Existing Guidelines for Indoor Air Quality: The Case Study of Hospital Environments

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Introduction

In Europe, exposure to organic and inorganic chemical pollutants and their related health aspects in indoor spaces, such as homes or shared communities (e.g. schools, hospitals, day care, sports facilities, libraries, restaurants, theatres, cinemas and public transport), has been taken into increasing consideration by the general public, governments and, in particular, by the main environmental and health institutions (WHO 1982, 1984, 2000).

The hospitals and first-aid/healthcare centres can be ranked among indoor environments. In such structures, different activities take place, such as research, diagnosis, teaching and training, rehabilitation and prevention (Astley et al. 2015; Alfonsi et al. 2014). About 10% of workers in European Union belong to the health and welfare sector, and many of them work in hospitals (EC 2010).

Therefore, a variety of persons recognizing different exposure risks (professional vs. non professional exposure, and associated sensitivity and vulnerability) share the same indoor environment, such as students, physicians, nurses, young and old patients and visitors (WHO 1982; Buffoli et al. 2007; Capolongo et al. 2015a).

Within this frame, dedicated guidelines and standard operating procedures were already issued on professional exposure in healthcare centres, according to the specific work duty in the different units [i.e. surgery unit, antineoplastic unit and sterilization/sanitization service (Capolongo 2016)].

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S. Capolongo et al. (eds.), *Indoor Air Quality in Healthcare Facilities*,
SpringerBriefs in Public Health, DOI 10.1007/978-3-319-49160-8_2

Until now, for the administrative staff, training and teaching personnel, patients and visitors, biological hazards and related risks have been mainly taken into account, and only recently, the chemical agents released from indoor sources as consequence of the anthropogenic activities have been considered (D'Alessandro et al. 2016; Capolongo et al. 2015a).

Exposure to indoor chemical compounds of anthropic origin may contribute significantly to a population's and workers' overall intake of pollutants. As a result of a long-term work from 1970s (Suess 1992), WHO has shifted from devoting a chapter in its air quality guidelines on indoor air pollutants, mainly associated with radon and environmental tobacco smoke (WHO 1987, 1999, 2000, 2006) and with specific indoor air quality guidelines (WHO 2009, 2010). These guidelines cover various pollutants such as benzene, nitrogen dioxide, polycyclic aromatic hydrocarbons (e.g. benzo[a]pyrene), naphthalene, carbon monoxide, radon, trichloroethylene and tetrachloroethylene (WHO 2010) and also mould and dampness (WHO 2009).

The European Environmental Agency (EEA) highlights that the quality of air inside buildings is affected by the quality of ambient air, construction materials, air circulation, electrical appliances, cleaning products used, habits of occupants, such as smoking, and by building's upkeep (such as energy-saving steps) (EEA 2010, 2013). A vast range of pollutants, with different patterns of dispersion, can concentrate on indoor environments in relation not only to the outdoor concentrations but also to the activities carried out by individuals, to the presence of pets, to the use of furniture and construction materials, as European Collaborative Action "Urban Air, Indoor Environment and Human Exposure" stated (ECA-IAQ 2012).

In the past twenty-five years ago, the European commission (EC) has also funded numerous projects, for example the THADE project "Towards Health Air in Dwellings in Europe" (2002–2004) (Franchi et al. 2004), the EnVIE project "Indoor Air Quality and Health Effects" (de Oliveira Fernandes et al. 2010), the AIRMEX project "European Indoor Air Monitoring and Exposure Assessment Project" (2003–2008) (Kotzias et al. 2005, 2009) and the EXPOLIS study (1996–2000). All these projects have attempted, at least partially, to increase awareness on indoor air quality and definition of priorities and objectives (Coulson et al. 2005).

At the European level, there is a trend for an integrated promotion of the quality of indoor air in order to drastically reduce the presence of pollutants of various kinds; but regulations in various European member states are still absent.

Through discussing a national case, it is possible to consider all the norms and legal reference values that are currently available in Europe for indoor air quality (Settimo 2012, 2013, 2015; Oppio et al. 2016). All the norms and references available in Europe constitute a framework that can provide support in case of absence of national legislation and, in any case, a legislation is going to be organized.

Limit Values and Technical Recommendations

Although norms on indoor air pollution in various European member states are still absent, there are various reference values available in many states (Table 1). It is important and necessary to proceed soon to a harmonization by establishing the elements (such as collection and analysis methods) as well as the parameters which need to be considered for indoor air pollution control. This means to review according to established protocols the available information, gathered in a systematic way, on the quantity, nature and origin of pollutants. In this respect, the European Regulatory Committee (CEN) and International Organization for Standardization (ISO) have provided a set of specific instructions on standard operating procedures for indoor air quality monitoring (ISO 16000). The EC within the European Collaborative Action (ECA) has carried out a multidisciplinary collaboration among experts, producing a collection of 27 specific papers, published between 1988 and 2012.

In terms of harmonization, important information is also available at WHO for drafting the indoor air quality guidelines, for which evidence on health effects is considered reasonably certain (WHO 2010). WHO guidelines have taken into consideration the following: benzene, nitrogen dioxide, polycyclic aromatic hydrocarbons (especially benzo[a]pyrene), naphthalene, carbon monoxide, radon, trichloroethylene and tetrachloroethylene.

Regarding cancerogenous pollutants in the air, WHO provides risk assessment for the general population. The guidelines constitute a base for establishing legal norms (and limits), adopted by various states, subject to periodic revision. However, the guidelines related to airborne pollutants are quite limited due to the large number of indoor airborne pollutants, and this has lead to a proliferation of norms and reference values that constitute a peculiar European framework.

Currently, we are far from the past situation when industrial occupational exposure limit values were used to assess non-industrial indoor air quality in case of absence of reference values, a practice already considered inappropriate by WHO (1982).

Reference values allowed for indoor environments are more restrictive than those suggested for workplaces, based on 8-h a day, 5-day a week exposure and for a maximum period of 40 years, and targeted to the protection of workers against professional illnesses (WHO 2010; Italy 2008).

Moreover, it is worth considering European reference documents drafted by standardization agencies, such as the CEN and the ISO. Such organizations have long been involved in researching the best technical solutions regarding the methodologies for conducting tests (sampling, analysis and measurement). Currently, the EN norms can provide support for indoor air pollution monitoring and reduction. In fact, all of the previously listed EN norms have been ratified in Italy by the Italian National Board of Unification (UNI). The main norms on measurement of indoor air quality parameters that can be identified are thirty-three.

Table 1 Guidelines for air quality[a] and for individual risk in different European states issued by WHO[b] regarding certain pollutants (Settimo 2015; D'Alessandro and Capolongo 2015)

μg/m^3	WHO ambient air	WHO indoor air	French	German	Netherlands	UK	Belgium	Finland[c]	Austrian	Portugal	Norway	Poland home	Poland public office
Benzene	No guidelines values 6 × 10^{-6} (μg/m^3)$^{-1}$ (UR/lifetime) 1.7 μg/m^3 (UR/lifetime) 10^{-6} 17 μg/m^3 (UR/lifetime) 10^{-5}	No guidelines values 6 × 10^{-6} (μg/m^3)$^{-1}$ (UR/lifetime) 1.7 μg/m^3 (UR/lifetime) 10^{-6} 17 μg/m^3 (UR/lifetime) 10^{-5}	30 μg/m^3 (1 Daily–1 year) 10 μg/m^3 (1 year) da UR WHO: 0.2 μg/m^3 (UR/lifetime) 10^{-6} 2 μg/m^3 (UR/lifetime) 10^{-5} 5 by 1 January 2013 2 by 1 January 2016	–	20	5 (1 year)	≤2 10	–	–	5 (8 h)	–	10 (24 h)	20 (8 h)
Formaldehyde	100 (30 min)	100 (30 min)	50 (2 h) 10 (1 year) 30 by 1 January 2018, 10 by 1 January 2023	12	120 (30 min) 10 (1 year) 1.2 year-long exposure	100 (30 min)	≤10 (30 min) 100 (30 min)	50	100 (30 min 60 (24 h)	100 (8 h)	100 (30 min)	50 (24 h)	100 (8 h)
Carbon monoxide mg/m^3	100 (15 min) 60 (30 min) 30 (1 h) 10 (8 h)	100 (15 min) 35 ((1 h) 10 (8 h) 7 (24 h)	100 (15 min) 60 (30 min) 30 (1 h) 10 (8 h)	60 (30 min) 15 (8 h)	100 (15 min) 60 (30 min) 30 (1 h) 10 (8 h)	100 (15 min) 60 (30 min) 30 (1 h) 10 (8 h)	5.7 (24 h) 30 (1 h)	8	–	10 (8 h)	25 (1 h) 10 (8 h)	25 (1 h)	10 (8 h)
Nitrogen dioxide	200 (1 h) 40 (1 year)	200 (1 h) 40 (1 year)	200 (1 h) 40 (1 year)	350 (30 min) 60 (week)	200 (1 h) 40 (1 year)	300 (1 h) 40 (1 year)	≤135 (1 h) 200 (1 h)	–	–	–	200 (1 h) 100 (24 h)	–	

(continued)

Table 1 (continued)

μg/m³	WHO ambient air	WHO indoor air	French	German	Netherlands	UK	Belgium	Finland[c]	Austrian	Portugal	Norway	Poland home	Poland public office
Naphthalene	–	100 (1 year)	10 (1 h)	20–200 (week)	25	–	–	–	–	–	–	100 (24 h)	150 (8 h)
Styrene	260 (week) 70 (30 min)	–	–	30–300 (week)	900	–	–	–	40 (week) 10 (1 h)	–	–	20 (24 h)	30 (8 h)
Polycyclic aromatic hydrocarbons PAH (BaP) ng/m³	No guidelines values 8.7×10^{-5} $(\mu g/m^3)^{-1}$ (UR/lifetime) 0.12 ng/m³ (UR/lifetime) 10^{-6} 1.2 ng/m³ (UR/lifetime) 10^{-5}	No guidelines values 8.7×10^{-5} $(\mu g/m^3)^{-1}$ (UR/lifetime) 0.12 ng/m³ (UR/lifetime) 10^{-6} 1.2 ng/m³ (UR/lifetime) 10^{-5}	–	–	1.2	0.25 (1 year)	–	–	–	–	–	–	–
Tetrachloroethylene	250 (1 year)	250 (1 year)	1380 (1–14 days) 250 (1 year)	1 (week)	250	–	≤100	–	250 (week)	250 (8 h)	–	–	–
Trichloroethylene	No guidelines values 4.3×10^{-7} $(\mu g/m^3)^{-1}$ (UR/lifetime) 23 μg/m³ (UR/lifetime) 10^{-6} 230 μg/m³ (UR/lifetime) 10^{-5}	No guidelines values 4.3×10^{-7} $(\mu g/m^3)^{-1}$ (UR/lifetime) 23 μg/m³ (UR/lifetime) 10^{-6} 230 μg/m³ (UR/lifetime) 10^{-5}	800 (14 days–1 year) da UR WHO: 2 μg/m³ (UR/lifetime) 10^{-6} 20 μg/m³ (UR/lifetime) 10^{-5}	1 (week)	–	–	≤200	–	–	25 (8 h)	–	150 (24 h)	200 (8 h)
Dichloromethane	3000 (24 h) 450 (week)	–	–	200–2000 (24 h)	200 (1 h)	–	–	–	–	–	–	–	–

(continued)

Table 1 (continued)

μg/m^3	WHO ambient air	WHO indoor air	French	German	Netherlands	UK	Belgium	Finland[c]	Austrian	Portugal	Norway	Poland home	Poland public office
Toluene	260 (week) 1000 (30 min)	–	–	300–3000 (1–14 days)	200 (1 h)	–	≤260	–	75 (1 h)	250 (8 h)	–	200 (24 h)	250 (8 h)
Volatile organic compounds VOC	–	–	–	–	200 (1 h)	–	≤200	–	–	600 (8 h)	400	400	–
PM_{10}	50 (24 h) 20 (1 year)	–	50 (24 h) 20 (1 year)	–	50 (24 h) 20 (1 year)	–	≤40 (24 h)	50	–	50 (8 h)	90 (8 h)	90 (8 h)	–
$PM_{2.5}$	25 (24 h) 10 (1 year)	–	25 (24 h) 10 (1 year)	25 (24 h)	5 (24 h) 10 (1 year)	–	≤15 (1 year)		–	25 (8 h)	40 (8 h)	40 (8 h)	–

Notes

[a]Guidelines of the quality of indoor air report levels of concentration of pollutants in air, for exposure times indicated, for which no adverse effects on health are expected, concerning substances which are not cancerogenous

[b]The assessment of the increase in unitary risk (Unit risk-UR) refers to the additional risk of cancer, which could take place in a hypothetical population in which all individuals are continuously exposed, from birth for their entire life, to a concentration of the risk factor in the air they breathe

[c]The guidance values for indoor environments are valid under the following frame: space taken up at least 6 month long, with the venting systems turned on in continous

The European Framework

When national norms providing guidelines or reference values to be used for assessment activities are not available, it is possible to refer to criteria and norms adopted in other states or apply the ones available in the scientific literature, or by analogy, other standards such as those relative to ambient air (EU 2008).

In addition, several European states in these last few years have created working groups responsible for drafting the indoor air quality guidelines (Table 1). In the France, Finland, Poland, Portugal and Austria, the recommended guidelines values have legal validity because they have been adopted in legislative acts; on the contrary, in Germany, the Netherlands and UK, the recommended guidelines do not have legal validity but can be used in assessing and improving the quality of indoor air.

Currently, in France the new "Plan d'action sur la qualitè de l'Air Interieur", published in 2013, indicates a series of measures, including also anticipates the requirement of indoor monitoring in hospital and healthcare facilities. It was originally scheduled for 2023.

Methods are a fundamental aspect, as well as the reference values. In all countries, the reference values proposed are related to the methods of sampling and analysis developed by national authorities, for example by the German Institute for Standardization-DIN, Association Française de Normalisation-AFNOR, Bureau de Normalisation-NBN, Finnish Standards Association SFS, Austrian Standards Institute-ASI, Netherlands Instituut Normalisatie-NEN, British-BSI Standards.

So it is possible to consider the existence of a European framework if we summarize the main figures add significant details, regarding the pollutants taken into consideration in guidelines by national countries and WHO, as Table 1 shows.

In Italy, there is not a specific law on indoor air quality, but in recent years, awareness in indoor issues has grown considerably, and specific working groups were activated to address this issue. Already in 1983, the issue of formaldehyde was a matter of concern, and the Ministry of Health suggested, experimentally and temporarily, a maximum concentration limit of 0.1 ppm (0.124 mg/m^3) in neighbourhoods and homes (Ministero della Salute 1983). More recently, the Italian Ministry of Health (Ministero della Salute 2012) has pointed out that indoor air pollution, in non-industrial places but for home, leisure, work and transportation, is an important issue for public health, with major social and economic implications. The report also states that indoor pollutants can be present in concentrations such that while not causing acute effects, they can produce negative effects on human health, especially if linked to prolonged exposure (Ministero della Salute 2012).

Although a law on indoor air pollution does not exist, there are two agreements in force (Italia 2010, 2001). Such agreements, thought far from providing information on timing and procedures to be used regarding limits or standards to be adopted, may nevertheless represent a useful contribution to the enactment of guidelines and to the identification of reference collection and analysis techniques.

So far, in Italy or other European countries, in the absence of a reference legislation information, reference values for indoor air pollution are those available in the scientific literature or norms adopted in other European states or by analogous standards, for example for ambient air.

The application of standards developed in other European countries can also help overcoming difficult situations for monitoring institutions. Reference values represent an important parameter to be used in the risk assessment.

For example, the Italian National Health Institute (Istituto Superiore di Sanità—ISS) has activated a national research group (GdS-ISS) with representatives of various agencies, such as Ministry of Health, Ministry of Environment, Ministry of Labor and Social Policy, regions and several research institutes to provide scientific support for fine-tuning the guidelines for an appropriate control strategy of indoor spaces. The GdS-ISS has developed eight reference documents on strategies for:

- monitoring strategies for volatile organic compounds (VOCs) in indoor environments (Fuselli et al. 2013a, b);
- monitoring strategies of biological air pollution in indoor environments (Bonadonna et al. 2013);
- workshop. Issues related to indoor air pollution: current situation in Italy. Istituto Superiore di Sanità. Rome, 25 June 2012. Proceedings;
- workshop. Indoor air quality: current national and European situation. The expertise of the National Working Group on indoor air (Santarsiero et al. 2015a, b);
- monitoring strategies to assess the concentration of airborne asbestos and man-made vitreous fibres in the indoor environments (Musmeci et al. 2015);
- microclimate parameters and indoor air pollution (Santarsiero et al. 2015a, b);
- presence of CO_2 and H_2S in indoor environments: current knowledge and scientific field literature (Settimo et al. 2016a, b);
- monitoring strategies to PM_{10} and $PM_{2.5}$ in indoor environments: characterization of inorganic and organic micropollutants (Settimo et al. 2016a, b).

These documents represent a set on how to operate in these environments, the choice of sampling points, techniques, storage and analysis, and determination of other parameters such as, air speed, temperature and the relative humidity. Other factors such as vulnerability of the population and exposure conditions are surely fundamental elements that need to be known for a proper comprehension of the problem. Related to this issue, it has to be considered that the Scientific Committee on Health and Environmental Risks (SCHER) of the European Commission (EU 2007) suggests that the risk assessment be focused on more vulnerable groups such as children, pregnant women, the elderly (over 65), people suffering from asthma, other respiratory or cardiovascular diseases, following a "case-by-case" approach.

Conclusions

Since many years, problems from exposure to indoor air pollutants have been a matter of concern for national as well as European Union legislators, and an increasing numbers of states have been addressing the need for policies regarding health and strategy through specific studies.

The European Union has often addressed the importance to measure and assess indoor air quality, the relative impact on health and possible recommendation regarding future measures (EC 2002; Capolongo et al. 2015a, b).

In-depth knowledge of hygienic-sanitary aspects' assessment of indoor environments is quite important, especially regarding organic and inorganic pollutants, even though the possible levels present in the various spaces are already well known. In order to satisfy the needs for evaluating and controlling indoor spaces, the CEN and ISO have started working on a whole series of specific norms, enacting the ISO 16000 (Table 2).

In some countries (German, the Netherlands, UK), specific guideline values for IAQ have been processed, and they represent reference values and provide methods for sampling and analysis to be used in control and assessment situations (the Netherlands 2007). In other countries (France, Belgium, Finland, Poland), such procedures are already in force through the institution of mandatory monitoring and are periodically applied by public control organs specifically created (France 2011a, b).

Table 2 UNI, CEN and ISO norms on the measurement of IAQ parameters

ISO 16000 indoor air	
Published standards	
Part 1	General aspects of sampling strategy
Part 2	Sampling strategy for formaldehyde
Part 3	Determination of formaldehyde and other carbonyl compounds—active sampling method
Part 4	Determination of formaldehyde—diffusive sampling method
Part 5	Sampling strategy for volatile organic compounds (VOCs)
Part 6	Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID
Part 7	Sampling strategy for the determination of airborne asbestos fibre concentrations
Part 8	Determination of local mean ages of air in buildings for characterizing ventilation conditions
Part 9	Determination of the emission of volatile organic compounds from building products and furnishing—emission test chamber method
Part 10	Determination of the emission of volatile organic compounds from building products and furnishing—emission test cell method

(continued)

Table 2 (continued)

ISO 16000 indoor air	
Published standards	
Part 11	Determination of the emission of volatile organic compounds from building products and furnishing—sampling, storage of samples and preparation of test specimens
Part 12	Sampling strategy for polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polycyclic aromatic hydrocarbons (PAHs)
Part 13	Determination of total (gas- and particle-phase) polychlorinated dioxin-like biphenyls and polychlorinated dibenzo-p-dioxins/dibenzofurans—collection on sorbent-backed filters with high-resolution gas chromatographic/mass spectrometric analysis
Part 14	Determination of total (gas- and particle-phase) polychlorinated dioxin-like biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDDs/PCDFs)—extraction, clean-up and analysis by high-resolution gas chromatography/mass spectrometry
Part 15	Sampling strategy for nitrogen dioxide (NO_2)
Part 16	Detection and enumeration of moulds. Sampling of moulds by filtration
Part 17	Detection and enumeration of moulds. Culture-based method
Part 18	Detection and enumeration of moulds. Sampling by impaction
Part 19	Sampling strategy for moulds
Part 20	Detection and enumeration of moulds—sampling from house dust
Part 21	Detection and enumeration of moulds—sampling from materials
Part 22	Detection and enumeration of moulds—molecular methods
Part 23	Performance test for evaluating the reduction in formaldehyde concentrations by sorptive building materials
Part 24	Performance test for evaluating the reduction in volatile organic compounds (except formaldehyde) concentrations by sorptive building materials
Part 25	Determination of the emission of semi-volatile organic compounds by building products—microchamber method
Part 26	Sampling strategy for carbon dioxide (CO_2)
Part 27	Standard method for the quantitative analysis of asbestos fibres in settled dust
Part 28	Sensory evaluation of emissions from building materials and products
Part 29	Test methods for VOC detectors
Part 30	Sensory testing of indoor air
Part 31	Measurement of flame retardants and plasticizers based on organophosphorus compounds—phosphoric acid ester
Part 32	Investigation of buildings for the occurence of pollutant
Part 33	Determination of phthalates with gas chromatography/mass spectrometry (GC-MS)
Standard under development	
Part 34	General strategies for the measurement of airborne particles
Part 35	Measurement of polybrominated diphenylether, hexabromocyclododecane and hexabromobenzene

(continued)

Table 2 (continued)

Standard under development	
Part 36	Test method for the reduction rate of airborne bacteria by air purifiers using a test chamber
Part 37	Strategies for the measurement of $PM_{2.5}$
Published standards	
UNI EN ISO 16017 Indoor, ambient and workplace air. Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography	
Part 1	Pumped sampling
Part 2	Diffusive sampling
UNI EN 13779	Ventilation for non-residential buildings: Performance requirements for ventilation and room-conditioning systems
UNI EN 14412	Indoor air quality: Diffusive samplers for the determination of concentrations of gases and vapours. Guide for selection, use and maintenance
UNI EN 15242	Ventilation for buildings: Calculation methods for the determination of air flow rates in buildings including infiltration
UNI EN 15251	Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics

It is crucial that countries that lack national guidelines in the near future manage to adhere, through the promotion of specific programmes and through a coordination of various agencies, to the objectives of the European Community (Jantunen et al. 2011). Currently, for example, in Italy, specific legislation on reference values on IAQ is absent, and this implies the need to use reference values, criteria or standards adopted in other countries or to use values from the scientific literature or, by analogy, use other standards, such as those relating to the ambient air (WHO 1982, 1984, 2000, 2006; Capolongo et al. 2016). In Italy, as well as many other countries, it is necessary to provide guidelines and reference values in accordance with the WHO guidelines for the IAQ (WHO 2010).

References

Alfonsi E, Capolongo S, Buffoli M. Evidence based design and healthcare: an unconventional approach to hospital design. Ann Ig. 2014;26(2):137–43. doi:10.7416/ai.2014.1968.

Astley P, Capolongo S, Gola M, Tartaglia A. Operative and design adaptability in healthcare facilities. Technè. 2015;9:162–70. doi:10.13128/Techne-16118.

Bonadonna L, Briancesco R, Brunetto B, Coccia AM, De Gironimo V, Della Libera S, et al. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor. Strategie di monitoraggio dell'inquinamento di origine biologica dell'aria in ambiente indoor. Roma: Istituto Superiore di Sanità; 2013. Rapporti ISTISAN 13/37. http://www.iss.it/binary/publ/cont/13_37_web.pdf.

Buffoli M, Capolongo S, Cattaneo M, Signorelli C. Project, natural lighting and comfort indoor. Ann Ig. 2007;19(5):429–41.

Capolongo S. Social aspects and well-being for improving healing processes' effectiveness. Ann Ist Super Sanità. 2016;52(1):11–4. doi:10.4415/ANN_16_01_05.

Capolongo S, Bottero MC, Lettieri E, Buffoli M, Bellagarda A, Birocchi M, et al. Healthcare sustainability challenge. In: Capolongo S, Bottero MC, Buffoli M, Lettieri E, editors. Improving sustainability during hospital design and operation: a multidisciplinary evaluation tool. Cham: Springer; 2015a. p. 1–10. doi:10.1007/978-3-319-14036-0_1.

Capolongo S, Mauri M, Peretti G, Pollo R, Tognolo C. Facilities for territorial medicine: the experiences of Piedmont and Lombardy Regions. Techne. 2015b;9:230–6. doi:10.13128/Techne-16128.

Capolongo S, Gola M, di Noia M, Nickolova M, Nachiero D, Rebecchi A, et al. Social sustainability in healthcare facilities: a rating tool for analyzing and improving social aspects in environments of care. Ann Ist Super Sanità. 2016;52(1):15–23. doi:10.4415/ANN_16_01_06.

Coulson G, Bartonova A, Bøhler T, Broday DM, Colbeck I, Fløisand I, et al. Exposure risks from pollutants in domestic environments: the urban exposure project. Indoor Built Environ. 2005;14(3–4):209–13.

D'Alessandro D, Capolongo S. Ambiente costruito e salute. Linee d'indirizzo di igiene e sicurezza in ambito residenziale. Roma: Franco Angeli; 2015.

D'Alessandro D, Tedesco P, Rebecchi A, Capolongo S. Water use and water saving in Italian hospitals. A preliminary investigation. Ann Ist Super Sanità. 2016;52(1):56–62. doi:10.4415/ANN_16_01_11.

de Oliveira Fernandes E, Jantunen M, Carrer P, Seppänen O, Harrison P, Kephalopoulos S. EnVIE co-ordination action on indoor air quality and health effects. Final Activity report of EnVIE; 2010. http://paginas.fe.up.pt/~envie/finalreports.html.

EC. Sixth Community Environment Action Programme. Decision n.1600/2002/EC of the European Parliament and of the Council of 22 July 2002. Bruxelles; 2002.

EC. European Commission (Directorate-General for Employment, Social Affairs and Inclusion). Occupational health and safety risks in the healthcare sector. Guide to prevention and good practice. Luxembourg: European Commission; 2010. doi:10.2767/27263.

ECA-IAQ. Harmonised framework for indoor products labelling schemes in the EU. Report No 27. Luxembourg: European Union; 2012.

EEA. The European Environment—State and outlook 2010: synthesis. European Environment Agency, Copenhagen. 2010. http://www.eea.europa.eu/soer/synthesis/.

EEA JRC report. Environment and human health. Report No 5; 2013. http://www.eea.europa.eu/publications/environment-and-human-health/download.

EU European Union. SCHER—Scientific Committee on Health and Environmental Risks. Opinion on risk assessment on indoor air quality. European Community. 2007. http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_055.pdf.

EU. Directive 2008/50/EC of the European Parliament and of the council of 21 May 2008 on ambient air quality and cleaner air for Europe. Official Journal of the European Union. 2008.

France. Décret No. 1727 du 2 décembre 2011 relatif aux valeurs-guides pour l'air intérieur pour le formaldéhyde et le benzene. Paris; 2011a.

France. Décret No. 1728 du 2 décembre 2011 relatif à la surveillance de la qualité de l'air intérieur dans certains établissements recevant du public. Paris; 2011b.

Franchi MA, Carrer P, Kotzias D, Rameckers Edith MAL, Seppänen O, van Bronswijk JE, et al. Towards healthy air in dwellings in Europe. Brussels: EFA Central Office; 2004.

Fuselli S, Musmeci L, Pilozzi A, Santarsiero A, Settimo G. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor. Workshop. Problematiche relative all'inquinamento indoor: attuale situazione in Italia. Istituto Superiore di Sanità. Roma, 25 giugno 2012. Atti. Roma: Istituto Superiore di Sanità; 2013a. Rapporti ISTISAN 13/39. http://www.iss.it/binary/publ/cont/13_39_web.pdf.

Fuselli S, Pilozzi A, Santarsiero A, Settimo G, Brini S, Lepore A, et al. Strategie di monitoraggio dei composti organici volatili (COV) in ambiente indoor. Roma: Istituto Superiore di Sanità; 2013b. Rapporti ISTISAN 13/4. http://www.iss.it/binary/publ/cont/13_4_web.pdf.

ISO. Interior air of road vehicles. ISO 2012;12219-1. https://www.iso.org/obp/ui/#iso:std:iso:12219:-1:ed-1:v1:en.

Italia. Ministero della Salute, Regioni, Province Autonome. Linee-Guida per la Tutela e la Promozione della Salute negli Ambienti Confinati. Gazzetta Ufficiale No. 276. Agreement, 27 September 2001.

Italia. President of the Republic. Testo Unico Sicurezza Lavoro. Legislative Decree Law 81. Rome; 2008.

Italia. Ministero della Salute, Regioni, Province Autonome. Linee di indirizzo per la prevenzione nelle scuole dei fattori di rischio indoor per allergie ed asma. Agreement, 18 November 2010.

Jantunen M, de Oliveira Fernandes E, Carrer P, Kephalopoulos S. Promoting actions for healthy indoor air (IAIAQ). Luxembourg: European Commission Directorate General for Health and Consumers; 2011.

Kotzias D, Koistinen K, Kephalopoulos S, Schlitt C, Carrer P, Maroni M, et al. Critical appraisal of the setting and implementation of indoor exposure limits in the EU. INDEX project. Luxembourg: Office for Official Publications of the European Communities; 2005.

Kotzias D, Geiss O, Tirendi S, Barrero J, Gotti A, et al. Exposure to multiple air contaminants in public buildings, schools and kindergartens—the European indoor air monitoring and exposure assessment (AIRMEX) study. Fresen Environ Bull. 2009;(18)5a. http://www.jrc.ec.europa.eu/project/airmex/index.htm.

Ministero della Salute. Usi della formaldeide: rischi connessi alle possibili modalità di impiego. Bollettino Ufficiale, No. 57 Roma: Ministero della Salute, 22 June 1983.

Ministero della Salute. Relazione sullo Stato Sanitario del Paese 2009–2010. Roma: Ministero della Salute; 2012. http://www.rssp.salute.gov.it/rssp/documenti/RSSP_2009_2010.pdf.

Musmeci L, Fuselli S, Bruni BM, Sala O, Bacci T, Somigliana AB, et al. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor. Strategie di monitoraggio per determinare la concentrazione di fibre di amianto e fibre artificiali vetrose aerodisperse in ambiente indoor. Roma: Istituto Superiore di Sanità; 2015. Rapporti ISTISAN 15/5. http://www.iss.it/binary/publ/cont/15_5_web.pdf.

Oppio A, Buffoli M, Dell'Ovo M, Capolongo S. Addressing decisions about new hospitals' siting: a multidimensional evaluation approach. Ann Ist Super Sanità. 2016;52(1):78–87. doi:10.4415/ANN_16_01_14.

Santarsiero A, Musmeci L, Fuselli S. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor (Eds). Workshop. La qualità dell'aria indoor: attuale situazione nazionale e comunitaria. L'esperienza del Gruppo di Studio Nazionale Inquinamento Indoor. Istituto Superiore di Sanità. Roma, 28 maggio 2014. Atti. Roma: Istituto Superiore di Sanità; 2015a. Rapporti ISTISAN 15/4. http://www.iss.it/binary/publ/cont/15_4_web.pdf. Accessed 18 Mar 2016.

Santarsiero A, Musmeci L, Ricci A, Corasaniti S, Coppa P, Bovesecchi G, et al. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor. Parametri microclimatici e inquinamento indoor. Roma: Istituto Superiore di Sanità; 2015b. Rapporti ISTISAN 15/25. http://www.iss.it/binary/publ/cont/15_25_web.pdf.

Settimo G. Qualità dell'aria negli ambienti confinati: aspetti tecnici e legislativi. Workshop. La qualità dell'aria indoor: attuale situazione nazionale e comunitaria. Rapporto ISTISAN 15/04. http://www.iss.it/binary/publ/cont/15_4_web.pdf.

Settimo G. La qualità dell'aria in ambienti confinati: nuovi orientamenti nazionali e comunitari. Notiziario Ist Super Sanità. 2012;25(5):7–10.

Settimo G. Inquinamento dell'aria in ambienti confinati: orientamenti e valutazioni in campo nazionale e comunitario. In: Workshop. Problematiche relative all'inquinamento indoor: attuale situazione in Italia. Istituto Superiore di Sanità. Roma, 25 June 2012. Atti. Roma: Istituto Superiore di Sanità; 2013. (Rapporti ISTISAN 13/39). p. 7–20.

Settimo G. Qualità dell'aria negli ambienti confinati: aspetti tecnici e legislativi. In: Workshop. La qualità dell'aria indoor: attuale situazione nazionale e comunitaria. L'esperienza del Gruppo di Studio Nazionale Inquinamento Indoor. Istituto Superiore di Sanità. Roma, 28 May 2014. Atti. Roma: Istituto Superiore di Sanità; 2015. (Rapporti ISTISAN 15/4).

Settimo G, Musmeci L, Marzocca A, Cecinato A, Cattani G, Fuselli S. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor. Strategie di monitoraggio del materiale particellare PM_{10} e $PM_{2,5}$ in ambiente indoor. Caratterizzazione dei microinquinanti organici e inorganici. Roma: Istituto Superiore di Sanità; 2016a. Rapporti ISTISAN 16/16. http://www.iss.it/binary/publ/cont/16_16_web.pdf.

Settimo G, Turrio Baldassarri L, Brini S, Lepore A, Moricci F, de Martino A, et al. Per il Gruppo di Studio Nazionale sull'Inquinamento Indoor. Presenza di CO_2 e H_2S in ambienti indoor: conoscenze attuali e letteratura scientifica in materia. Roma: Istituto Superiore di Sanità; 2016b. Rapporti ISTISAN 16/15. http://www.iss.it/binary/publ/cont/16_15_web.pdf.

Suess MJ. The indoor air quality programme of the WHO regional office for Europe. Indoor Air. 1992;2(3):180–93.

The Netherlands. RIVM-National Institute for Public Health and the Environment. Health-based Guideline Values for the Indoor Environment. Report 609021044; 2007.

WHO. Indoor air pollutants exposure and health effects report on a WHO meeting. Copenhagen: EURO reports and studies WHO; 1982. No. 78.

WHO. Indoor air quality research. EURO reports and studies. Copenhagen: WHO; 1984. No. 103.

WHO. Air quality guidelines for Europe. Copenhagen: WHO; 1987.

WHO. Strategic approaches to indoor air policy-making. Copenhagen: WHO European Centre for Environment and Health Bilthoven; 1999.

WHO. Air quality guidelines for Europe. Copenhagen: WHO; 2000.

WHO. Air quality guidelines. Global update 2005. Copenhagen: WHO; 2006.

WHO. WHO guidelines for indoor air quality: dampness and mould. Copenhagen: WHO; 2009.

WHO. Guidelines for indoor air quality: selected pollutants. Copenhagen: WHO; 2010.

http://www.springer.com/978-3-319-49159-2

Indoor Air Quality in Healthcare Facilities
Capolongo, S.; Settimo, G.; Gola, M. (Eds.)
2017, XVII, 132 p. 10 illus., 8 illus. in color., Softcover
ISBN: 978-3-319-49159-2