were two consecutive workdays that were sampled to determine the variation present during workdays. The protocol required the participants to collect their own samples: 30 minutes after wakening; 4 hours after the first sample; 8 hours after the first sample; and before bed time. The saliva samples were collected using cotton dental rolls held in the mouth until saturated, and then stored in Salivette tubes (Sarstedt Ltd., Leicester, UK). Participants were instructed to take their samples without brushing their teeth, eating, drinking or smoking in the preceding 30 minutes. To ensure the participants' correct understanding of the procedure, they were provided with written instructions (see Appendix 4).

Compliance for salivary sampling was determined using the Medication Event Monitoring System (MEMS) coupled with sampling logs, so that the participants could indicate the time of the saliva collection, and whether any cigarettes were smoked, or liquid other than water taken, within 30 minutes of the collection.

2.2.1.2 Heart-rate variability (HRV)

Heart-rate variability is a marker of the dynamic and cumulative load on the cardiovascular system. It has been associated with deleterious processes that lead to the development of cardiovascular disease (Dekker 2000). Time- and frequency-domain HRV indices have been used to assess physiological variations in sympathovagal balance. It is generally accepted that the standard deviation of normal R-R intervals (SDNN) reflects global variability, whereas high-frequency (HF) power is reasonably linked to vagal activity. Despite divergent opinions, low-frequency (LF) power is considered mainly to be an index of sympathetic activity with a parasympathetic component (Togo and Takahashi 2009). The normalized LF/(LF+HF) ratio is believed to represent sympathovagal balance at rest.

Heart-rate variability was measured using monitors (Polar®, USA) worn throughout the day for three consecutive days. The research protocol required the participants to do simultaneous heart-rate and cortisol monitoring. Polar monitors are non-invasive; they strap around the chest, under the clothing, and connect wirelessly to a watch. We extracted heart-rate variability using appropriate software to translate the signal into the time and frequency domains (Task Force 1996). Each subject met a research assistant and was shown how to use the equipment. To reinforce their correct understanding of the equipment, an instruction sheet was given and daily meetings were held to collect the logged data.

2.2.2 Self-reported measurements

Following a literature review of existing validated scales for the assessment of stress and work-related stress, the development of self-reported tools led the development of two types of self-reported measurements that were evaluated in Phase I: (a) a *study questionnaire* (see Appendix 1) to assess traits potentially acting as modifiers or confounders and stable stress sources, such as perception of the acoustical environment, work-related stress and noise-related stress; and (b) a *daily diary* (see Appendix 2) to capture daily variations in the workers' perceived stress, as well as the aggressive events to which they were exposed, while controlling for their mood.

2.2.2.1 Noise-Perception Scale (NPS)

The NPS had three sections—the first two measured the workers' perceived exposure; the final section asked the participants to gauge the psychological and physical impacts of the noise to which they were exposed.

2.2.2.2 Disturbance Due to Noise in Hospitals Scale (DDNHS)

Developed by Topf (Topf et al. 1998), the DDNHS questionnaire was modified according to the feedback provided by the participants who completed the Noise-Perception Scale in LTC_PP. This survey was initially developed to assess noise-induced stress among patients on a postoperative unit of a Veterans' Administration Hospital. It has also been used to assess patients' noise-induced stress in hospital critical-care and maternity units. Later, its authors revised it to assess the noise-induced stress of hospital-based critical-care and neonatal nurses. It would be possible to use it in long-term-care settings, provided its validity to yield credible results was confirmed. The author of the DDHNS recommended keeping the format and scaling of the original scale, as it can be argued that the particular format and scaling contributed to the original reliability and validity evidence (personal communication with Dr. Topf).

2.2.2.3 Violence

Exposure to violence was recorded in the daily diaries that the participants in LTC_MR completed during two working days of the three-day sampling campaign. The scale had five items taken from the Violence in Healthcare Worker Survey, recently developed by the Provincial Violence Prevention Steering Committee.

2.2.2.4 Burnout (MBI)

The Maslach Burnout Inventory (MBI) (Maslach et al. 1989) is designed to assess three components of the burnout syndrome: emotional exhaustion, depersonalization and reduced personal accomplishment. Since the main research questions postulated that simultaneous stressors (i.e., work stress, noise-induced stress, and threats of violence) exhaust coping resources and lead to burnout (which is one of the main risk factors for staff turnover), we included the MBI scale in the *study questionnaire* completed only once in LTC_MR.

2.2.3 Confounders and effect modifiers

Since the goal of the pilot study in LTC_MR was to determine whether the study tools provided an adequate assessment of both psychological and physiological stress responses, the following scales were administered and compiled, except for the time-varying variables in the study questionnaire, to control for major constructs described in the work and stress research literature.

2.2.3.1 Time-varying control variables

Along with the daily stress biomonitoring, the daily diary encompassed the short form of the Perceived Stress Survey (4 items; Cohen et al. 1983), the affect measure (10-items; Thompson et al. 2007) and the 5-item violence scale. The daily diary was given to the workers at the start of their work block, and was to be completed at the end of each work day. The choice of scales and their development were mainly dictated by the need to not overburden the participants and to obtain their compliance, while still using validated tools. This short tool was designed to be completed in about 5 minutes, with the stress-assessment section before

the questions about violence. The ordering of these questions was the same for all the participants, and the deliberate choice was made to start with the perceived stress and affect scales to avoid any informational bias related to the recall of violent events that might have skewed the stress questions negatively.

2.2.3.2 Non-time-varying control variables

Several scales, listed below, were chosen and compiled into one *study questionnaire* for the second pilot study in LTC_MR, which was conducted to assess the feasibility of the physiological measurements. The study questionnaire encompassed all aspects of work-related stress, as well as potential confounders, to tease out the effects of noise-induced stress from all other stress sources. This questionnaire also included the Noise-Perception Scale, which was pre-tested during the first pilot study at UBC Hospital and CC_CHC.

Psychosocial (JCDS)

A questionnaire relevant to our study population has recently been published by Sundin et al. (2007). Building on the job-control-demand-support model, the authors specifically modified the job-demand scale to better grasp specificities of nurses and nursing assistants, our target population. By adopting this scale, our goal was to develop a questionnaire that is sensitive enough to capture the work-related causes of stress in this particular population.

The first pilot study (survey of staff in LTC_PP) allowed the collection of anecdotal evidence about the main issues at work. We generated a list of potential stressors and compared them with those proposed by Sundin and colleagues, to assess the relevance of the items of the JCDS scale.

Depression (CES-D10)

Depression is a trait that influences the diurnal pattern of cortisol. We used the Center for Epidemiologic Studies Short Depression Scale (CES–D10) to measure it.

The three "Barefoot" subscales – Hostility, Cynicism, Aggressive Responding

The Cook-Medley hostility scale (Cook and Medley 1954) is a 50-item, true-false scale derived from the MMPI that attracted considerable interest among behavioural-medicine researchers when prospective associations were shown between its scores and cardiovascular events (Barefoot, Dahlstrom and Williams 1983). However, one of the strongest criticisms of the Cook-Medley scale lies in its heterogeneous item content. Using rational-item analysis, Barefoot et al. (1989) showed that three subscales (Cynicism, Hostile Affect and Aggressive Responding) have strong relationships with cardiovascular outcomes. The three "Barefoot" subscales (27 items) associated with cardiovascular disease are frequently used in isolation. Here, this set of subscales was used to control for traits that might confound the relationship between noise-induced stress and subclinical symptoms.

2.2.3.3 Effect modifier: noise sensitivity

Sensitivity is a known trait that may alter noise perception and annoyance. We tested a revised and shortened version of the original Weinstein scale (Kishikawa et al. 2006). The WNS-6B has a great advantage in predicting noise effects on mental health, as well as annoyance, and is considered a more appropriate measurement scale because the responses to each question and the total score are obtained independent of noise exposure.

2.3 Motivation and Incentives

The reliability and validity of surveys rest on a two-fold questionnaire-design strategy: (i) design to reduce biases, and (ii) design to maximize response rates. While the first effort is addressed by the adoption of tested and validated questionnaires, the need for full participation is driven by concerns about precision: the greater the response, the more accurate are the estimated population parameters (Kanuk and Berenson 1975). Securing high-quality data is important for the correct inferences drawn from a study and for appropriate knowledge translation.

Methods to increase response rates are numerous; however, only certain techniques have been empirically tested. Yammarino et al. (1991), pooling the qualitative work of 115 survey reports, found that the major factors associated with response rates were the number of contacts made with respondents, whether monetary incentives were provided, and the length of the questionnaires used. A recent randomized, controlled trial (Kalantar and Talley 1999) corroborated this qualitative conclusion and emphasized the value of follow-ups with participants.

The tools we proposed to use to ensure the quality of the obtained data encompassed these highlighted techniques: (1) lottery and monetary incentives; (2) reasonable questionnaire lengths; (3) monitoring through an automated monitoring system (MEMS); (4) follow-up efforts to establish good relationships between the research team and the participants, and to foster commitment since the participants were asked to do several tasks with different natures and schedules (i.e., biological monitoring, daily diary and completing the questionnaire).

For instance, the study questionnaire was given to the participants during an information session before the start of the biological sampling, to allow for sufficient time to complete its different components delineated above (i.e., JCDS, DDHNS, CES-D, three Barefoot subscales, MBI, WNS6B, NPS[2]). Since we did not expect these assessed factors to have much day-to-day variability, we asked the participants to complete the questionnaire once, outside their work environment, at their preferred time, to maximize the response rate and enhance the data quality.

[2] JCDS: Job Control Demand Support – DDHNS: Disturbance Due to Noise in Hospital – CES-D: Center for Epidemiologic Studies Depression Scale – MBI: Maslach Burnout Inventory – WNS6B: Weinstein's Noise Sensitivity Scale – NPS: Noise Perception Scale

2.4 Summary of Data Collected – Phase I

Following is a summary of the settings in which data were collected, the objectives of the data collection, and of the specific data collected:

- Pilot study 1:
  - Setting: UBC Hospital Acute and Residential Care (AC_UC, LTC_PP) and North Shore Community Care (CC_CHC)
  - Aim: to consolidate the physical-acoustical measurements, develop the Noise-Perception Scale, and identify the healthcare-delivery setting where noise-induced-stress research was thought to be most needed.

- Pilot study 2:
  - Setting : Minoru Residence Residential Care (LTC_MR)
  - Aim: to develop the research protocol, test the feasibility of the physiological stress measurements, and test the study questionnaire for Phase II.

Table 1. Summary of data collection by type and setting

Data Type		UBC Hospital Acute Care (AC_UC)	UBC Hospital Residential Care (LTC_PP)	North Shore Community Care (CC_CHC)	Minoru Residence Residential / Long-Term Care (LTC_MR)
Physical-acoustical measure-ments	Acoustical-parameter measurement	✓	✓	✓	✓
	Long-term noise monitoring	✓ (1 position, 1 day)	✓ (1 position, 24-hr)	✓ (3 positions, 2 days)	✓ (various positions, 5 shifts)
	Noise dosimetry	✓ (n = 8)	✓ (n = 2)	✓ (n = 9)	✓ (n = 0)
Study question-naire	Noise Perception Scale	✓ (n = 8)	✓ (n = 8)	✓ (n = 9)	✓ (n =14)
	Disturbance Due to Hospital Noise Scale	×	×	×	✓ (n=14)
	Weinstein Noise Sensitivity Scale	×	×	×	✓ (n=14)
	Short Depression Scale (CES-D 10)	×	×	×	✓ (n=14)
	Maslach Burnout Inventory (MBI)	×	×	×	✓ (n=14)
	Job Demand Control Support Scale	×	×	×	✓ (n=14)
Adherence data (MEMS)		×	×	×	✓ (n=14)
Biological markers	Heart-rate monitoring	×	×	×	✓ (n=14)
	Cortisol sampling	×	×	×	✓ (n=14)
Daily diary	4-item Perceived Stress Survey	×	×	×	✓ (n=13)
	10-item Affect Measure	×	×	×	✓ (n=13)
	5-item Violence in Healthcare Worker Survey	×	×	×	✓ (n=13)

3 RESEARCH FINDINGS

3.1 Exposure-Assessment Results

3.1.1 Long-Term Care vs. Community Care vs. Acute Care

To evaluate the acoustical characteristics of each unit, we relied on the criteria suggested by the Interim Sound and Vibration Guidelines for Healthcare Facilities (ASA/AIA 2006). In particular, it contains criteria for background-noise levels and the criteria that were used for the assessment of verbal-communication quality, as measured by the Speech Intelligibility Index (SII).

All surveyed sites comprised spaces that were either "multiple-occupant patient-care areas" or "corridors and public spaces". In both cases, the recommended SPLs ranged from 40 to 50 dB(A). We adopted this range as the recommended criterion for the facilities monitored in our studies.

3.1.1.1 Area

Table 2 shows the area-monitoring results. It seems that sound levels in the acute-care setting are similar to those in residential care (LTC_PP). However, a more detailed look at the variations of sound levels with time, as seen in Figure 2, indicate that we need to compare and contrast time periods where human activity occurs. Moreover, the Peakiness in the residential setting is clearly higher than in the acute-care unit.

Aside from the continuous monitoring of the ambient-noise levels, "spot" measurements were also performed. Critical areas in the acute-care unit, such as the open space where physicians view and discuss X-ray results, had average levels of 60 dB(A). Around the patients' beds, the average SPLs were 54 dB(A). The nursing station had an average of 57.6 dB(A). The waiting area had a high background-noise level due to the ventilation system; the average level in this unoccupied space was 52 dB(A). The central area had an even higher background-noise level, averaging 58 dB(A), possibly related to all of the equipment noise and the ventilation system. Background-noise levels in adjacent offices were 50 dB(A), on average. There was more variability in sound levels, especially around "rush time" (i.e., after 5 pm), as shown with L90. All these levels, both in acute- and residential-care units, are clearly above the guidelines for acceptable noise levels in healthcare settings. In summary:

➔ Overall sound levels at UBC Hospital in both the acute- and residential-care units were above 50 dB(A)
➔ The LTC_PP Leq,C curve shows that there was more variability in residential than in the urgent care.

Table 2. Acoustical descriptors in two types of healthcare-delivery units at UBC Hospital.

Unit	Duration	Leq	Leq, A	Leq, C	L10	L90	Peakiness
AC_UC	14 hours	59.9	55.6	62.2	61.9	58.8	1.7
LTC_PP	24 hours	59.8	54.9	61.9	57.7	50.1	3.6

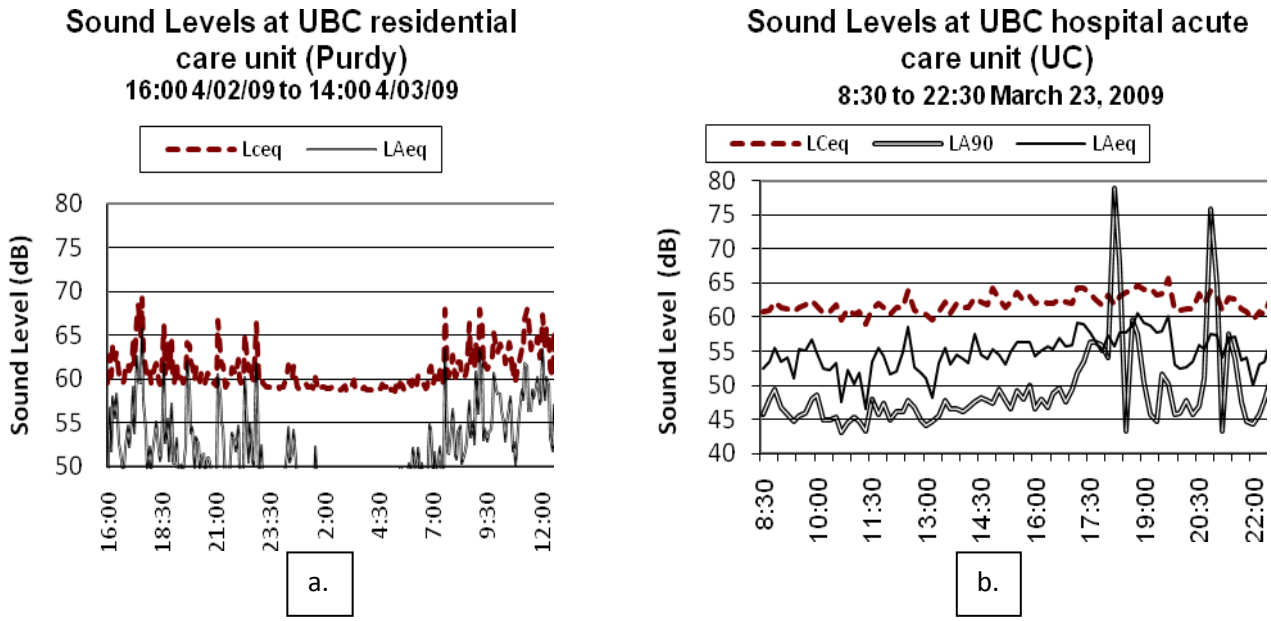


Figure 2. Measured time variation of sound levels in UBC Hospital: a) in the long-term-care unit (LC_PP); and b) in the urgent-care unit (AC_UC).

When comparing time periods when human activities occur, the sound levels were slightly higher in the residential-care unit compared with the acute-care unit at UBC Hospital (Table 3). Moreover, the Peakiness, which is a descriptor of the intermittence of the sound levels, showed a clear difference between the residential- and acute-care settings.

Comparing the sound levels between units (Table 3), community care was slightly quieter than the noise environment found in both the acute- and residential-care units at UBC Hospital. However, the Peakiness on both floors of this unit reflected the intermittent activity of the healthcare setting, in which most interactions for the patients of the community-care nurses, and clients of the health inspectors, were dealt with by way of phone conversations.

It is important to note (in Figure 3) the variability found in residential care, with LTC_MR showing clearly different acoustical environments between shifts compared to LTC_PP. This result begs further study of different LTCs, and a comparison of the impact of their acoustical environments on healthcare workers.

➔ This is the first insight into the variability that can occur across different residential-care units.

Table 3. Comparison of the active time periods in acute-, residential- and community-care (LTC) units.

Unit	Duration	Leq	Leq, A	Leq,C	Peakiness
AC_UC	14 hours	59.9	55.6	62.2	1.7
LTC LC_PP	day	61.4	56.9	63.2	3.5
LTC LC_PP	evening	60.3	55.6	62.2	4.2
RC_CHC, 6th floor	8 hours	51.4	52.2	63.0	3.9
RC_CHC, 5th floor	8 hours	52.6	50.5	59.7	2.4

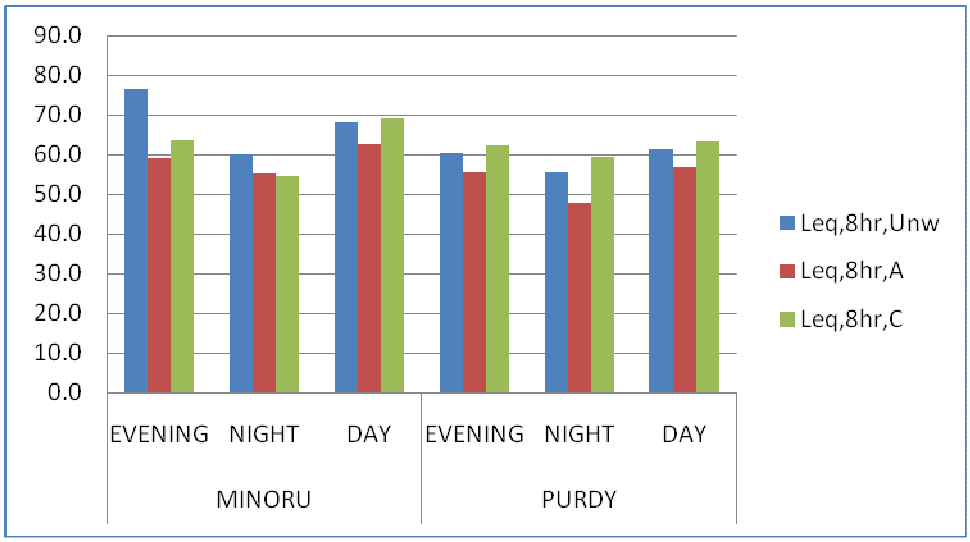


Figure 3. Time and space variability of sound levels in residential care.

The variability described above is also true for other acoustical descriptors, such as Peakiness and the statistical levels (L10 and L90), as shown in Table 4.

Verbal-communication quality

In all three sites, speech-source and receiver positions were placed at different locations, with appropriate orientations of the speech source, to mimic real-world situations. For instance, in the acute-care unit of UBC Hospital, the source was placed in the admitting area and the receiver at the admitting clerk's desk with the speech source facing the receiver. Such a test configuration allowed the determination of whether a patient disclosing information could be overheard by the clerk (or nurse) at the admission desk without having to raise her/his voice or being overheard by other patients. In this setting, good speech intelligibility is very important. On the other hand, an example where speech privacy is important involved the source at the nursing station and the receiver at a patient's bed. In this case, conversations at the nursing station should not be overheard by patients lying in their beds. The SII results, the type of communication required, and whether or not the measurement met the guidelines are summarized in Tables 5a and 5b. It should be noted that a normal voice level was used to calculate the results.

Table 4. Comparison of sound levels in residential-care units across time period.

	Shift	L10	L90	Peakiness
MINORU	Evening	81.6	62.7	8.8
	Night	60.9	54.7	3.6
	Day	70.1	65.0	3.7
PURDY	Evening	58.6	49.4	4.2
	Night	49.6	45.9	1.9
	Day	59.7	52.4	3.5

Table 5a. Speech-intelligibility measures in AC_UC for different source-receiver positions.

Source	Receiver	RT*	Lp,v	Ln	SN	SII	Type of need	Rating
Admitting clerk area	Admitting patient area	1.0	57	55	10	0.16	Intelligibility	Poor
Admitting clerk area	Nurses' station	1.2	58	45	16	0.36	Privacy	Poor
X-Ray board in central area	X-Ray board in central area	1.3	59	50	13	0.37	Intelligibility	Poor
X-Ray board in central area	Patient's bed in central area	1.3	51	50	5	0.13	Privacy	Acceptable
X-ray board in central area	Patients' chairs	1.2	45	50	-1	0.05	Privacy	Excellent
Nurses' station	Nurses' station	1.2	58	45	17	0.39	Intelligibility	Poor
Nurses' station	Patient's bed	1.3	49	50	9	0.21	Privacy	Poor
Office	Patients' chairs	1.2	46	50	6	0.17	Privacy	Acceptable
Patient's bed	Patient's bed	1.2	49	50	3	0.09	Privacy	Good

RT = average reverberation time at 1-4 kHz (s)
Lp,v = speech-source output SPL (dBA)
Ln = ambient-noise level (dBA)
SN = signal-to-noise ratio
SII = Speech Intelligibility Index

In CC_CHC, verbal-communication quality was mainly relayed to privacy, as the healthcare providers work in cubicles in an open-office area. In this unit, a sound-masking system had been installed because of previous staff complaints about the lack of privacy. Using WinMLS, the reverberation time can be measured using three different metrics: Early Decay Time (EDT), T30 and T20 (determined from the average rate of decay over 10, 30 and 20 dB parts, respectively, of the sound-decay curve). In a hard room, with homogenous absorption areas, these three metrics should have the same values. However, this is seldom the case (results not shown here), especially in healthcare-delivery settings, where nursing stations have low ceiling heights, shared spaces have large volumes, and much medical equipment (e.g., medical carts) is present. Then the three values can be different and give different SII values. Using T20 as the reverberation-time parameter, we are able to examine the effectiveness of this sound-masking system and to compare it to that on the 6th floor, which has a similar layout but no sound-masking system (see Table 6). In summary:

Table 5b. Speech-intelligibility measures in LTC_PP for different source-receiver positions.

Source	Receiver	RT	Lp,v	Ln	SN	SII	Need	Rating
Central area	Kitchen/central area	1.1	48	41	10	0.40	Privacy	Poor
Central area	Central area (near)	1.1	60	41	23	0.54	Intelligibility	Excellent
Central area	Central area (distant)	1.1	53	41	15	0.44	Privacy	Poor
Central area	Nursing station	1.5	49	48	7	0.22	Privacy	Poor
Nursing station	Central area	1.1	48	41	10	0.37	Privacy	Poor
Nursing station	Nursing station	1.5	55	48	12	0.40	Intelligibility	Borderline
Nursing station	Hallway	1.2	50	44	9	0.38	Privacy	Poor

Table 6. Verbal-communication quality in CC_CHC.

Source-receiver distance (m)	5th Floor *Without masking*	5th Floor *Masking system on*	6th floor	Need	Rating
1	0.79	0.74	0.66	Communication	Excellent on 5th floor Good on 6th
2	0.74	0.70	0.66	Communication* with some privacy	Poor privacy and good communication
4	0.65	0.50	0.56	Privacy	Poor
8	0.48	0.30	0.42	Privacy	Effective masking on 5th floor, acceptable privacy. Very poor privacy on 6th floor.

***(ideal is 0.2 to 0.4)**

- ➔ Verbal-communication quality was poor in all three types of settings. The needs were different, but consistently not met
- ➔ Methods exist to improve the acoustical environment, as demonstrated in CC_CHC with the sound-masking system
- ➔ In residential-care settings, a lack of privacy is the main problem for staff (e.g., conversations about patients can be heard in public spaces) and for residents (e.g., family/visitor discussions can be overheard at the nursing station).

3.1.1.2 Personal noise assessments

In each of the units surveyed, we attempted to recruit a sample of clerical and nursing staff of different qualifications. In UBC Hospital, eight participants were recruited in each unit (i.e., acute and residential care). At the North Shore CHC, eight subjects wore the dosimeters and completed the Perceived-Noise Scale. All of the participants had similar demographic characteristics. In the long-term care unit, the mean age was 45.6 years compared with 44.6 years for the emergency-unit staff and 45.5 years for the community-care-facility staff. Similarly, their duration of employment was approximately the same, with a mean of 12.6, 11.5 and 10.5 years of employment in the residential-, acute- and community care units, respectively. Residential staff showed the highest level of personal noise exposure. While the acute-care facility had a very wide range of personal exposures, workers in residential care were all exposed to levels of about 75 dB(A) (see Table 7). It should be noted that the dosimetry results in LTC_PP were similar to those obtained from earlier measure-ments collected in LTC_MR where four staff members had Lex ranging between 69 and 76 dB(A), for an average of 73 dB(A).

Table 7. Dosimetry results across the three types of healthcare-delivery units.

	Days of sampling	Number of subjects	Lex range dB(A)	Average Lex dB(A)
Acute care	5	8	59.0-92.5	70.0
Community care	3	9	67.0-72.0	68.7
Residential care	2	2	74.9–75.6	75.0

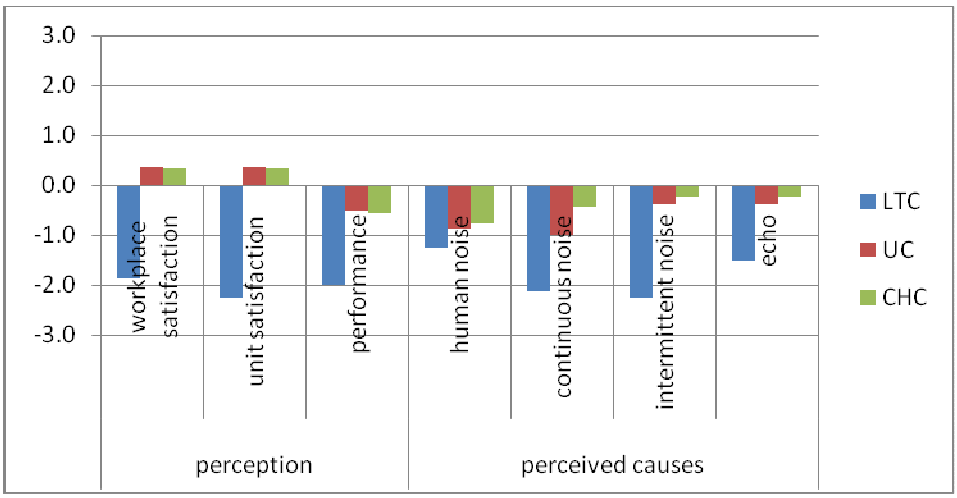


Figure 4. Comparison of the Noise-Perception-Scale results across acute- (AC_UC), residential- (LTC) and community-care (CHC) units: perceived satisfaction and possible causes.

3.1.2 Noise-Perception Scale: comparison across LTC, AC and CC.

Figure 4 shows a comparison of the Noise-Perception-Scale results across the acute- (UC), residential- (LTC) and community-care units (CHC) with respect to the participants' perceived satisfaction and its causes. It shows that:

- ➔ LTC constantly ranked more negatively compared to the other types of healthcare setting.
- ➔ The questionnaire was modified when used in a second study of LTC_MR only. We removed the distinction between workplace and unit satisfaction, and added a question about perceived loudness, as well as a question about the "building noise" as a source of noise that affected or enhanced the daily work routines.
- ➔ Table 8 shows that the result in LTC_MR was more "negative" than in the LTC_PP.
- ➔ LTC always ranked lower for positive effects and higher for negative effects.
- ➔ LTC_PP staff were more "affected" by the noise than were the LTC_MR staff in terms of their satisfaction with the acoustical work environment, as well as regarding the impact of the noise on their ability to complete their work. The differences between the two LTCs were not statistically significant, although the dosimetry results indicated that the personal noise exposure was somewhat greater among the participants monitored in the LTC_PP.

Figure 5 shows the perceived psychological and physical effects of the acoustical workplace environment. It reveals very low perceptions of the positive effects, as virtually all average scores were below 3, which is the

Table 8. Comparison of NPS results in LTC_MR and LTC_PP.

	Overall satisfaction	Perceived loudness	Perceived performance	Human noise	Continuous noise	Intermittent	Echo	Building noise
LTC_MR	-0.5	1.6	-1.1	-1.8	-1.8	-1.1	-1.1	-1.4
LTC_PP	-1.9	NA	-2.0	-1.3	-2.1	-2.3	-1.5	NA

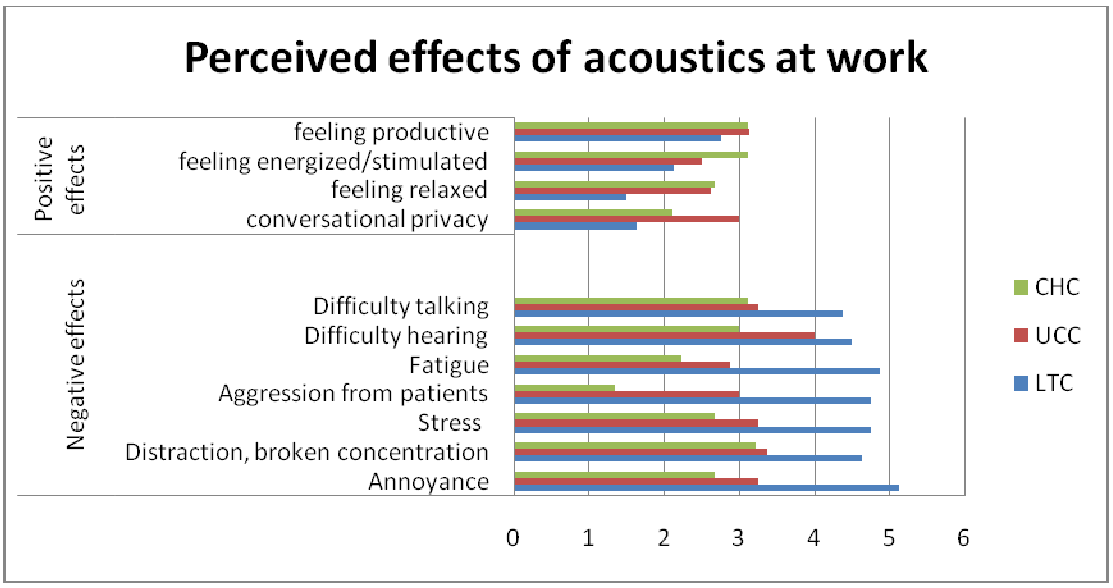


Figure 5. Perceived psychological and physical effects of the acoustical workplace environment, with 0 = no effect at all, 3 = neutral effect, 6 = very strong effect.

neutral-effect score. After debriefing the respondents, it was found that the mid-point scale (originally put at 0 with extreme scores anchoring at -3, +3) was often interpreted as "I don't feel either productive or non-productive," if we consider, for instance, the first item "feeling productive". Conversely, in the residential setting, all the answers to "to what extent do you feel the following negative consequences from the acoustics in your workplace?" scored above 3, which indicate perceived negative effects. However, the staff in community care was clearly less affected by the acoustics, as all scores were at about 3 or below. Finally, the picture was less clear for the respondents in the acute-care unit, because fatigue and aggression from their patients were not perceived to result from the acoustics in their workplace.

3.1.3 Participant- vs. researcher-assessed exposure: are perceived and observed exposures correlated?

Perceived exposure can be understood from the overall responses to the question, "Are you satisfied with the noise levels in your workplace/unit?", with negative responses indicating dissatisfaction.

In light of the results shown in Figure 5, it seems that the workers in the residential settings constantly gave lower rankings in terms of the positive effects of the acoustical environment. Similarly, they had the highest scores for the negative effects. Health-care staff in residential-care facilities constantly reported low satisfaction, compared to staff from the other two types of facilities. This result corresponds to the measured exposure, as the noise levels were higher in this type of healthcare-delivery setting compared to the acute- and community-care facilities.

Interestingly, the respondents held a negative perception of the verbal-communication quality in the acute-care unit, which was mirrored by the speech-intelligibility results shown in Table 5b, where all of the criteria were classified as 'poor' at positions where good speech intelligibility was needed. In summary:

- ➔ Perceived effects relating to verbal-communication quality can be captured by acoustical measures such as Speech Intelligibility Index.
- ➔ Acoustical measures such as Leq (unweighted and weighted) showed some small differences
- ➔ Peakiness looks "promising", as we see statistically significant ($p < .05$) differences between acute, community- and residential-care facilities, which mirrored the Noise-Perception-Scale results
- ➔ Based on pilot-study #1, we added a question about perceived loudness, as well as about building noise as potential causes of respondents' dissatisfaction with the acoustics of their workplace. Moreover, the distinction between workplace and unit was not clearly understood, so both questions were merged into one that asked respondents about their satisfaction with noise levels in their work environment.

3.2 Results of Pilot Study #2: LTC_MR

3.2.1 Acoustical descriptors

As discussed in Section 1, it is important to evaluate the acoustical environment according to work shift. The morning shift (7 am - 3 pm) is usually characterized by social activities for the residents (e.g., physical activity with on-site staff, music). The evening shift (3 pm - 11 pm) has a time window specific to residential-care settings where the residents are affected by the "sun-downing" effect, which is believed to trigger agitation among those with psychiatric conditions. Table 9 reflects the variability in exposure with monitoring time. For instance, the Peakiness during the evening is more than double that found in the morning and night shifts, possibly due to the residents' agitation and vocalization that often occurs at about 7 pm.

We developed other acoustical descriptors, to assess whether they would correlate with the different stress measures. In particular, we computed the Occurrence Rate, which is the percentage of time a certain threshold level is attained. It can be viewed as the reciprocal of the Ln statistical metric, with the advantage that it can be computed for different sound descriptors—in particular, Lpeak and Leq,C.

The Occurrence Rate for the peak levels on average were 39% and 6% for thresholds above 90 and 100 dB, respectively. There was a large amount of variability between shifts, with the evening shift showing an average Occurrence Rate of 11% compared to 3% in the morning shift for peak levels above 100 dB. We found similar variability between shifts (i.e. between 2 and 7% for night and morning shifts, respectively) for the C-weighted Occurrence Rate above 70 dB(C), with an average of 6% across the measurements.

3.2.2 Noise-Perception Scale

After pre-testing the Noise-Perception Scale among staff in LTC_PP during the first pilot study, we found that

Table 9. Sound levels and Peakiness in LTC_MR during morning, evening and night shifts.

Shift	Leq	Leq, A	Leq, C	Lmax	Lmin	Lpeak	Peakiness
Morning	68.1	62.7	69.0	73.6	63.3	93.3	3.6
Evening	76.6	59.0	63.6	89.3	61.4	102.6	8.8
Night	60.2	55.1	54.6	73.8	53.4	95.8	3.5

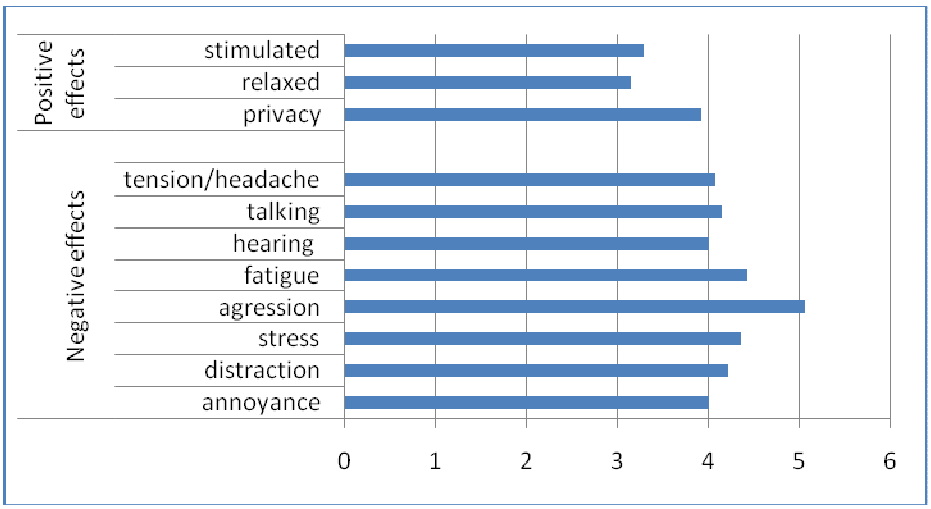


Figure 6. Perceived psychological and physical effects due to the acoustics in the workplace, with 0 = no effect at all, 3 = neutral, 6 = very strong effect.

almost all the participants (93%) perceived LTC_MR to be a loud working environment; the remaining 7% were neutral (i.e., they perceived it as neither loud nor quiet).

While there was an overall agreement that LTC_MR is a loud working environment, 64% of the respondents were dissatisfied with the facility's acoustics and they perceived the situation to interfere with their ability to do their work. None of the respondents perceived the acoustics to enhance their performance, yet 28.5% were relatively satisfied with the acoustics in LTC_MR. Figure 6 shows that all of the respondents provided a score of at least 4 (a somewhat strong effect) for all of the negative psychological and physical effects. Note that aggression was clearly reported to have a strong negative impact on the level of noise in the workplace. In summary:

- ➔ A new scale should be "narrower" and have 5 rather than 7 points.
- ➔ Despite pre-testing the scale items, their scoring did not reflect the "true" perceptions. **The final scale should ask the likelihood of agreement rather than ratings, to avoid an acquiescence bias,** which Figure 7 demonstrates: while all respondents during the debriefing stated that the noise in their workplace made them feel tense and irritable, on average they scored 3 = "neutral". It is possible that the confusion stems from the wording "neutral", which was open to many interpretations.
- ➔ Factor analysis showed that the NPS loaded on four factors: disturbance, mental health, communication, and aggression.

Based on these observations, the Noise Perception Scale was improved for use in Phase II (see Appendix 3); note that this is a hybrid tool, combining exposure and health effects.

3.2.3 Stress assessment

The questionnaires, daily diaries, heart-rate and salivary-cortisol monitoring protocols were administered to 14 study subjects. Demographic data in Table 10 reveals that the participants were similar, across the shifts, with respect to their age, body mass index (BMI) and the psychological characteristics, except for hostility and

Table 10. Socio-demographics and situational factors of the study population in LTC_MR.

	Morning (n=8)			Evening (n=3)			Night (n=3)		
	Mean	(SD)	Range	Mean	(SD)	Range	Mean	(SD)	Range
Age (SD)	51.9	(3.7)	10.0	54.0	(3.6)	8.0	49.7	(5.5)	13.0
BMI (SD)	28.9	(6.7)	20.4	26.0	(3.9)	9.2	23.5	(3.8)	9.1
Adherence[3]:									
30' after waking	20.8	(49.4)	234	53.1	(60.6)	156	14.0	(20.5)	55
4 hours	22.5	(49.9)	243	68.4	(93.0)	219	12.4	(19.4)	61
8 hours	25.5	(57.5)	267	46.8	(72.4)	216	39.2	(57.7)	153
Before bed	64.5	(154.7)	723	192.9	(299)	720	7.1	(10.9)	35
Depression	19.4	(1.9)	7	20	(2.9)	7	23	(3.3)	8
• "Barefoot" subscale:									
Cynicism	1.4	(1.7)	5	3.0	(1.4)	3	5.0	(4.1)	10
Hostility	0.4	(0.5)	1	0.7	(0.5)	1	1.7	(1.7)	4
Aggressive responding	2.0	(1.4)	5	2.3	(0.5)	1	2.7	(1.7)	4
• Ethnicity:									
Filipino	37.5%			0%			67%		
South Asia	37.5%			0%			0%		
Chinese	12.5%			33%			33%		
European descent	12.5%			67%			0%		
• Job title:									
PCA	50%			0%			33%		
LPN	49%			33%			33%		
RN	1%			66%			33%		

cynicism, for which the night-shift workers had relatively higher scores. With regard to job rank, there were clear differences among the shifts: the morning shift had more patient-care aides (PCAs) than did the evening and night shifts, when the staffing was reduced yet of better-educated employees with broader scopes of practice (i.e., mostly LPNs, and RNs).

Maina et al. (2009) have noted several factors that are potential confounders which may account for the discrepancies among studies that have examined the associations between cortisol levels and stressors. In this study, socio-demographic characteristics (gender, educational attainment), situational factors (weekday, sleep quality, diet quality and adherence to the sampling protocol) were considered to be potential confounders and were included as covariates in the statistical analysis. Table 10 displays all the factors that were assessed, as well as the more stable traits that may act as exogenous confounders in the association between noise and stress.

Compliance with the sampling schedule was objectively assessed using an electronic monitoring device. We assessed the adherence to the protocol on the basis of the absolute value of the time difference between the electronic and self-reported times. We note that most of the evening-shift workers took their last salivary samples at the end of their shifts, rather than at the actual times they went to bed. Additionally, the cortisol indices, which we used for analysis, measured the total output rather than awakening responses or diurnal

[3] Adherence is the absolute difference between the self-reported and objective times for each measurement occasion.

Table 11. Noise-induced stress, sensitivity and burnout scores.

	Statistic	Noise Stress (DDHNS)	Sensitivity (WNS6B)	Burnout (MBI) EE	DP	PA
Morning shift (n=8)	Mean	60.5*	3.9	28.7	8	46.4‡
	Median	66	5	29	7	46
	Range	33	3	13	11	12
Evening shift (n=3)	Mean	56.0*†	4.0	31.7	10	47.0
	Median	45	4	34	9	47
	Range	35	2	17	7	4
Night shift (n=3)	Mean	60.7†	4.7	25.3	11	36.7‡
	Median	52	5	24	7	36
	Range	38	1	14	12	8

*statistically significant difference between evening and morning shifts
†statistically significant difference between evening and night shifts
‡statistically significant difference between night- and morning-shift staff

variations. Therefore, the adherence was assessed for each shift, based on the daily pattern: a participant was classified as non-adherent if the absolute difference between the self-reported and objective times was greater than one standard deviation of the mean for the group for a given shift for a given day. Using this classification, 15% of the participants were non-adherent.

3.2.4 DDHNS and MBI results

Among all of the participants, the average score for the Disturbance Due to Hospital Noise Scale (DDHNS) was 59.5 (SD = 13.4) (see Table 11).

The DDHNS had a significant correlation with Occurrence Rates only (Occurrence Rate for Lpeak above 90 dB and 100 dB, as well as Occurrence Rate for Leq,C above 80 dBC), with correlation coefficients ranging between .2 and .3, all p-values < .05.

The researchers who developed the DDHNS found an association between burnout and the scale. In our study population, this relationship was only true for the personal-accomplishment subscale, as we found a statistically-significant negative association between them (r = -.48, p = .001).

We performed a canonical correlation analysis for the three burnout dimensions and the NPS items. We found that the first canonical correlation was most strongly influenced by depersonalization (1.4); for the second dimension, by emotional exhaustion (-0.8); for the third dimension, by personal accomplishment (-1) and emotional exhaustion (1). For the NPS items, the first dimension correlated strongly with annoyance (1.4) and aggression (1.5). For the second dimension, stress was the dominating variable (0.7). Finally, the third dimension comprised annoyance (0.9), fatigue (0.4) and speech quality (0.4). In summary:

- ➔ Burnout and DDHNS were correlated only for the PA dimension; lack of robust results may be related to the lack of statistical power (n = 14)
- ➔ Burnout correlated with NPS only for the negative impact items

Table 12. Sensitivity of biological markers.

Biological marker	Work Day Mean (SD)	Day off Mean (SD)	p-value
AUCg (nmol/L)	4.8 (3.7)	3.4 (2.2)	.007
AUCi (nmol/L)	3.2 (2.4)	2.2 (1.6)	.002
SDANN (ms)	58.7	78.0	.02
VLF (%)	23.2	26.9	.04
LF (%)	65.5	61.7	.04
LF/HF	8.01 (0.9)	6.99 (0.9)	.20

➔ Burnout was significantly associated with Lpeak Occurrence Rate above 90 dB

➔ Subjective measures seemed to better predict the burnout scores.

3.2.4.1 Salivary-cortisol and HRV parameters

Salivary cortisol: Salivary-cortisol levels were quantified by means of several indices, based on the calculation of the area under the curve of cortisol concentration over time (AUC). This measure can be calculated either relative to ground (AUCt) or with respect to increase (AUCi) (Pruessner et al., 2003) using all four samples. According to the interpretations offered by Clow et al. (2004) and Wust et al. (2000), the AUCt provides information about the diurnal activity of the HPA axis during the day, while the AUCi provides information about the reactivity of the system during the same period. The cortisol awakening response, which reflects basal activity, could not be obtained, because this index would have imposed the collection of a 5^{th} sample at awakening.

Heart-Rate Variability (HRV): We computed all HRV indices form both time and frequency domain data. While the time-domain analyses were mainly descriptive, the frequency analysis of the HRV provides results that are more suited to physiological interpretation. We focused our analyses on three time-domain measures: the standard deviation of all normal-to-normal (NN) intervals (SDNN), the SDNN index and the SDANN. The two latter indices were measured from 5-min standard deviations of the NN intervals, with the SDNN index being the measure of variation due to cycles shorter than 5 minutes, and the SDANN the measure of variation due to cycles longer than 5 minutes. For the frequency-domain indices, we used the low-frequency power of HRV, as it reflects both sympathetic and parasympathetic activity, as well as the normalized LF/HF ratio, which is considered to mirror the sympathovagal balance.

In analyzing the participants' days off work, we showed that there is a significant change in cortisol output, and in some heart-rate-variability indices, between days on and off shift. While this does not demonstrate any causation with exposure to noise, it shows the sensitivity of the selected biological markers. Table 12 displays the LF/HF ratio, as it shows a slight elevation during work days even if not statistically significant. This leads to the following recommendations:

➔ For Phase II, biomonitoring should only be conducted during work days

➔ Add a fifth sample at awakening to measure not only diurnal activity, but also basal activity.

Table 13. Spearman correlation coefficients between acoustical metrics and perceived effects of acoustics.

Metric	Annoyance	Distraction	Stress	Fatigue	Tension/ Headache	Hearing	Talking
Leq	0.26	**0.40**					
Leq,A		0.32					
Lpeak	0.26		0.27		0.37	0.37	0.34
Occurrence Rate, Lpeak>80 dB		0.21					
Occurrence Rate, Lpeak>90 dB				0.37			
Occurrence Rate, Lpeak>100 dB		**0.78**	**0.40**	**0.46**	**0.51**		

Analyses during work days

In order to analyze all of the collected data, we set criteria to select "promising" covariates: the covariation was retained if r>.2 and the correlation was present on two consecutive working days.

Correlations between physiological measures (AUCg and AUCi) show that there was no significant variation between working days. For future sampling campaigns, there are two possible options: (1) reduce the timing of measurements to one day only, or (2) use an aggregate measure of two days' worth of data.

In order to investigate the feasibility of the proposed options, we investigated the correlation between sampling times (e.g., 30 minutes after awakening) and found significant correlations only for morning-shift workers for all sampling times and for evening-shift workers for two out of four sampling times. Night-shift workers only showed correlated measures for 30 minutes after waking and 4 hours after the first sample. The option of aggregating the measures does not seem well adapted, given the observed heterogeneity.

Analysis of variance of repeated measurements (two work days) of total cortisol output (AUCg) showed a slight difference between work shifts ($F = 2.19$, $p = .08$).

3.2.4.2 Comparing exposure with perceived effects

We computed Spearman's rho to examine the relation between noise exposure and NPS items. Table 13 shows only significant correlations ($p < .05$) and correlations above .20.

➔ Note that the majority of strong correlations (i.e., ≥ .40) involve the non-traditional acoustical metrics.

3.2.4.3 Comparing exposures with physiological measures

In this analysis, we ran Generalized Estimating Equation (GEE) models to assess the relationships between repeated measurements (either cortisol or heart-rate-variability indices) and different exposure metrics. As shown in Table 14, there was very little association between the acoustical descriptors and the cortisol output parameters. The area under the curve with respect to the increase shows no correlation. This indicates that the cortisol awakening response should be sampled, for a better approximation of the AUCi diurnal and AUCi basal.

Table 14. Univariate analysis for cortisol parameters and acoustical descriptors.

Acoustical descriptor	Cortisol parameter	Coefficient	p-value
Peakiness	Aucg	-0.41	.06
Occurrence Rate, Leq,C>80 dB	Aucg	-0.13	.05
Occurrence Rate, Leq,C>80 dB	Auci	-	-

Compared to the cortisol output, HRV showed more significant associations between four time-domain indices and some of the acoustical descriptors we developed (see Table 15). Surprisingly, in the frequency domain, the VLF showed strong association with the Occurrence Rate of C-weighted sound levels. The use of VLF has been promoted in the latest exhaustive review of the uses of HRV in occupational-health observational studies (Togo et al. 2005).

3.2.4.4 Daily diaries

Violence: Evening-shift workers reported more (on average 1.5 per day) violent events than did the morning- or night-shift staff (on average 1 event per day) over the course of two consecutive working days. It is noteworthy that the acoustical descriptors in Table 4 showed that evening shifts had the highest levels.

Transient Perceived Stress: Both evening- and night-shift workers had similar scores (3.7 and 4.0, respectively) over two consecutive working days. Morning workers displayed a higher score than other workers. On a ten-point scale, their score (average 4.9, standard deviation 2.9) showed that they had the highest scores on both days the daily diaries were completed. MANOVA tests showed no significant difference in the perceived-stress scores between the different shifts. Note that the stress scores did not correlate with

Table 15. Univariate analysis for time- and frequency-domain heart-rate variability and acoustical descriptors.

Acoustical descriptor	HRV index	coefficients	p-value
	TIME DOMAIN		
Leq	SDANN	-1.80	.02
Peakiness		-4.10	.05
Occurrence Rate, Lpeak>80		-1.10	.03
Occurrence Rate, Leq,C>60dB		-0.46	.02
L10		-1.73	.04
Lmax		-1.49	.03
Occurrence Rate, Leq,C>70dB	SDNN-index	3.53	.03
Occurrence Rate, Leq,C>80dB		8.46	.03
Occurrence Rate, Leq,C>70dB	RMSSD	0.58	.02
Occurrence Rate, Leq,C>80dB		1.47	.01
Occurrence Rate, Leq,C>80dB	Pnn50	0.39	.06
	FREQUENCY		
Lpeak	LF/HF	0.92	<.01
Peakiness		1.41	<.01
Occurrence Rate, Lpeak>100 dB		0.6	.01
Occurrence Rate, Leq,C>80dB	VLF	115.6	.06
Occurrence Rate, Leq,C>80dB	HF	158.9	.06

the acoustical descriptors and did not correlate with exposure to violence. In the absence of statistical power, it is not clear that this lack of results shows a "habituation" phenomenon; neither does it preclude the use of this scale in the larger ecological study.

Affect: The workers had higher scores for the positive-affect items than for negative affect items. There were no significant differences between shifts, as well as no difference in affect between days at work and days off work. In summary:

- ➔ Exposure to violence did not affect the workers' perceived stress. However, it is interesting to note that the highest reporting of violence corresponded to shifts with the highest values of the acoustical descriptors (SPLs, Occurrence Rates and Peakiness)
- ➔ The timing of the shift did not seem to have a significant effect on either perceived stress or positive and negative affect.

We conducted repeated regressions between all candidate acoustical descriptors and cortisol with the affect (PANAS, Thompson) and stress (Cohen's PSS 4-items) covariates. The candidate acoustical variables were chosen based on the univariate-regression results, with a cut-off p-value at .10. We found no statistically significant relationships. In conclusion:

- ➔ Complex relationships involving sound-exposure measures against cortisol output (AUCg), while controlling for personality and daily stress, necessitate greater variability than our data provided. There is a need for dosimetry, because no statistically-significant associations were found given the lack of variance in the exposures assessments.

4 IMPLICATIONS FOR FUTURE RESEARCH AND KNOWLEDGE TRANSFER

4.1 What Have We Learned?

4.1.1 Feasibility

The research conducted at four different sites was mainly motivated by the need to assess whether stress measures, both psychological and physiological, can be collected in the field with minimal disruption of work routines and the care provided to patients or residents. We have identified tools for evaluating acoustical environments and have developed and fine-tuned a feasible stress-measurement research protocol for a larger-scale study on acoustics and the risk of stress and aggressive behaviour in residential care.

4.1.2 Qualitative sense from the field work

Healthcare-staff involvement was extremely important for the successful conduct of this research, and to obtain the results reported here. This was achieved through a close interpersonal relationship between each participant and the research assistant who conducted the field work. Engagement was almost immediate when participants understood that this work would lead to further studies that may bring change to the quality of their work environments. Most importantly, the notion that they were giving input as to how research should be conducted was essential in obtaining a very good response rate and protocol adherence.

During the post-questionnaire debriefing, most participants acknowledged that it was important to "do something about the noise".

4.1.3 Preliminary results

The VCH authority describes its different care settings as acute, community and residential. Following this classification, we sampled in all three settings and tried to obtain a general overview of the acoustical work environment and staff perceptions of these environments. We were able to identify, based on our sample, that residential care has the indicators most in favour of pursuing research efforts related to the effects of acoustics on healthcare workers to prevent burnout and disease. We note, however, that our sample is not fully representative of each care setting. For instance, in acute care we did not survey neonatal units, often reported in the literature on acoustics in healthcare. Our results give support to indirect pathways between noise and burnout, and show some correlations with physiologic measures of stress with a set of acoustical descriptors we developed.

The main problem with the acoustical environment as perceived by staff is the overall lack of privacy. Interestingly, there needs to be more awareness among staff that the noise (most often from anthropogenic sources) and its reverberation can be mitigated through behavioural and engineering changes.

4.2 How to Do Future Research?

We have demonstrated that the acoustical environment is important to healthcare-worker health, safety and well-being. Research questions about the relationship between noise and subclinical indicators of cardiovascular disease and burnout have emerged and are worth pursuing. This series of pilot studies has prepared the groundwork for a Phase II epidemiological study (already funded), and has identified some pitfalls to avoid in this large-scale study, as follows:

- Noise-exposure assessment needs to be complemented with dosimetry.
- Physiological-stress measurements need to be carried out only during working days, for a minimum of two days. An additional sample of cortisol needs to be collected at awakening, and adherence monitoring is crucial. For HRV, there was a slight mismatch between the technical skills required to run the Polar watches for heart-rate monitoring and their simplicity for regular users.
- Questionnaire: the Noise-Perception Scale (NPS) was tested and pre-tested, and is to be included in the Phase II in the study questionnaire. The English expression was adequate for the study population.
- Data collected during different shifts (morning vs. evening vs. night) should not be pooled.

4.3 Knowledge Transfer

The results of this Phase I pilot study will mainly inform the conduct of the subsequent Phase II full study. The dissemination of this research agenda (Phase I and Phase II) will fundamentally recommend that all projects that address health and safety in healthcare workplaces should consider acoustics. This will be accomplished in the following ways:

(a) workshops for healthcare workers and facility managers, to raise awareness of acoustical issues; for example, a presentation of the results will be made to long-term-care facility managers in February 2011;
(b) preparation of a scientific-journal article;
(c) conference presentations planned for the special session on acoustics and health-care at the Acoustical Society of America meeting in Seattle, WA in May 2011, and for the International Conference on the Biological Effects of Noise in London, UK in July 2011.

5 BIBLIOGRAPHICAL REFERENCES

ANSI(1997) S3.5-1997 "American National Standard Methods for Calculation of the Speech Intelligibility Index"(American National Standards Institute, New York).

ASA/AIA (2006). Draft Acoustical Guidelines for Health-Care Facilities (Acoustical Society of America and American Architectural Institute, New York).

Babisch W. 1998. Epidemiological studies of the cardiovascular effects of occupational noise - A critical appraisal. Noise Health 1(1):24-39.

Barefoot JC, Dahlstrom WG, Williams RB. 1983. Hostility, CHD incidence, and total mortality: a 25-year follow-up study of 225 physicians. Psychosomatic Medicine 45: 59-63.

Berger E, Royster L, Royster J, Discoll D, Layne M, eds. 2000. The Noise Manual. Fairfax:American Industrial Hygiene Association.

Blomkvist V, Eriksen CA, Theorell T, Ulrich R, Rasmanis G. 2005. Acoustics and psychosocial environment in intensive coronary care. Occup Environ Med 62(3):e1.

Busch-Vishniac IJ, West JE, Barnhill C, Hunter T, Orellana D, Chivukula R. 2005. Noise levels in Johns Hopkins Hospital. J Acoust Soc Am 118(6):3629-3645.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. Journal of Health and Social Behavior, 24, 385-396.

Dekker J, Crow G, Folsom A, Hanna P, Liao D, Swenne C. (2000) Low Heart Rate Variability in a 2-minute rhythm strip predicts risk of coronary heart disease and mortality from several causes: the ARIC study. Circulation 102: 1239-1244.

di Martino V. 2003. Relationship between work stress and workplace violence in the health sector. Geneva: World Health Organization.

Fischer JE, Calame A, Dettling AC, Zeier H, Fanconi S. 2000. Experience and endocrine stress responses in neonatal and pediatric critical care nurses and physicians. Crit Care Med 28(9):3281-8.

Hodgson MR, Kennedy SM, et al. 1999. Measurement and prediction of typical speech and background noise levels in university classrooms during lectures J. Acoust. Soc. Am, 105 (1): 226-233.

Hetu et al. 1994.Problems of noise in school settings: a review of literature and results of an exploratory study. J.Speech Lang. Path. Audio. 14: 31-39.

Kalantar JS and Talley NJ. 1999. The effects of lottery incentive and length of questionnaire on health survey response rates: A randomized study. Journal of Clinical Epidemiology 52(11):1117-22.

Kanuk L and Berenson C. 1975. Mails surveys and Response rates: a literature review. Journal of Marketing Research 12(4): 440-453.

Kamarck. 2005. Assessment of Hostility: Theoretical Background. [last accessed March 2009, from http://pmbcii.psy.cmu.edu/core_c/Hostility_12_20051.pdf].

Kennedy SM, Hodgson MR et al 2006. Subjective assessments of listening environments in university classrooms: perceptions of students. J. Acoust. Soc. Am, 119 (1): 200-309.

Kishikawa H, Matsui T, Uchiyama I, Miyakawa M, Hiramatsu K, Stansfeld SA. 2006. The development of Weinstein's noise sensitivity scale. Noise Health;8 :154-60.

Maina, G., Palmas, A., Bovenzi, M. and Filon, F. L. (2009), Salivary cortisol and psychosocial hazards at work. American Journal of Industrial Medicine, 52: 251–260.

Maslach C, Jackson SE. 1981. The Measurement of Experienced Burnout. Journal of Occupational Behaviour;2(2):99-113.

McEWEN, B. S. (1998), Stress, Adaptation, and Disease: Allostasis and Allostatic Load. Annals of the New York Academy of Sciences, 840: 33–44.

Task Force. 1996. Heart Rate Variability: Standards of measurement, physiological interpretation and clinical use. Circulation. 93:1043-1065.

Thompson ER. 2007. Development and Validation of an Internationally Reliable Short-Form of the Positive and Negative Affect Schedule (PANAS). Journal of Cross-Cultural Psychology ;38(2):227-242.

Steeneken and Houtgast. 1980. A physical method for measuring speech-transmission quality. J.Acoust.Soc.Am.67:318-326.

Steininger, G and Hodgson, M. (2007). Acoustical Evaluation of the Minoru Residence. University of British Columbia.

Sundin L. 2007. A scale for measuring specific job demands within the health sector: development and psychometric assessment. International Journal of Nursing Studies 45: 914 – 923.

Togo F and Takahashi M. 2009. Heart Rate Variability in Occupational Health. Industrial Health. 47: 589-602.

Topf M and Dillon E. 1988. Noise-induced stress as a predictor of burnout in critical care nurses. Heart and Lung: Journal of Critical Care 17(5):567-73.

US-EPA(1974)"550/9-74.004 Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety"(Environmental Protection Agency, New York).

Westman JC and Walters JR. 1981. Noise and stress: A comprehensive approach. Environ Health Perspect 41:291-309.

WHO. 1999. Guidlines for Community Noise. Geneva: World Health Organization.

Yammarino FJ, Skinner SJ, Childers TL. 1991. UNDERSTANDING MAIL SURVEY RESPONSE BEHAVIOR A META-ANALYSIS. Public Opin Q 55(4):613-39.

Ulrich R, Zimring C. 2004. The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity. Center for Health Systems and Design, College of Architecture, Texas A&M University, College of Architecture, Georgia Institute of Technology.

Westman JC and Walters JR. 1981. Noise and stress: A comprehensive approach. Environ Health Perspect 41:291-309.

Zagreus L. and Huizenga C.: Using the CBE Occupant survey to assess facility management performance in GSA facilities, summary report, Center For the Built Environment, UC Berkeley, August 2003.

Zagreus L., Huizenga C., Arens E. and Lehrer D. Listening to the occupants: a Web-based indoor environmental quality survey, Indoor Air, Vol 14 (Suppl 8), 65-74, 2004.

Appendix 1: Study Questionnaire

Understanding the Impact of Noise in Long-Term Care on the Healthcare Workforce

PARTICIPANT ID #_____

Thank you for participating in this research project.

This survey is about the potential effect of noise in your workplace on your work life. It includes questions about your perceptions about the noise as well as your views about the job, your co-workers, and the patients based on your experience in your nursing unit.

The survey will take about 30 minutes to complete and consists of three (3) sections. Please

- Do NOT write your name anywhere on the survey
- Read the instructions carefully before start filling each section of this questionnaire.
- Answer ALL of the questions

All your answers will remain **confidential** and **anonymous**. NO ONE at work will ever see your answers.

It is important that you answer each question as honestly as possible. There are no right or wrong answers, only your individual opinions are required. Your answers are important to this research project.

Prizes will be given!

See at the end of questionnaire for instructions

SECTION 1: THE SOUND ENVIRONMENT

1. Perception of the acoustical (or sound) environment in the workplace

This first section of the survey asks you about your opinions and perceptions of the sound environment on average. In answering these questions, try to assess the overall sound environment, including days with more and less intense activities.

Please circle the most appropriate answer.

1. How satisfied are you with noise levels in your workplace?

Not satisfied at all	Somewhat dissatisfied		Neutral	Somewhat satisfied		Very satisfied
-3	-2	-1	0	1	2	3

2. Overall, how loud is your workplace?

Very quiet	Somewhat quiet		Neutral	Somewhat Loud		Very loud
-3	-2	-1	0	1	2	3

3. Overall, does the acoustical quality in your workplace enhance (positive impact) or interfere (negative impact) with your ability to get the job done?

Negative impact Positive impact

Interferes a lot	Somewhat interferes		Neutral	Somewhat enhances		Enhances a lot
-3	-2	-1	0	1	2	3

4. Below are different types of activities and sound sources. To what extent does each activity enhance (+) or interfere (-) with your ability to do your work:

People (including patients) moving, talking, yelling

- ⟷ **+**

Interferes a lot	Somewhat interferes	Neutral	Somewhat enhances	Enhances a lot
-3	-2 -1	0	1 2	3

Continuous noise

- ⟷ **+**

Interferes a lot	Somewhat interferes	Neutral	Somewhat enhances	Enhances a lot
-3	-2 -1	0	1 2	3

Intermittent noise (on/off noise)

- ⟷ **+**

Interferes a lot	Somewhat interferes	Neutral	Somewhat enhances	Enhances a lot
-3	-2 -1	0	1 2	3

Reverberation (Echo or Sound traveling down corridors)

- ⟷ **+**

Interferes a lot	Somewhat interferes	Neutral	Somewhat enhances	Enhances a lot
-3	-2 -1	0	1 2	3

Building noise (machines, equipment, alarms)

- ⟷ **+**

Interferes a lot	Somewhat interferes	Neutral	Somewhat enhances	Enhances a lot
-3	-2 -1	0	1 2	3

5. To what extent do you experience the following NEGATIVE consequences of the sound environment?

Annoyance / Irritation

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Distraction, broken concentration

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Stress

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Aggression from patients

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Fatigue

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Difficulty hearing

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Difficulty talking

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

Tension and headaches

Not at all (no effect)			Neutral			Very much (negative effect)
-3	-2	-1	0	1	2	3

6. To what extent do you experience the following POSITIVE consequences of the acoustical (sound) environment?

Conversational privacy
(you can't overhear others or be overheard by them)

Not at all (no effect)			Neutral			Very much (positive effect)
-3	-2	-1	0	1	2	3

Feeling relaxed

Not at all (no effect)			Neutral			Very much (positive effect)
-3	-2	-1	0	1	2	3

Feeling stimulated /productive

Not at all (no effect)			Neutral			Very much (positive effect)
-3	-2	-1	0	1	2	3

6. Overall, how much do patients and/or their families react positively or negatively to the acoustical environment?

Strong negative reaction	Somewhat negative reaction		Neutral	Somewhat positive reaction		Strong positive reaction
-3	-2	-1	0	1	2	3

Please give details:

_____

_____

_____

2. Noise Sources

Instruction: Circle the number that described how much each of the sounds listed bothers and disturbs you most at work

Sound	Not at all (1)	Somewhat (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
1. telephones	1	2	3	4	5
2. Personnel beepers	1	2	3	4	5
3. Cell phones	1	2	3	4	5
4. computer printers and faxes	1	2	3	4	5
5. conversations (background conversations during report, or between hospital personnel at the bedside);	1	2	3	4	5
6. Loud talk in hallways	1	2	3	4	5
7. Doors opening, closing, slamming	1	2	3	4	5

Sound	Not at all (1)	Somewhat (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
8. televisions	1	2	3	4	5
9. Radios	1	2	3	4	5
10. alarms on equipment	1	2	3	4	5
11. Continuous beeping of security alarms (doors, etc.)	1	2	3	4	
12. equipment used for patients such as suction and/or breathing machines, bedside treatments such as respiratory therapy, dialysis	1	2	3	4	5
13. intercom and call lights	1	2	3	4	5
14. patient sounds such as coughing, snoring, gagging, moaning;	1	2	3	4	5
15. excessive traffic on the unit such as change of shift, visitors, paging system	1	2	3	4	5

Sound	Not at all (1)	Somewhat (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
16. cleaning equipment such as vacuum cleaners, heating and cooling equipment	1	2	3	4	5
17. medicine and linen carts;	1	2	3	4	5
18. falling objects such as pans, patient charts	1	2	3	4	5
19. air conditioning, heating, or ventilation systems	1	2	3	4	5
20. ice machine	1	2	3	4	5
21. traffic outside residence (for example Sirens)	1	2	3	4	5
22. Ventilators	1	2	3	4	5
23. Squeaking parts on beds or equipment	1	2	3	4	5

3. Noise outside work

Please check the answer that best corresponds to your usual reactions in daily life and not only at work.

	Yes	No
I am easily awakened by noise	☐	☐
I get used to most noises without much difficulty.	☐	☐
I find it hard to relax in a place that's noisy.	☐	☐
I'm good at concentrating no matter what is going on around me.	☐	☐
I get mad at people who make noise that keeps me from falling asleep or getting work done.	☐	☐
I am sensitive to noise.	☐	☐

SECTION 2: YOU and YOUR WORKPLACE

1. Your Health

Instructions:
Below is a list of some of the ways you may have felt or behaved. Please indicate how often you have felt this way during **the past week**; (**circle ONE number** on each line)

0	1	2	3
Rarely or none of the time (less than 1 day)	Some or a little of the time 1 – 2 days	Occasionally or a moderate amount of time 3 – 4 days	All of the time 5 – 7 days

	1	**2**	**3**	**4**
DURING THE PAST WEEK…	Rarely or none of the time	Some or a little of the time	Occasionally or a moderate amount of time	All of the time
1. I was bothered by things that usually don't bother me	1	2	3	4
2. I had trouble keeping my mind on what I was doing	1	2	3	4
3. I felt depressed	1	2	3	4
4. I felt that everything I did was an effort	1	2	3	4
5. I felt hopeful about the future	1	2	3	4
6. I felt fearful	1	2	3	4
7. My sleep was restless	1	2	3	4
8. I was happy	1	2	3	4
9. I felt lonely	1	2	3	4
10. I could not "get going	1	2	3	4

2. You and Your Work Environment -

Instructions: Next to each statement, you can **circle** a number reflecting how you feel about the question using the scale from 1 to 4 as indicated below

	1	2	3	4
HOW OFTEN:	**No Almost never**	**Sometimes**	**Always**	**Yes Almost always**
1. Do you have to work fast?	1	2	3	4
2. Do you have to work intensively?	1	2	3	4
3. Does your work demand too much effort?	1	2	3	4
4. Do you have enough time to do everything?	1	2	3	4
5. Does your work often involve conflicting demands?	1	2	3	4
6. Do you have to care for dying patients?	1	2	3	4
7. Do you face numerous deaths in a row?	1	2	3	4
8. Do you have to care for patients with severe chronic pain?	1	2	3	4
9. Does your work involve unexpected or dramatic deaths?	1	2	3	4
10. Do you experience difficulties in giving or obtaining pain relief?	1	2	3	4
11. Do you have to care for patients with prolonged disease?	1	2	3	4
12. Does you work involve being alone in identifying the needs of patients relatives and not receiving support for this?	1	2	3	4
13. Does your work involve receiving and bearing the worries of the relatives or patients?	1	2	3	4
14. Does you work involve being alone in identifying patients' needs and not receiving support for this?	1	2	3	4
15. Does your work involve receiving and bearing the worries/burden/ life stories of your patients?	1	2	3	4
16. Do you experience threats from patients?	1	2	3	4
17. Do you have to care for aggressive and threatening patients?	1	2	3	4
18. Do you feel worried about being reported?	1	2	3	4
19. Do you feel worried about making mistakes?	1	2	3	4
20. Do you have the possibility of learning new things through work?	1	2	3	4
21. Does your work demand a high level of skill or expertise?	1	2	3	4
22. Does your job require you to take the initiative?	1	2	3	4
23. Do you have to do the same thing over and over again?	1	2	3	4
24. Do you have a choice in deciding how you do your work?	1	2	3	4
25. Do you have a choice in what you do at work?	1	2	3	4
26. Do you have a calm and pleasant atmosphere where you work?	1	2	3	4
27. Do you get on well with each other where you work?	1	2	3	4
28. Do your co-workers support you?	1	2	3	4
29. Do your co-workers understand if you have a bad day?	1	2	3	4

3. YOUR BELIEFS and ATTITUDES

Please answer the following questions about yourself by **checking either** "true" or "false."

1. I have often had to take orders from someone who did not know as much as I did	☐ true	☐ false
2. I think a lot of people make their problems seem bigger than they are just to get other people to feel sorry for them	☐ true	☐ false
3. Most people won't believe the truth unless you argue a lot to convince them	☐ true	☐ false
4. I think most people would lie to get ahead	☐ true	☐ false
5. The main reason people tell the truth is they're afraid of getting caught	☐ true	☐ false
6. Most people will cheat to win, rather than lose	☐ true	☐ false
7. No one cares much what happens to you	☐ true	☐ false
8. It is safer not to trust anybody	☐ true	☐ false
9. The reason most people make friends is so they will have people to help them	☐ true	☐ false
10. Deep inside, most people don't like putting themselves out to help other people	☐ true	☐ false
11. I often have met people who were supposed to be experts at something, but they were no better than I was	☐ true	☐ false
12. Most people want more respect for their own rights than they are willing to give other people's rights	☐ true	☐ false
13. People often disappoint me	☐ true	☐ false
14. I feel like I should get back at people who do me wrong – just because it's the thing to do	☐ true	☐ false
15. I get inpatient when people interrupt me when I'm working on something – even if it's to ask my advice	☐ true	☐ false
16. Some people in my family have habits that bug and annoy me very much	☐ true	☐ false
17. I can be friendly with people who do things which I think are wrong	☐ true	☐ false
18. I think it's OK for people to try to get as much for themselves as they can in this world	☐ true	☐ false
19. I don't blame a person for taking advantage of someone who is a "sucker"	☐ true	☐ false
20. I don't get angry easily	☐ true	☐ false
21. I would very much enjoy tricking somebody who was trying to pull a trick on me	☐ true	☐ false

22. At times, I have had to get rough with people who were rude or "bugging" me ☐ true ☐ false
23. I dislike certain people so much that I am secretly happy when they get in trouble for something they have done ☐ true ☐ false
24. When someone has disagreed with me or been on opposite sides, I often want to try extra hard to beat them at something – even if it's a small thing ☐ true ☐ false
25. If I don't like someone, I don't try to hide it from them ☐ true ☐ false
26. Most of the time, I argue strongly for my ideas ☐ true ☐ false
27. A large number of people are guilty of bad sexual conduct ☐ true ☐ false

4. Job-related feelings

The purpose of this section is to find out how people in helping professions view their jobs and the people with whom they work closely.

On the following page are 22 statements of job-related feelings. Please read each statement carefully and decide if you ever feel this way about your job.

HOW OFTEN:	Never	A few times a year or less	Once a month or less	A few times a month	Once a week	A few times a week	Every day
1. I feel emotionally drained from my work.	1	2	3	4	5	6	7

Exampl

INSTRUCTIONS: Below there are several statements referring to job-related feelings. Please read each statement carefully and decide if **YOU** ever feel this way about **YOUR JOB**. Please **CIRCLE** the number that best describes **how frequently** you experience these job-related feelings.

- If you have NEVER had this feeling, CIRCLE the "1" (one) to the right of each statement.
- If you have had this feeling, indicate **HOW OFTEN** by CIRCLING the number (from 2 to 7) that **best describes how frequently you feel that way**.

Please **CIRCLE** only **ONE** response for each statement.

HOW OFTEN:	1 Never	2 A few times a year or less	3 Once a month or less	4 A few times a month	5 Once a week	6 A few times a week	7 Every day
1. I feel emotionally drained from my work.	1	2	3	4	5	6	7
2. I feel used up at the end of the workday.	1	2	3	4	5	6	7
3. I feel fatigued when I get up in the morning and have to face another day on the job.	1	2	3	4	5	6	7
4. I can easily understand how my patients feel about things.	1	2	3	4	5	6	7
	1	**2**	**3**	**4**	**5**	**6**	**7**
HOW OFTEN:	**Never**	**A few times a year or less**	**Once a month or less**	**A few times a month**	**Once a week**	**A few times a week**	**Every day**
5. I feel I treat some patients as if they were impersonal objects.	1	2	3	4	5	6	7
6. Working with people all day is really a strain for me.	1	2	3	4	5	6	7
7. I deal very effectively with the problems of my patients.	1	2	3	4	5	6	7
8. I feel burned out from my work.	1	2	3	4	5	6	7
9. I feel I'm positively influencing other people's lives through my work.	1	2	3	4	5	6	7
10. I've become more callous toward people since I took this job.	1	2	3	4	5	6	7
11. I worry that this job is hardening me emotionally.	1	2	3	4	5	6	7
12. I feel very energetic.	1	2	3	4	5	6	7
13. I feel frustrated by my job.	1	2	3	4	5	6	7
14. I feel I'm working too hard on my job.	1	2	3	4	5	6	7
15. I don't really care what happens to some patients.	1	2	3	4	5	6	7
16. Working with people directly puts too much stress on me.	1	2	3	4	5	6	7
17. I can easily create a relaxed atmosphere with my patients.	1	2	3	4	5	6	7
18. I feel exhilarated after working closely with my patients.	1	2	3	4	5	6	7
19. I accomplish many worthwhile things in this job.	1	2	3	4	5	6	7
20. I feel like I'm at the end of my rope.	1	2	3	4	5	6	7
21. In my work, I deal with emotional problems very calmly.	1	2	3	4	5	6	7
22. I feel patients blame me for some of their problems.	1	2	3	4	5	6	7

Please ensure that you have answered **ALL** of the questions. If YOU have NEVER had these feelings, CIRCLE "1".

SECTION 3: General Information

This section asks you general questions about you and your background.

Please **CIRCLE** the number that corresponds to your answer, or where indicated, **FILL IN** the blanks.

1. What was your **first educational qualification** (initial program completed) **in nursing**?

CIRCLE ONE RESPONSE

Licensed Practical Nurse Diploma 1
Registered Psychiatric Nurse Diploma 2
Registered Nurse Diploma (**hospital program**) 3
Registered Nurse Diploma (**community college program**) 4
Baccalaureate Program in Nursing 5
Other (PLEASE SPECIFY) _____ 6

2. What **year** did you complete your **first/initial education program in nursing**?

19 ☐ **or** 20 ☐

3. In **what country** did you complete your **first/initial education program in nursing**?

CIRCLE ONE RESPONSE

Canada 1
Other 2
IF OTHER, PLEASE SPECIFY _____ 3

4. If you answered "**OTHER**" to Question 3, **how long have you lived in Canada**? (PLEASE SPECIFY EXACT NUMBER OF YEARS OR MONTHS)

Number of **years** lived in Canada = ☐ **or** Number of **months** lived in Canada = ☐

5. What is your **highest** educational qualification **in nursing**?

CIRCLE ONE RESPONSE

Licensed Practical Nurse Diploma 1
Registered Psychiatric Nurse Diploma 2
Registered Nurse Diploma..... 3
Bachelor of Nursing..... 4
Master of Nursing 5
PhD (Nursing)..... 6
Other (PLEASE SPECIFY) _____ 7

6. What is the **highest level** of **non-nursing education** that you have received?

CIRCLE ONE RESPONSE

Bachelor degree 1
Master degree 2
PhD 3
Other (PLEASE SPECIFY) _____ 4
Not applicable 5

7. If you are a Registered Nurse, have your received **post-basic specialty education and/or certification**?

CIRCLE ALL THAT APPLY

No 1
Yes, from my employer/health authority 2
Yes, from a college/university 3
Yes, from the Canadian Nurses Association specialty certification program 4
Not applicable..... 5

8. If you answered "**YES**" to Question 7, please **specify your area of specialty**.

My area(s) of specialty is/are

9. What **language** do you speak **most often** at home?

CIRCLE ALL THAT APPLY

English 1
French 2
Mandarin 3
Cantonese 4
Taiwanese 5
Punjabi 6
Hindi 7
Tagalog (Filipino) 8
Other (PLEASE SPECIFY) _____ 9

10. To which **ethnic or cultural group(s)** did your **ancestors** belong? (PLEASE SPECIFY AS MANY GROUPS AS APPLICABLE)

For example, Canadian, French, English, Chinese, Italian, German, Scottish, Irish, Cree, Micmac, Métis, Inuit (Eskimo), East Indian, Ukrainian, Dutch, Polish, Portuguese, Filipino, Jewish, Greek, Jamaican, Vietnamese, Lebanese, Chilean, and Somali.

_____

_____

_____

_____

_____

11. Are you . . .

CIRCLE ALL THAT APPLY

White 1
Chinese 2
South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc) 3
Black 4
Filipino 5
Latin American 6
Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese, etc) 7
Arab 8
West Asian (e.g., Afghan, Iranian, etc.) 9
Japanese 10
Korean 11
Other (PLEASE SPECIFY) _____ 12

12. Have you been **diagnosed** with any of the following . . .

CIRCLE ALL THAT APPLY

Diabetes 1
High blood cholesterol 2
High Blood Pressure (hypertension) 3
Heart Disease (arrhythmia, congenital heart disease, etc.) 4
Hearing loss 5
Ear Infection 6
Depression 7
Other medical conditions diagnosed by a medical doctor (PLEASE SPECIFY) _____

13. Have you ever had any of the following . . .

CIRCLE ALL THAT APPLY

Ear Surgery 7
Heart Surgery 8
Depression 9
Other Surgery (PLEASE SPECIFY) _____

YOU ARE DONE ☺

You can put the questionnaire in the envelope provided to you and seal it.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION!

Please indicate the option that you prefer for the prize

Option A: Grocery Store Gift Card* (Circle one)

Safeway Save on Foods

Option B: Restaurant Gift Card* (Circle one)

White Spot Red Robin

Option C: Metro Gift Card (for MetroTown)

* The store that has the majority of votes will be chosen.

Appendix 2: Daily Diary

ID #: _____

Name: _____

***

QUICK INSTRUCTIONS

1. **You are kindly asked to keep this log with you everyday.**
2. There are three (3) sections in this log.
3. Please make sure you complete the short questionnaire at the **end** of your shift.
4. Base your ratings on the experiences of the **current** day you are filling the log. Remember, what we value most if honest & accurate reporting!
5. Call us if there is any problem at 604 827-3509 during daytime or 604 221-7794 in the evening.

***

DAY 0 (off-work): _____

TIME: _____

The questions in this scale ask you about your feelings and thoughts during the **last 24 hours**. Please indicate with a check how often you felt or thought a certain way.

1. How often have you felt that you were unable to control the important things in your life?
__0=never __1=almost never
__2=sometimes ___3=fairly often ___4=very often

2. How often have you felt confident about your ability to handle your personal problems?
__0=never _1=almost never
___2=sometimes ___3=fairly often ___4=very often

3. How often have you felt that things were going your way?
__0=never _1=almost never
___2=sometimes ___3=fairly often ___4=very often

4. How often have you felt difficulties were piling up so high that you could not overcome them?
___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers:

1	2	3	4	5
Very slightly or not at all	a little	moderately	quite a bit	extremely

_____ interested	_____ irritable
_____distressed	_____ alert
_____ excited	_____ ashamed
_____ upset	_____ inspired
_____ strong	_____ nervous
_____guilty	_____ determined
_____ scared	_____ attentive
_____ hostile	_____ jittery
_____ enthusiastic	_____ active
_____ proud	_____ afraid

Instructions:

During work in the past 24 hours, have you or your colleagues encountered the following (please check ALL that apply)

	No	Yes, to me	Yes, to a co-worker
Swearing			
Threats of assault			
Other verbal abuse			
Intimidating gestures			
Throwing/ striking objects.			
Spitting			
Inappropriate touching			
Individuals with weapons			
Physical assault			
Uncontrolled animals			
Other Specify:			

Instructions:

The following questions ask you about your lifestyle, sleep and diet during the **last 24 hours**. In each question, please indicate your answer with a check.

1. How would you rate your sleep quality overall

   ____Very good ____ Fairly bad

   ____Fairly good _____Very bad

2. How would you rate your food intake (quality and quantity of your meals)

   ____Very good ____ Fairly bad

   ____Fairly good _____Very bad

3. Did you smoke?

____yes ____no

4. Did you consume any alcohol?

____yes ____no

DAY 1 (work day) : _____

TIME: _____

The questions in this scale ask you about your feelings and thoughts during the **last 24 hours**. Please indicate with a check how often you felt or thought a certain way.

1. How often have you felt that you were unable to control the important things in your life?
__0=never __1=almost never
__2=sometimes ___3=fairly often ___4=very often

2. How often have you felt confident about your ability to handle your personal problems?
__0=never _1=almost never
___2=sometimes ___3=fairly often ___4=very often

3. How often have you felt that things were going your way?
__0=never _1=almost never
___2=sometimes ___3=fairly often ___4=very often

4. How often have you felt difficulties were piling up so high that you could not overcome them?
___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

This scale consists of a number of words that describe different feelings and emotions.
Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment.
Use the following scale to record your answers:

1	2	3	4	5
Very slightly or not at all	a little	moderately	quite a bit	extremely

_____ interested	_____ irritable
_____distressed	_____ alert
_____ excited	_____ ashamed
_____ upset	_____ inspired
_____ strong	_____ nervous
_____guilty	_____ determined
_____ scared	_____ attentive
_____ hostile	_____ jittery
_____ enthusiastic	_____ active
_____ proud	_____ afraid

During work in the past 24 hours, have you or your colleagues encountered the following (please check ALL that apply)

	No	Yes, to me	Yes, to a co-worker
Swearing			
Threats of assault			
Other verbal abuse			
Intimidating gestures			
Throwing/ striking objects.			
Spitting			
Inappropriate touching			
Individuals with weapons			
Physical assault			
Uncontrolled animals			
Other Specify:			

The following questions ask you about your lifestyle, sleep and diet during the **last 24 hours**. In each question, please indicate your answer with a check.

5. How would you rate your sleep quality overall

   ____Very good ____ Fairly bad

   ____Fairly good _____Very bad

6. How would you rate your food intake (quality and quantity of your meals)

   ____Very good ____ Fairly bad

   ____Fairly good _____Very bad

7. Did you smoke?

____yes ____no

8. Did you consume any alcohol?

____yes ____no

DAY 2 (last work day): _____

TIME: _____

The questions in this scale ask you about your feelings and thoughts during the **last 24 hours**. Please indicate with a check how often you felt or thought a certain way.

1. How often have you felt that you were unable to control the important things in your life?
__0=never __1=almost never
__2=sometimes ___3=fairly often ___4=very often

2. How often have you felt confident about your ability to handle your personal problems?
__0=never _1=almost never
___2=sometimes ___3=fairly often ___4=very often

3. How often have you felt that things were going your way?
___0=never _1=almost never
___2=sometimes ___3=fairly often ___4=very often

4. How often have you felt difficulties were piling up so high that you could not overcome them?
___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

This scale consists of a number of words that describe different feelings and emotions.
Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment.
Use the following scale to record your answers:

1	2	3	4	5
Very slightly or not at all	a little	moderately	quite a bit	extremely

_____ interested	_____ irritable
_____distressed	_____ alert
_____ excited	_____ ashamed
_____ upset	_____ inspired
_____ strong	_____ nervous
_____guilty	_____ determined
_____ scared	_____ attentive
_____ hostile	_____ jittery
_____ enthusiastic	_____ active
_____ proud	_____ afraid

During work in the past 24 hours, have you or your colleagues encountered the following (please check ALL that apply)

	No	Yes, to me	Yes, to a co-worker
Swearing			
Threats of assault			
Other verbal abuse			
Intimidating gestures			
Throwing/ striking objects.			
Spitting			
Inappropriate touching			
Individuals with weapons			
Physical assault			
Uncontrolled animals			
Other Specify:			

The following questions ask you about your lifestyle, sleep and diet during the **last 24 hours**. In each question, please indicate your answer with a check.

9. How would you rate your sleep quality overall

____Very good ____ Fairly bad

____Fairly good _____Very bad

10. How would you rate your food intake (quality and quantity of your meals)

____Very good ____ Fairly bad

____Fairly good _____Very bad

11. Did you smoke?

____yes ____no

12. Did you consume any alcohol?

____yes ____no

APPENDIX 3:
NOISE-PERCEPTION SCALE

This survey asks you your opinions about and perceptions of the sound environment on average. There are no right or wrong answers. Simply circle the most appropriate answer.

In answering these questions, try to assess the overall sound environment on average, including days with more and less intense activities.

1. Please put a check mark"√" in the space that best reflects your opinion on each of the following statements -

Statement	*Strongly agree*	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
1. I am satisfied with the noise level in my workplace					
2. My workplace is noisy					
3. Overall, the sound environment in my workplace **interferes** with (has a negative impact on) my ability to get my job done					
4. Overall, the sound environment in my workplace **enhances** (has a positive impact on) my ability to get my job done.					

2. Below are different types of sound sources or activities that generate sound.

Please circle the appropriate number in each row to indicate the extent to which each item interferes with your ability to do your work.

Activities/sound sources that may interfere with your work	***Not at all***	***Somewhat***	***Moderately***	***Quite a bit***	***A lot***
23. People (staff, patients, visitors) moving, talking, yelling	1	2	3	4	5
24. Continuous/steady noise (e.g. ventilation system)	1	2	3	4	5
25. Intermittent/non-continuous noise (e.g. door slams, items falling)	1	2	3	4	5
26. Reverberation (echo or sound travelling down corridors)	1	2	3	4	5
27. Building noise (machines, equipment, alarms)	1	2	3	4	5
28. Outdoor noise (transportation vehicles, police or ambulance sirens)	1	2	3	4	5

3. Following is a list of different types of effects that people may experience due to the sound environment in their workplace.

Please circle the appropriate number in each row to indicate the extent to which you experience the following consequences of the sound environment in your workplace.

The sound environment at work causes me to feel:	***Not at all***	***Somewhat***	***Moderately***	***Quite a bit***	***A lot***
1. Annoyance, irritation	1	2	3	4	5
2. Distraction, broken concentration	1	2	3	4	5
3. Conversational privacy (you can't overhear others or be overheard by them)	1	2	3	4	5
4. Productive at work	1	2	3	4	5
5. Headaches	1	2	3	4	5
6. Stimulated to work	1	2	3	4	5
7. Difficulty hearing	1	2	3	4	5
8. Aggression (from patients, visitors, co-workers)	1	2	3	4	5
9. Relaxed	1	2	3	4	5
10. Stress	1	2	3	4	5
11. Difficulty talking	1	2	3	4	5
12. Fatigue	1	2	3	4	5

4. Overall, how do patients and/or their families react to the sound environment?

Strong negative reaction	*Moderate negative reaction*	*Neutral reaction*	*Moderate positive reaction*	*Strong positive reaction*
-2	-1	0	1	2

Please give details:

_____

_____

_____

5. Please put a "√" on the appropriate answer

In my workplace, I have to raise my voice to talk to someone who is:

☐ 1 meter (3 feet) away

☐ 2 meters (6 feet) away

☐ 3 meters (10 feet) away

☐ I don't have to raise my voice at all to talk to someone.

APPENDIX 4: Monitoring Instructions

SALIVA COLLECTION

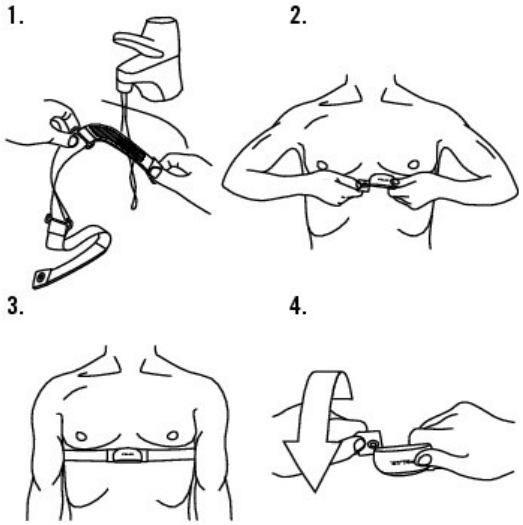
If possible, please refrain from smoking, brushing your teeth, eating or drinking anything but water **at least 30 minutes** before taking a saliva sample

1. Remove a cotton swab for the vial
2. Put the cotton swab in your mouth and chew gently for 40-60 seconds
3. Return the cotton swab back into the cylinder and back inside the tube.
4. Write (a) the time on the label; and (b) circle indicate if you have eaten, smoked and drunk by circling Yes or No
5. Adhere the label and the tube and put into the sealed bag
6. After collecting the four samples for the day, seal the bag.

HEART RATE MONITORING

The heart rate monitor comes as 2 pieces - the chest strap, and the watch.

Wearing the Chest Strap

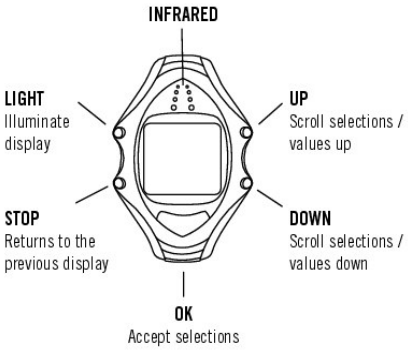


1. Moisten the electrode areas of the strap under running water and make sure that they are well moistened.
2. Attach the connector to the strap. Adjust the strap length to fit snugly. Secure the strap around your chest, just below the chest muscles, and snap the second fastener. The sensor must be worn against bare skin.
3. Check that the wet electrode areas are firmly against your skin and that the Polar logo the connector is in a central, upright position.
4. To detach the connector from the strap, apply pressure with your thumb and forefinger and turn your hand as indicated in the picture

Starting/Stopping the Heart Rate monitor

Please turn on the heart rate monitor when you start your shift.

1. Warm up heart rate measurement by pressing the red "OK" button.
2. Within 15 seconds, your heart rate appears on the display
3. Start heart rate monitor by pressing the red "OK" button again
4. At the end of your shift, press the "Stop" button. A study researcher will meet you to collect the information logged.



Schedule

Day off – DAY 0

- **Saliva collection -** Please see other side of this sheet for instructions
  - 4 times (30 minutes after waking; + 4 hours after waking; + 8 hours after waking; before bed). Please mark time of collection on label and adhere on the tube and keep saliva tubes refrigerated.
- **Heart rate monitoring.**

A study coordinator will meet with your at the end of the last day of your previous workblock to set up the heart rate monitor. You should only activate it on your last day off before the next workblock.

- **Daily diary questionnaire.**

Please complete **only day 0 of the daily diary** at the ***end*** of your saliva and heart rate monitoring.

First day of workblock – DAY 1

- **Continue saliva collection.** 4 times per day with the same schedule.
- **Heart rate monitoring.**

A study coordinator will meet with you at the start of shift to download your data and set up the monitor for the day, and at the end of the shift to download the data and collect your samples.

- **Daily diary questionnaire.**

Please complete **only day 1** of the daily diary at the end of your saliva and heart rate monitoring.

Second day of workblock – DAY 2

- **Continue saliva collection.** 4 times per day with the same schedule and indicating the time on the labels for each sample.
- **Heart rate monitoring.**

A study coordinator will meet with you at the start of shift to download your data and set up the monitor for the day, and the end of the shift to download the data and collect your samples.

- **Daily diary questionnaire.**

Please complete **only day 2** of the daily diary at the end of your saliva and heart rate monitoring.

SHIFT QUESTIONNAIRE will be collected at the end of day 2 or later when completed (use the stamped envelope).