DESIGN AND TECHNOLOGY. PEOPLE, ENVIRONMENT, SYSTEMS

AMMIN/Rockfon - Non-auditory effects of noise in hospitals and management of associated stressors for the staff

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Context of the research activity	The PhD research activity aims to advance knowledge on the non-auditory effects of noise experienced by hospital staff, both in wards and in other healthcare facilities. The project will provide evidence through selected case studies, investigated primarily in the laboratory but also in the field, with the support of immersive virtual reality. Expanding its scope and recognising the intrinsic complexity of hospital environments — where multiple functions, technical systems, and sensitive user groups coexist — the project will address a broadened concept of comfort. This involves layering the primary focus on acoustic performance with other critical and interacting factors such as surface cleanability, long-term maintainability and accessibility of ceiling systems, resistance to intensive sanitisation, microbial growth control, air tightness to prevent airborne contamination between spaces, and the influence of color and visual environment on mood, spatial perception, and restorative potential.
	Details of the research activity: The research activities are organised in five phases. Activity 1 – Literature Review: • Analysis of the state of the art on acoustic well-being and non-auditory effects of noise for hospital staff. • State of the art on acoustic treatments in hospitals and evidence on improved quality, integrating literature on associated environmental quality factors (surface cleanability, intensive sanitisation resistance, microbial growth control, air tightness, and color in relation to mood and spatial perception). • In-depth study of the risks related to noise exposure and the amplification of such risks when combined with other environmental stressors. Activity 2 concerns the study of hospital layouts, including analysis of space

Objectives	aggregation typologies, identification of acoustically and environmentally critical areas, and selection of sites in agreement with hospital authorities (e.g., ENT Department, AOU Città della Salute e della Scienza di Torino). Aligned with the BRIC INAIL project, sites are categorised as follows: Core areas – necessarily included due to their constant use, diverse acoustic and environmental requirements, and direct impact on staff well-being and patient outcomes: • Wards • Corridors • Operating rooms • Clinical laboratories • Staff dining areas (canteens) and restaurants • Staff support areas (e.g., changing rooms, lounges, break rooms) • Waiting areas for patients and families Additional areas – subject to availability and relevance for specific objectives: • Rehabilitative gyms For each selected environment, additional data will be gathered on accessibility for maintenance, particularly of ceiling systems, to ensure that acoustic and environmental treatments do not hinder servicing of mechanical, electrical, or medical installations in the plenum space. Within Activity 2 and/or Activity 3, a user journey mapping may be conducted. This strategic and visual tool, widely applied in healthcare design, can be used to analyse the experience of healthcare staff throughout daily routines. It helps identify pain points, inefficiencies, and opportunities for improvement, producing maps that highlight touchpoints, perceptions, interactions, and processes, providing valuable insights for strategic planning. Activity 3 includes field investigations with: Acoustic measurements (in occupied conditions for long term monitoring): • Acoustic performance (reverberation time, sound insulation between rooms, façade insulation) • Long-term monitoring using multisensors that collect real-time data on noise levels, air quality, illuminance, temperature, VOCs, and fine particulate matter • Personal dosimetry for healthcare staff • Ambisonics spatial audio recordings with a 19 capsule spherical microphone array (Zylia ZM 1) • 360° video recording with the Insta360 Pro camera Biometric parameter measurements: • Heart rate, respiration, body temperature, posture (wearable sensors such as EmotiBit or similar) • Correlation of biometric indicators with environmental parameters including noise, air quality, and perceived cleanliness, safety, and visual comfort levels Subjective surveys: • Interviews and questionnaires administered to staff (Internal note: include questionnaire items on perceived hygiene, indoor air quality, and the influence of color/visual environment on comfort, stress, communication, and perceived safety) If possible, pilot acoustic/environmental improvement interventions will be tested through comparative pre and post intervention surveys. Field measurements are planned during the first year of the PhD, in collaboration with the University of Florence within the BRIC INAIL project framework. Activity 4 consists of laboratory studies in the Audio Space Lab of Politecnico di Torino, where Ambisonics and 3D videos will reproduce hospital environments while preserving privacy. From the journey maps and

	interviews, fictional user profiles based on real data will serve as a basis for creating virtual avatars for immersive simulations. If video recording is not allowed, hyper-realistic environments will be rendered with software such as Blender, Unity, or Unreal Engine. Activity 5 consists of cognitive and intelligibility tests that will be defined through literature review, staff interviews, neuroscientific collaboration, and statistical design (G Power, ethics, analysis). Tests will be implemented in the lab, with results published internationally. Activity 6 focuses on analysis and dissemination: data processing to define parameters and thresholds for INAIL guidelines and UNI 11532-4 draft, and preparation of design recommendations, technical solutions, and best practices for facility management. The protocol, aligned with BRIC INAIL 2024, aims to integrate data from multiple centres to advance research in this unexplored field.

Skills and competencies for the development of the activity	Knowledge of the fundamentals of acoustics, statistics, acoustic measurements in the field and laboratory, and programming skills in Python and/or MATLAB. It is expected that the PhD student will spend a period of 6 months at UCL in London to work with Prof. Jian Kang, an expert in noise indoor or at the Institute for Hearing Technology and Acoustics (IHTA) at RWTH Aachen University, with Prof. Janina Fels, an expert in 3D acoustic rendering and subjective tests.