Educational Challenges in Healthcare Design: Training Multidisciplinary Professionals for Future Hospitals and Healthcare

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Abstract

Background. *Healthcare environments are one of the most complex and demanding fields of work. Scientific, technological and research developments along with new discoveries within health promotion and prevention strategies are increasingly requiring a multidisciplinary and interdisciplinary approach. Therefore, it is likely that the current professions will need to be significantly adapted to accommodate new and more specialized roles.*

Objectives. *To present an overview of the current educational and training courses of the emerging professions, such as hospital planner, physician-engineer, doctor-architect, nurse-architect or engineer, we review the present global training courses (BSc, MSc, specialization and PhD courses) related to healthcare design focusing on the fields of Medicine and Nursing, Architecture and Engineering sciences.*

Results. *The paper analyses the literature review and website analysis about active teaching programs and courses. Several academic institutions offer BSc, MSc and PhD degree programs in Healthcare Design, Environmental and Building Hygiene, and Public Health. In addition, there are several professional post-graduate courses, either in classroom, hybrid-based or online.*

Conclusions. *A considerable number of international training experiences addresses the topic of training multidisciplinary professionals. Further in-depth investigations are needed to examine the content, teaching format and impact of the courses, student outcomes and professional careers, fields of interest and the degree of collaborations with other institutions.*

Introduction

Scientific, technological and research developments along with new discoveries within health promotion and prevention strategies, in particular regarding the design and management of hospital settings, require a deep reflection of the entire professional training curricula. The hospital environment is one of the most complex

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work domains such in the design of cancer hospitals (1) and hybrid cardiovascular treatment rooms (2). There is the growing need of specialization with a multidisciplinary and interdisciplinary approach related to healthcare processes, design of functional layouts, engineering plants, safe and security strategies, etc. (3). The medical field is being influenced by management, policies and technologies, that are needed to shape the built environment, healthcare technologies and ergonomics (4-6). There is a growing concern with healthcare workers wellness and increased rates of burnout, and how best to address employee wellness by incorporating new designs into healthcare facilities (7). Healthcare design is gradually evolving toward a more holistic and multidisciplinary approach in healthcare planning, design and/or management. Nevertheless, the knowledge about the transformation is still relegated into "disciplinary silos". There is a lack of systematic understanding of the global evolution of such professions toward a more multidisciplinary and interprofessional approach (8).

It has become clear that the new trends in healthcare design require new typologies of training and pedagogical strategies, as well as an innovative approach in knowledge, skills and attitudes (9). There is a growing recognition that the current training programs are not adequate for the needs of society and that the present narrow profession roles will need to be replaced and flanked by more specialized ones (10). Furthermore, the present training programs are not adequately addressing the UN SDG goal 3 of improving health and wellness in particular.

We embarked on a preliminary investigation and general overview of the current educational courses for the emerging professional fields such the physician-engineer or architect, the nurse-architect or engineer, and the hospital planner referring to the worldwide available training courses (BSc, MSc, specialization and PhD courses) related to healthcare design (11). The scope of this analysis highlights what type of actions and directions universities are taking, as well as what type of competences and professional skills are expected for the graduates, and the market demand for these new professionals.

Methods

We conducted a preliminary review of the literature and websites looking for several keywords related to university and/or college, architecture and health, design and health, hospital design, healing architecture, healthcare design, hospital designer, healthcare designer, healthcare architect, hospital planner, medical planner, doctor architect, physician architect, physician engineer, doctor engineer, nurse architect, hospital makerspace, nurse engineer, etc.

The search was limited to courses, degrees or teaching events conducted by universities, and mainly active programs (and well-known courses currently no longer provided). Research centres that do not have courses or teaching activities were excluded. The results were collected and clustered according to the typology of professional disciplines including: Healthcare Designer, Hospital or Medical planner, Physician-architect, Physician-engineer, Nurse-architect and Nurse-engineer.

Results and Discussion

A. Current programs and degrees

Worldwide there are several typologies of courses. In general, University Master's degrees attest to a particular knowledge or skills in a specific field of study or in a professional activity, and internationally they can be distinguished in:
- **Bachelor degree** (degree of first level) that provides undergraduate students

with adequate knowledge of general scientific principles and mastery of methods as well as specific professional skills;

- **First level Master**, also well known as **graduate certificate**, that provides specialization and continuing education in specific fields;
- **Master degree** (degree of second level) that provides graduate students with advanced education and training for highly qualified professions in specific sectors. It regards also the single cycle degree programs in medicine, pharmacy, etc.;
- **Second level Master** that provides a higher level of specialization and continuing education in specific fields;
- **Specialization** course (Residency in the case of medical field), that provides knowledge and skills for specific professions. Set up exclusively on the basis of specific national laws or EU directives (medical specialization, secondary school teacher education, legal professions);
- **Doctoral Degree** provides postgraduates with training (including study periods abroad and training periods at public or private research bodies) for highly specialized research at universities as well as in the public and private sector. It is the highest training qualification, which the main purpose is to train research and university teaching and during the program a research project is produced and developed (12).

In addition to the traditional degrees, Universities also promote **specialized professional training courses**, that permit professionals to improve their knowledge on specific topics, such as the updating on data collection, methods and topics, etc. Typically, students obtain a certification of their participation and professional training credits, but these courses do not issue a qualification.

B. The Healthcare Designer

There are several universities that offer training in architecture, engineering and design with dedicated research centres, Master programs, and PhD programs related to Healthcare Design (Table 1).

Master's Degrees

There are only a few universities that offer a Master's degree in **healthcare design** for training **healthcare designers** and **architects**: Clemson University in USA and Ontario College of Art and Design University in Canada, as well as Boston Architectural College, Kent State University and Kansas University. In particular:

- **Clemson University** offers Bsc, Msc and PhD programs in **Architecture + Health**. The present Director of Graduate Studies is Prof. David Allison. The programs are subdivided into (16):
  - the Bachelor in Architecture + Health offers the opportunity to study Architecture with courses related to healthcare architecture and the relationships between health and the built environment;
  - the Master of Science in Architecture + Health offers the opportunity to analyze the complex challenges associated with healthcare architecture and the relationships between health and environment built on multiple scales;
  - the PhD program aims to focus on the primary objective of the relationship between environment and health and to generate new knowledge and theories that demonstrate how human health and well-being can be improved through design (evidence based design).
- **Ontario College of Art and Design University** offers a **Master of Science in Design for Health.** This program develops skills in healthcare design

Table 1 - International University Degree Award Conferring Programs (13-36)

University	Research Center	Representative	Master Degree	Source
America				
Ball State University, USA	Health Environmental Design Research Lab	Shireen Kanakri	Planning and Design of Healthcare Environments	(13)
Boston Architectural College Boston, USA	Design for Human Health	Dak Kopec	Master of Design Studies Design for Human Health	(14-15)
Clemson University Clemson, USA	Center for Health Facilities Design and Testing	David Allison	Architecture + Health	(16)
Kent State University Kent, USA	/	Sara Bayramzadeh	Health Systems and Facilities Design	(17)
Ontario College of Art and Design University Ontario, Canada	Health Design Studio	Michelle Wyndham-West	Master of Science in Design for Health	(18-20)
Texas Tech University Lubbock, USA	/	Debajyoti Pati	/	(21)
The University of Kansas Lawrence, USA	Institute of Health + Wellbeing design	Frank Zilm	Master of Architecture with Health + Wellness	(22-23)
University of Nevada, Las Vegas	/	Joshua Vermillion	Master of Healthcare Interior Design	(24)
University of Texas Arlington, Arlington, USA	/	Southern Ellis	/	(25)
Europe				
Chalmers University of Technology Gothenburg, Sweden	Center for Healthcare Architecture	Göran Lindahl	/	(26)
ETH Zürich, Zurich, Switzerland	/	Tom Guthknecht	/	(27)
Politecnico di Milano Milan, Italy	Cluster "Design of Healthcare Facilities" and Design & Health Lab	Stefano Capolongo	/	(28)
Politecnico di Torino Turin, Italy	Architectures for Health (AxS)	Riccardo Pollo	/	(29
Sapienza University of Rome, Italy	/	Tiziana Ferrante	/	(30)
Technischen Universität Berlin, Berlin, Germany	Architecture for Health (dept.)	Lars Steffensen	/	(31)
Technischen Universität Wien, Wien, Austria	/	Morten Gregersen	/	(32)
Università degli Studi di Firenze, Florence, Italy	TESIS Center "Systems and technologies for healthcare facilities"	Roberto Bologna	/	(33)
University of Groningen Groningen, The Netherlands	/	Cor Wagenaar	/	(34-35)
Oceania				
University of Sydney Sydney, Australia	Design Lab (Designing for Health and well-being)	Soojeong Yoo	/	(36).

through several topics related to the increase in chronic diseases, population aging, increased costs and reduced budgets, the emergence of new infections/epidemiological trends, cultural diversity on the rise, a shift to multi-setting healthcare delivery, and the diffusion of digital technologies. The program has four main themes provided primarily through studio learning with associated projects: Health context (developing knowledge of the domain in the field of health, healthcare, communications, technology and innovation); Research and application (identify, design, conduct and apply qualitative, co-design and evidence-based techniques for health challenges); Design and innovation (creating new, ethical and sustainable solutions with stakeholders, patients and partners in the healthcare sector); Competence and leadership within interdisciplinary collaborations (being integrated into interdisciplinary teams that include patients, healthcare providers and designers to develop design solutions and communicate results) (18).

- **Boston Architectural College** offers a Master of Design Studies in **Design for Human Health.** This program develops skills in design and health through several topics related to Universal Design, Environment & Behaviour, Advanced Theories in Design for Wellbeing, Environmental Health, Health Conditions and Design, Environmental Psychology, and others (14).
- **Kent State University** offers a graduate certificate in **Health systems and facilities design**. The coordinator of the Healthcare Design program is Prof. Sara Bayramzadeh. The purpose of the program is to develop an understanding of how healthcare operations and quality are implicated by design strategies (17).

- **Kansas University**, **Master of Architecture with Health + Wellness** coordinated by the Dean and Director of the Institute for Health+Wellness Design Prof. Frank Zilm, permits all the students in their final year of the master of architecture program to choose the option to concentrate and focus their studies on Health + Wellness curriculum with three training activities: Architecture of Health course (related to healthcare facilities and systems); Health + Wellness Internship in a professional firm; Health + Wellness Capstone Studio. Students who complete the required course sequence receive the Graduate Certificate in Architecture of Health + Wellness (22).

PhD Programs

Many universities offer PhD programs related to healthcare design (hospital design, elderly, architecture and neuroscience, etc.), such as Aalborg University (Denmark), Beijing University of Civil Engineering and Architecture (China), National University of Singapore (Republic of Singapore), Queensland University of Technology (Australia), Technische Universität Delft (The Netherlands), Technion - Israel Institute of Technology (Israel), University of Belgrade (Serbia), University of Michigan (USA), etc.

Professional Postgraduate Masters

There are several training programs that offer a professional Postgraduate Masters related to training in **hospital design** for **healthcare designers**. Among the programs, there are:

- **Laboratory of Architecture for Healthcare Barcelona** (LA(H)B) promoted by **Universitat Politècnica de Catalunya (UPC)** and **Escola Sert del Collegi d'Arquitectes de Catalunya COAC** (5th ed.) in Barcelona (Spain). The director is the

arch. Mario Corea. It is a specialization program addressed to Architects and Engineers. The course is aimed at planning and designing hospital facilities, their components and technologies, their relationships with users and activities related to the healthcare processes, and hospital layouts (37).

- **Architecture of the Healthcare System (EASS)** at **Universidade Católica de Brasília** (Brasil) is a specialization course addressed to Architects and Engineers. The program, coordinated by prof. Marcio Oliveira, is aimed at designing healthcare facilities, their components and technologies, their relationships with users and activities related to the healthcare processes (38).
- **Master in Healthcare Facilities** at **UCL BREI** London (UK) is designed for professionals involved in the topics related to health and built environment to learn about the challenges facing the supply and operation of healthcare facility's real estate in the 21st century. The Programme Leader is arch. Evangelia Chrysikou. The program argues the following topics: Development and Capital Projects, Building Solutions and Systems, Modern Economics and Finance for Real Estate, Forms of Value for Real Estate, Health Systems, Services and Technologies, Health Services: Primary Care, Health Services; Hospitals and Complex Facilities, and Health Services: Long-term Care (39).
- The Elliot Program for **Master of Healthcare Design** (MHCD) at **Kent State University** in Kent (USA) is a post-professional degree. Coordinator of the Master is Prof. Sara Bayramzadeh. The program equips students with the knowledge and skills required to design spaces that are conducive to safety, satisfaction, and efficiency for all end users, including patients, staff, and caregivers related to healthcare facilities (40).
- Post-professional degree program (and a full master) **Master of Healthcare Interior Design** of the **University of Nevada** in Las Vegas (USA) provides a cross-disciplinary and innovation-driven educational experience that is responsive to current and projected modes of professional practice in the design of health promoting and healthcare environments. The graduate coordinator is prof. Joshua Vermillion. The aim of the program is a specialized knowledge and skills to effectively participate in design and project delivery processes of health promoting and healthcare environments, in-depth knowledge relevant to the design and planning of building interiors, etc. (24).
- Postgraduate Master in **Hospital Planning and Design** by **Bharati Vidyapeeth University** (Center for Health Management Studies and Research) in Dhankawadi in Pune in India. In general, the program imparts necessary knowledge and skills about various aspects involved in planning, designing and construction of healthcare organizations with an emphasis on sustainability (41-42).

In addition, the **Nickl Academy** in Munich (Germany), in which Christine Nick-Weller, a renowned professor at the Technical University of Berlin, is a member of the board. This independent academy provides modules and lectures, and short courses related to healthcare facilities, medical concepts, healthcare facilities' design, project management, feasibility studies, tendering & financial analysis, hospitals management, healthcare systems, and leadership and soft skills development (43).

C. The Hospital or Medical planner

There is another emerging professional figure and that is the **hospital planner**, also known as a **medical planner**. The designer is a healthcare practitioner (physician, nurse, etc.) capable of interpreting social issues and healthcare needs and has experience in managing the complexity of the hospital. They must have multidisciplinary skills in order to support the different stakeholders involved (including the healthcare management) in the process of planning, programming, design and management of a healthcare facility.

There are several Hospital planner programs:

- Postgraduate Master "**Planning, Programming and Design of Hospital and Healthcare facilities**" promoted by **Politecnico di Milano** (director Prof. Stefano Capolongo) in collaboration with **Università degli Studi di Milano** (co-director Prof. Francesco Auxilia) and **Università Cattolica del Sacro Cuore in** Rome (co-director Prof. Umberto Moscato) in Italy. At the 11th edition, the Master has acquired a solid multi-disciplinarity and professionalism thanks to the network of experts, professionals and companies involved. The training course deals with the areas related to the organization, design, management, and safety and hygiene issues in architectures for health. The course is addressed at first to architects and engineers, and to managers, physicians and nurses, who intend to investigate issues related to the design and management of healthcare structures (44).
- Postgraduate Master **Planning and Designing a Healing Environment** at **Cornell College of Human Ecology** and **Cornell Engineering** (USA), promoted by Prof. Franklin Becker,

as an *e-learning course*, provides in-depth instructions on Evidence Based Design issues to improve healthcare environments. The courses mainly concern the components relating to the planning and design of healthcare facilities, focuses on US healthcare system and strategic vision for the healthcare organization. The course is for managers and designers of hospital and healthcare facilities and healthcare and non-healthcare staff (45).

- Postgraduate Master Program **Healthcare Facilities** (MSc) of the **Medical University of Wien,** represented by Prof. Micheal J. Hiesmayr, and **Technische Universität Wien**, coordinated by Prof. Christian Kühn, is characterized by the cooperation between the fields of architecture and spatial planning, business organization and medicine. The program pursues a holistic approach to the conception, planning, construction, operation and management of healthcare facilities in the service of patients. The aim of the program is to impart interdisciplinary, international knowledge and its application for successful and sustainable planning, design and restructuring of healthcare facilities. Its target is in particular related to architects, engineers, medical doctors and specialists, nursing staff, health and healthcare managers, physicists and computer scientists involved in the planning and design of healthcare (46).
- Graduate certificate in **Planning and Design of Healthcare Environments** at **Ball State University**, coordinated by Prof. Shireen Kanakri, provides a multidisciplinary webinar program that related to design, manage, and assess healing spaces. In particular, the courses are related to evidence-based design in healthcare settings, legal, ethical, and safety issues in

the healthcare industry, health environments for patient populations, and research in healthcare design. The target of the course is interior designer, architect, nurse, healthcare administrator, facility manager, and healthcare workers (13).

- **The New School Parsons** in New York City (USA), offers an on-line program **Human-Centered Healthcare**, and in particular the course **Design Thinking for Human-Centered Healthcare**. This course introduces students to the unique design opportunities available within healthcare and some of the methods used to apply design thinking. Using a project-based approach, participants learn to identify opportunities to have an impact in their chosen context, gain an understanding of the human experience of care, and develop strategies to shape a more human-centered experience for patients, staff, clinicians, and/or caregivers. This course is aimed at those with differing levels of design and/or healthcare experience and is appropriate for designers, administrators, clinicians, and entrepreneurs (47).

Our search highlighted two relevant programs that are not active but that are worthy of mention.

In the previous years, there was also the **MSc Planning Buildings for Health** promoted by the Medical Architecture Research Unit (**MARU**) of **London South Bank University** in UK, coordinated by Prof. Liz Whelan. The goal was to provide relevant skills to business planning, sustainable development, strategic planning and service activities, project briefing tools and customer focus, project leadership, lean thinking and change management, evaluation and research methods of the buildings in use, inclusive evidence-based design and therapeutic environment. The course takes place in the

following six modules: Planning Process in Healthcare Business, Strategic Planning of the Healthcare Estate, Procurement and Management of Construction, Project Briefing and evaluation, Project Leadership, and Comparative Health Estates Studies (48).

In conclusion, the **Danube University Krems** in Austria will soon provide a **MSc Technical Management in Healthcare**, coordinated by Profs. Michael Ogertschnig and Diethard Gstir. The program is aimed at training management skills and methods in healthcare and offering a complete overview of technical aspects, related in particular to legal, economic, medical and hygienic requirements. The general objective of the course is to impart the ability of implementing and applying the acquired management methods within the healthcare related work environment. In particular, the target of participants will be technicians and junior managers in the fields of technology and operational safety, technical management, facility management, ecology, logistics, business organization, technology-related purchasing and material management in healthcare facilities (49).

D. The Physician-Architect

Healthcare design requires the participation of both physicians and designers and together offer a balance between disease and health, inspiring a new mode of practice (50-52).

Regarding the relation between medicine and architecture, as Capolongo (53) and Loxterkam and Snider (54) highlighted, the built environment has a great influence on health.

There are several training programs targeting physicians such as:

- **Imperial College of London** (Faculty of Medicine) and the **Royal College of Art**, coordinated by Prof. Ashley Hall, gives rise to **Healthcare &**

Design MRes, a degree for providing students with a wide range of professional experiences with the tools and techniques to instigate and guide innovation in healthcare systems, services and spaces, with a focus on UK healthcare system. The course is open to physicians and healthcare professionals, and designers (55).

- **University of New South Wales** (UNSW Sydney), the Medicine and Arts program is an alternative course in which a student can obtain the Bachelor of Arts degree, together with the **Bachelor of Medical Studies / Master of Medicine**. Only students who have been admitted to UNSW Medicine can access the program. In order to complete the combined program in 7 years, students are required to complete courses related to the relationship between physical space and health (56).

- **Symbiosis School for Open and Distance Learning** (SSODL, Symboisis International Deemed University) provides a post-graduate diploma **Hospital Planning & Design** (PGDHPD) in Pune (India). This on-line program aims to offer to healthcare professionals relevant and recent knowledge and skill related to hospital planning and design with the aim to obtain the appropriate competencies for developing high quality infrastructures in pursuit of delivering modernized healthcare (57).

- The Sidney Kimmel Medical College of the **Thomas Jefferson University** provides a **Design (DES) Track**, coordinated by Prof. Bon S. Ku, in which students learn about design and creative problem solving methods, with competencies in healthcare systems, services, spaces, and devices (58). As part of a broader Medicine+Design initiative at Jefferson, the track draws from diverse fields, including architecture, industrial design, and systems engineering (59).

In conclusion, the specialization for MD in public health (in some EU countries such as Italy named as Public Health and Preventive Medicine and in the UK as Community Medicine) should provide residents with complete preparation on public health issues including the relationships between architecture and health, hospital design and management, urban health, engineering and technical systems applied to health (60-65). The core-curriculum of the Italian specialist, for example, incorporating the recommendation of ASPHER (66) has included these issues, also entrusting some architects and engineers with teaching activities among the 35 Italian schools (67-70)

E. The Physician-engineer

Another professional figure that is emerging is the **physician-engineer**, also named **doctor engineer**. In fact, as Larkin (71) suggests, "*what do point-of-care diagnostics, organs-on-chips and pacemakers have in common?*". They are products born by the interdisciplinary collaborations among doctors and engineers. Nowadays during a medical examination, the amount of technology used for both diagnosis and treatment is rapidly growing. As a consequence, the future of medicine depends on the development of new technologies; in fact 80% of the healthcare knowledge, instrumentations and techniques will completely change (72). One of the healthcare challenges is the ability to combine medical knowledge with the engineering and technological expertise to find smart solutions and the development of tools for new frontiers in healthcare.

Currently, some synergies between medical and technical fields are already being institutionalised and translated into university programs and degrees, in particular:

- **Texas A&M University (TAMU)** (Engineering faculty) and **Houston Methodist Hospital** are taking a further step forward in collaborations by launching the **Texas A&M University Engineering Medicine School (EnMed)** in USA. EnMed is an integrated school of educational medicine and research with a focus on innovation and entrepreneurship, which will offer a complete degree program with a Master's degree or a PhD in engineering (73). The curriculum will be designed to align some areas of clinical medicine with the corresponding areas of engineering technology (stents, ventricular and defibrillator devices, imaging technologies, biomaterials for hip and knee prostheses, etc.).

- **Humanitas University** and **Politecnico di Milano** in Milan (Italy) launched the MEDTech program that integrates and enhances the surgeon's skills with those typical of Biomedical Engineering. The coordinator of the program is Prof. Maria Laura Costantino. At the end of the program, the student obtains a Master of Science in Medicine and a bachelor's degree in Biomedical Engineering. The goal is to train physicians who are capable of understanding and knowingly managing the advanced technologies for offering innovative and personalized treatments for patients (74).

- The interdisciplinary approach of the **College of Medicine in Carle Illinois** combines the four pillars of basic sciences, clinical sciences, engineering and innovation and human science (75). The course of study provides several courses related to engineering.

- **Technion - Israel Institute of Technology** in Haifa (Israel) launched a double Degree Program in **Medicine and Biomedical Engineering** for the students of medicine. The aim of the program is to train graduates with in-depth knowledge in the fields of medicine, engineering and biomedical industry. The program guarantees a double degree: Master of Science in Medicine and a Bachelor's degree in Biomedical Engineering (76).

- The **Thomas Jefferson University** in Philadelphia (USA) provides the advanced practice certificate "**Using Design in Healthcare Delivery**", with online courses, coordinated by Prof. Mikael Avery. The program aims at providing practicing occupational therapy practitioners and healthcare professionals with specific knowledge in design principles and a distinct skill-set in design approaches and methods that will enhance their practice and expand inter-professional collaborative opportunities (77).

- **National University of Singapore** (NUS - Faculty of Engineering) and **Duke-NUS Medical School** in Singapore created the integrated program **NUS Engineering and Medicine track**. During their undergraduate course of study in the Faculty of Engineering, students will participate in the Innovation and Design Programme (IDP) that permits to have some courses at Duke-NUS Medical School. At the end of the program the student obtains a Master of Science in Medicine and a bachelor's degree in Engineering (78).

- **Master of Health Technology Innovation** at **University of Sydney** aims to train the challenges of healthcare systems through innovative data science and engineering solutions. The target of the course is health practitioner, engineer, IT professional, and scientist (79).

- In 2016 **Centrale Nantes** in France launched the double degree *"Double-*

diplôme Ingénieur-Medecin", with the possibility to obtain the double degree in engineering and medicine with the **Universitè de Nantes**, with the following organization: for all engineering students, the possibility of taking a biology course from the first year of the program; for some, the opportunity to choose a healthcare specialization (digital sciences for life sciences and healthcare), aimed at providing advanced training in the transdisciplinary field of digital sciences and technologies for applications to life sciences and health care; for few interested, the opportunity to obtain the double degree in engineering and medicine (80).

- **Delft University of Technology** in The Netherlands, there is Design Master Class for Professionals in **Design for Healthcare**, coordinated by Prof. Richard Goossens, by the Industrial Design Engineering dept. The program aims to gain insights in the healthcare design, investigation of the needs and experiences of patients and medical professionals, and multi-stakeholders systems and processes in healthcare. The target is related to designers and healthcare providers (81).

F. The Nurse-architect

There are two emerging professional figures that are the **nurse-engineer and nurse-architect**.

Florence Nightingale in *Notes on Nursing* had already highlighted in 1859 the importance of several environmental factors that are currently considered critical to patient care, such as cleanliness, noise control, natural lighting and views of nature (82). Despite the deep knowledge of nurses related to the patient's care environment, they had not always been an integral part of the healthcare

facilities' design, but nowadays more and more healthcare organizations, architectural firms and nursing groups are recognizing the value that this professional figure can affect in the design of healing environments, giving rise to the **nurse-architect**, well-known also with the term **hospital makerspace** (83). In fact, while many nurses believe that the healthcare sector needs to do a lot to ensure that medical staff can contribute significantly to the design of facilities, many nurses are helping to create - and even guide the design of – new innovative healthcare spaces (84). Some of those experiences are also resulting in high level academics achievements and researches in the fields of nursing care, architecture and health management (85-86).

There are several universities that offer design courses within Nursing School faculty programs:

- Double Nursing Degree at the **Münster University of Applied Sciences** in Munster (Germany), coordinated by Prof. Claudia Oetting-Roß, in which the skills of the training course are patient advice, introduction of national standards of experts in the sectors of activity, discharge management, quality management, promotion of multi-professional collaboration, and project management (87).
- **Clemson University** (Clemson, USA), coordinated by Prof. Susan 0'Hara, has some courses in design, architecture, and built environment (88).
- Nursing study program of the **American University of Frostburg** in Maryland (USA), coordinated by prof. Heather Gable, provides courses related to space planning (89).

G. The nurse-engineer

Engineers play an important role in the translation and implementation of knowledge but they focus on results, efficiency, systems and problem solving and finding the

solution. The **nurse engineer** merges the competencies of an engineer and a nurse. In fact, the growth and development of nursing engineering provides key resources to help focus on these critical aspects, advancing the science of nursing, supporting nursing practice and enabling the modernization of solutions in healthcare (90).

Among the training courses, there is a double degree in biomedical and nursing engineering, at **Duquesne University** in Pittsburgh (USA). The BME / BSN double degree provides in 5 years clinical knowledge and skills through a holistic nursing approach. Students acquire a deep clinical perspective and learn to develop technologies and solve real clinical problems (nurses are the ability to evaluate patients' functional health status and technological needs (91).

In addition, a nurse-engineering joint degree is being planned at **University of Massachusetts** in Boston (USA), Amherst Fellowship (92).

Moreover, as the "Nurse Engineer" webportal has listed, there are several opportunities for training competencies in engineering (93), such as:

- MSN, PhD or DNP Nursing Programs, such as Arizona State University with the program Nursing and Healthcare Innovation, University of Minnesota, University of Maryland, University of Wisconsin Milwaukee, Rush University, etc.
- MS or PhD Health Systems Engineering such as UW Madison – Industrial Engineering, University of Southern Florida, etc.;
- Masters in Medical Device and Innovation such as University of Minnesota with Master in Medical Device Innovation; Arizona State University with the Master in Health care Innovation (e-learning course); Johns Hopkins with the Master in Applied Biomedical Engineering, Bioengineering Innovation and Design; Stanford with Biodesign Innovation Fellowship, etc.

Limitations and future developments

This work is a preliminary investigation of available websites without a systematic analysis. We are aware that some international courses could be difficult to find due to language limitations, website restrictions or specific university policies. Nevertheless, we are confident that the preliminary results could be useful in tackling the challenges of healthcare architecture in the future (94). Starting from those considerations, a deeper and more structured investigation with the support or the direct involvement of the different universities will be conducted and multiple collaborations and discussions in this direction are needed.

Conclusions

Our preliminary analysis provides an overview of the current educational programs and training courses on hospital and healthcare design. The analysis can help support a broad learning network for improving knowledge and synergies among higher education institutions (95) needed to design and support safe high quality patient care (96-97). The study is the first attempt to collate the training programs across traditional and emerging disciplines to support a discussion on the topic of the future of healthcare planning and education. Further in-depth investigations will be conducted to highlight how these experiences will impact the field of hospital architecture and the health workforce (98-99), using mixed methods including surveys, interviews and focus groups to better understand the course organization, students' outcomes and professional career, fields of interest and collaborations with other institutions.

Riassunto

Sfide educative nella progettazione sanitaria: formazione di professionisti con competenze multidisciplinari per la progettazione degli ospedali e delle strutture di assistenza sanitaria del futuro

Background. Gli ambienti sanitari sono una delle aree di lavoro più complesse e con diversi requisiti. Gli sviluppi scientifici, tecnologici e nell'ambito della ricerca, insieme a nuove scoperte nell'ambito delle strategie di promozione e prevenzione della salute, richiedono sempre più un approccio multidisciplinare e interdisciplinare. Pertanto, è probabile che le attuali professioni dovranno essere significativamente adattate per rispondere a ruoli nuovi e più specializzati.

Obiettivi. L'intento è presentare l'attuale scenario dei corsi di formazione delle professioni emergenti, come l'*hospital planner*, il medico ingegnere, il medico architetto, l'infermiere architetto o ingegnere. Nel paper vengono esaminati gli attuali corsi di formazione a livello internazionale (Laurea triennale, Laurea magistrale, corsi di specializzazione e Dottorato di ricerca) relativi alla progettazione sanitaria nell'ambito della medicina e scienze infermieristiche, architettura e scienze ingegneristiche.

Risultati. Il paper fa una disamina della revisione della letteratura e analisi di siti-web, su programmi e corsi di insegnamento attivi. Diverse istituzioni accademiche offrono corsi di laurea triennale, magistrale e di dottorato in progettazione ospedaliera, igiene ambientale degli edifici, e sanità pubblica. Inoltre, sono presenti diversi corsi postlaurea professionali, sia in aula che ibridi o online.

Conclusioni. Un numero considerevole di esperienze di formazione internazionale sta affrontando il tema della formazione di professionisti multidisciplinari. Sono necessarie però ulteriori indagini per esaminare maggiormente i contenuti, le modalità dell'insegnamento e l'impatto dei corsi, i risultati degli studenti e le carriere professionali, i campi di interesse e il grado di collaborazione con altre istituzioni.

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