NOISE MAPPING IN THE OPERATING ROOM

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Introduction Noise, defined as any unwanted sound, is a widespread pollutant, whose diffusion increases with technological development. Operating rooms (OR) are as susceptible to noise pollution as other working environments: staff and patients are exposed to a barrage of sounds, produced by electro medical machines, air-conditioning plant, telephones, surgical suckers, sterilizers, clanging of metal bowls, instruments, trolleys. This ensemble of sounds can be a hazard to human health, leading to decreased communication between staff, work performance and increased levels of stress for conscious patient in both operating and recovery room (1).
To mantain the comprehension of the 50% of syllables (that determine the comprehension of the 80% of a sentence and so a good level of intelligibility at the vocal normal sound value of 60 dB) the background noise hasn't to exceed the range of 50-60 dB. In intensive care units several sources (SpO_2 alarm, telephones, bed transfer, nursing care, opening packet and staff conversation) exceed this treshold and could influence quality of care and staff performances (2). Also in the OR patients are exposed to unnecessary and preventable sounds, in particular during induction and recovery phases of anaesthesia. Many patients are distressed by the surgical suite sound levels and would desire a quieter environment. Among the measures suggested to reduce noise pollution, the simplest and the most applicable is to reduce conversations that are not patient's care related (3). Beginning from the acoustic analysis of the main OR of an hospital placed in an ancient building of the town centre (Santa Maria Nuova Hospital, Florence-Italy), the aim of this work is to determine a general methodological approach to the OR acoustic mapping that will be applied to different scenaries through the definition of suitable models and simulation procedures.

Methods The chosen method of acoustic analysis of inner and external sources in an OR is composed of the following steps: sound levels measurements, frequency and statistic analysis, computation of indexes and definition of the acoustic atmosphere during standard surgical activities, study of acoustic quality of building, furniture, materials, means of sound propagation and radiation. Workers and patients are considered sources of noise as well as noise receivers. The workgroup is composed of anaesthesists and acoustic engineers, joining their experiences and approaches. A synoptic scheme of this method is shown in the following table.

1. SOURCES ANALYSIS	1. Sources identification and classification	*For each single source present in the cases scenery*
		Code
		Picture
		Structural and Functional description
		Technologic state of art for the type of source – Sound Emission Levels according to ISO standards
	1.b Emission theatre representation	Functional description of standard work cycles and each phase of activity
		Maps pointing out: - static and dynamic sources position, - motion areas of mobile sources, - working places, - position and motion areas for workers, - patients position, - position of other (eventual) active and passive receivers.
		Vertical Map, sections or 3D maps pointing out: - doors, - windows, - other points of sound transmission - sound reflecting areas in walls, floors and ceilings

2. SOUND LEVEL MEASUREMENT	2.a. Residual and Background noise level measurement in all the receiver points	Inside the operating theatre closed without any activity around [Leq]
		Inside the operating theatre closed with air conditioning systems on[Leq]
		Inside the operating theatre open without main sources activity [Leq] [L95]
		Inside the operating theatre open with standard speech between the staff [Leq]
		Inside the operating theatre open during preparation phase [Leq] e [L95]
	2.b Sources emission levels measurements	Emission levels - only source with no operating theatre activities: [Leq], [L90]. - with standard hospital and operating room activities (peculiar source contribution) [Leq], [L90], [L10], [SEL] + other statistic parameters - with omni-directional emission box - along the receivers' directions
		Critical phases levels - starting points and higher speed of machines, gas escaping, sucker in use, alarms…)
		Comparison of measured data with datasheets and technical reference's data of machinery in the following cases: - tested sources given by producers, - most recent machine of that kind, - most noise protected and lowest sound emitting machine of that kind
	2.c Noise mapping of two working days in the surgical theatre with full operating cycles	Time histories and evaluation of indexes behaviour in time and frequency. Sequence of measurement and single events' analysis [Leq], [L90], [L10] [SEL] + other statistic parameters
		Measurements with sound meters in LAF regulation for the most complex phases of the working cycles.
		Spot measurements during equipment cleaning, preparation, using glass bottles, metallic bowls, etc.
		Measurements performed in proximity of workers ears to determine their own exposure to noise pollution and the related hazard in term of professional disease. Calculation of day and week A-weighted equivalent levels [LEP,d][LEP,w].
	2.d Noise impact on the surgical theatre coming from outside.	Measurements of breaking in noise levels. Study of propagation model from sources located in outer spaces. Spatial and time decay law model for incoming Leq, determined by acoustic features of the surgical environment: noise radiation surfaces, propagation patterns toward receivers and critical areas.

Results

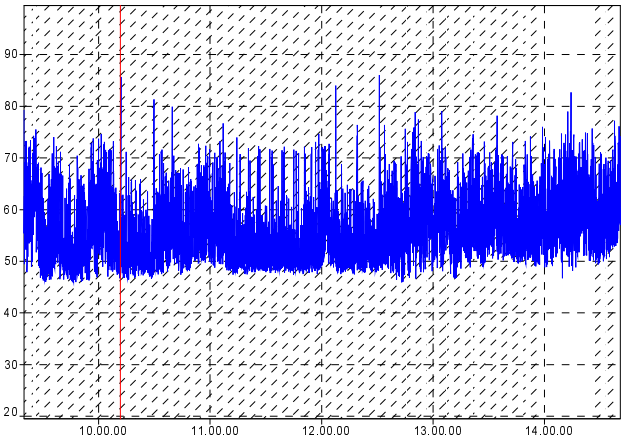

Fig.1 long term sound level working day related to surgical and anaesthetic activity.

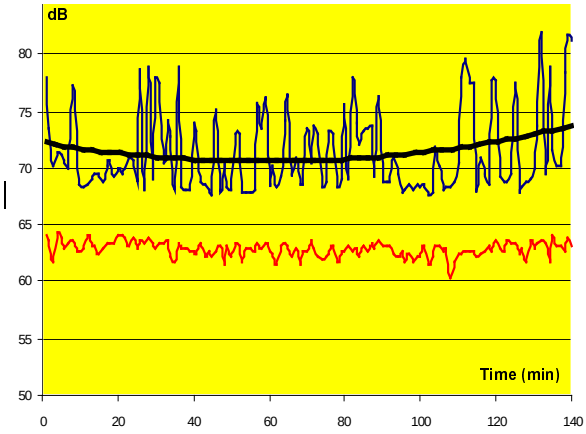

Fig.2 Minimum and equivalent linear levels measured during a general anaesthesia.

Discussion The collected data show that the min. noise level during the whole standard OR working day always exceeds 60dB. In particular noise pollution reaches the highest levels (80-90dB(A)) during the induction and recovery phases of anaesthesia. The definition of a general methodological approach to noise mapping of the surgical environment of a General Hospital represents the first methodological step of a project called ADOR (Acoustic Design of OR).

Keywords: noise pollution; noise mapping; operating room

References

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