An Experimental Analysis of the Bioharmological Properties of Polyclinics at Hospitals in December

[*1]CevdetEminEkinci[2]Nurdan Baykus
[*1]Technology Faculty Department of Civil Engineering, FiratUniversirty, Elazig-Turkey
[2]Vocational School of Technical Sciences, KilisYediAralık University, Kilis-Turkey

Abstract

This is an experimental study that explores the bioharmological properties of outpatient clinics at hospitals. Hospitals, in broad terms, are one of the institutions with the most complex structures. To ensure user satisfaction, it is highly important to indicate the bioharmological properties of polyclinics. The research sample includes hospitals in Elazig and uses the results of measurements for the parameters of CO, CO_2 and O_2, ambient temperature, light, relative humidity, noise, dust content and electromagnetic field. The results of the Image Permanence Institute (IPI) and Bioharmological Conformity Assessment (BCA) metrics are valid for the month of December. This study found that these outpatient clinics do not satisfy the criteria of auditory, visual and seasonal perception analyses.

Keywords: Bioharmology, Bioharmological Conformity Assessment, Particulate Matter, Polyclinics, Internal Air Quality

1. Introduction

Hospitals are institutions used by people with health problems to be diagnosed, treated and cured. People also go to hospitals to maintain their health. Hospitals are institutions where patients feel safe. Outpatient clinics are public or private health centers that provide outpatient diagnosis and treatment and some medical operations Polyclinics are mostly subject to the work hours indicated by the relevant regulations. One of the principles of hospital services is to examine patients the same day they visit the institution [1].

Service units that are related to each other should be grouped together in polyclinics. This provides a coordinated and efficient workflow, and helps to specify the physical connections, hygiene and sterility conditions, levels of cleanliness and the circulation of materials and humans [2].Almost all hospitals already include some outpatient diagnostic and treatment spaces. Many outpatient construction projects are responses to hospitals' increased outpatient workloads. By definition, all outpatient facilities are alike in having no overnight patients [3].

To provide a healthy and safe hospital environment for patients, polyclinics' setup, order and cleanliness -properties easily recognized by visual perception- as well as lightning, air conditioning and heating systems, and control of acoustic and sound insulation are highly important.

The hospital environment plays a great role in the spread of infections in hospitals. The hospital acquired infection rate worldwide is 5-7%, whereas it is 10-15% in Turkey. This is because the use of special units to maintain hospital hygiene and control infections is not prevalent in Turkey [3]. In enclosed spaces, decorative features such as furniture, carpet, wallpaper and wall paint, interior space criteria (location, material choice, area, volume, light,

[1]*Correspondingauthor: Address: Faculty of Technology, Department of CivilEngineering Fırat University, 23119, Elazig TURKEY. E-mail address: cee@firat.edu.tr, Phone: +905358498468

heat, air, etc.), the number of users and air conditioning can be potential contaminants [5]. These contaminants include many visible or invisible particles and microorganisms in an enclosed space. These particles are a serious threat to people [6]. Therefore, it became necessary to determine microbiologically the emission potential of contaminants and analyze interior air, find architectural and engineering solutions and maintain interior air quality in accordance with standards [7].

Bioharmology is a science that examines the conformity of a building with all the living and non-living beings that have direct or indirect relation with it. It provides solutions for a healthy, safe and professional environment and plays an effective role in the implementation of these solutions [1, 8]. Bioharmology is a field of study that includes all the units of construction and suggests standardization required in the construction of hospitals. Table 2 and 3 show reference values for Bioharmological Conformity Assessment (BCA) and the Image Permanence Institute (IPI) developed to satisfy the needs of development and progress in standardization [1, 8-9].

2. Research Significance

The quality of a hospital is recognized only in terms of its space standards and cost management. However, the aim should be healthy buildings and healthy living spaces and improving quality of life. Along with material factors, users' psycho-social needs and their purpose of use become more important, and solutions need to be found considering these issues. In this study, relative humidity, ambient temperature, quantity of light, carbon dioxide, carbon monoxide, level of noise, quantity of particulate matter and particles, oxygen, square meters, cubic meters and level electrical field were measured in outpatient clinics [1, 8]. This study will contribute to determining effective parameters for building construction, their implementation and achieving healthy outcomes.

3. TheExperimental Study and Its Principles

This experimental study measured the atmosphere of enclosed spaces in the units of polyclinics. The experimental measurements were taken with the written permission of Elazig Governorship Health Department. The results of the experiment were examined using EN ISO 14644 standards, IPI and BCA. The sample of the experimental study includes one public (H-1) and one private (H-2) hospital. The experimental measurements of IPI and BCA were done in December. A pre-interview was done with the administration of hospital to obtain information about its characteristics.

The aim of the design of H-1 and H-2's buildings was to provide health care services. There are four floors in the building of H-1. The general cleaning of its polyclinics is done hourly. There are air conditioners and natural air conditioning, ceiling fluorescent lighting and natural lighting. There is chipboard furniture, leather chairs with metal frames and chairs. The floor is marble. The ceilings, floors and wall have been painted with oil paint.

The building of H-2 has two basement levels, a ground floor, six higher floors and two attics. The general cleaning of outpatient clinics is done hourly. There are air conditioners and natural air conditioning, ceiling fluorescent lighting and natural lighting. It has metal armchairs and chairs covered with blue and orange polar fleece and chipboard furniture. The floor is covered with PVC (Polyvinyl Chloride). The ceilings, floors and wall have been painted with oil paint.

To measure the electrical fields in the outpatient clinics, an AARONIA AG (Spectran) ELF Meter (Triaxinal ELF Magnetic Field Meter) was used. To measure O_2, CO and CO_2, Gas Measurement Instruments (GMI) VISA-66268 were used. To measure light, heat, relative humidity and sound levels, a DT-8820 Environment Meter was used. To measure particle quantity, a LIGHTHOUSE Handheld 30133 was used. The surface area and volume of outpatient clinics were measured with a tape measure[1].

Cleanroom standards are mainly about classifying clean rooms. This classification is determined by the limit values indicating concentration of volatile substances in the air (number of particulates per unit volume). The particulate concentrations of the outpatient clinics were measured using the measurement values of 0.3 micrometers, 1.0 micrometer and 5.0 micrometers. The results of the measurements were compared with the EN ISO 14644 (International Organization for Standardization) classification system. The classes of clean rooms were determined. This classification is between 1 and 9, in which Class-1 indicates the most clean room and Class-9 indicates the dirtiest room. A clean room is a hygienic environment that meets the standards of particulate concentrations required for higher quality service or production. In these environments, heat, relative humidity, levels of noise, oxygen, and pressure and air movement should be controlled [1, 8-9-10].

Software available on the official IPI website, http://www.dpcalc.org, was used to determine IPI preservation metrics. The analysis of IPI and BCA are based on the data given in the Tables 2 and 3.

Table 1. Selectedairborneparticulatecleanlinessclassesforcleanroomsandcleanzones[11]

ISOClassication Number (N)	Maximum concentrationlimits (particles/m^3 of air) forparticlesequaltoandlargerthantheconsideredsizesshownbelow (concentrationlimitsarecalculated in accordancewith equation (1) in 3.2)					
	> 0.1 μm	> 0.2 μm	> 0.3 μm	> 0.5 μm	> 1 μm	> 5 μm
ISO Class1	10	2				
ISO Class2	100	24	10	4		
ISO Class3	1000	237	102	35	8	
ISO Class4	10 000	2 370	1 020	352	83	
ISO Class5	100 000	23 700	10 200	3 520	832	29
ISO Class6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class7				352 000	83 200	2930
ISO Class8				3 520 000	832 000	29 300
ISO Class9				35 200 000	8 320 000	293 000

Table 2. Relationship to human comfort and physical effect of temperature [8, 12]

Dew point temperature	Human perception
Over 26 °C	Severely high. Even deadly for asthma related illnesses
24–26 °C	Extremely uncomfortable, fairly oppressive
21-24 °C	Very humid, quite uncomfortable
18-21 °C	Somewhat uncomfortable for most people at upper edge
16-18 °C	OK for most, but all perceive the humidity at upper edge
13-16 °C	Comfortable
10-12 °C	Very comfortable
Under 10 °C	A bit dry for some
Ambient temperature	**Physical effect of temperature**
Over 28 °C	Highly disturbing
27-28 °C	Discomfort begins
25-27 °C	Transition value (Hot)
17-25 °C	Feeling comfortable environment
15-17 °C	Transition value (Cold)
Under 15 °C	Discomfort begins

Table 3. IPI preservation metrics [13]

Corrosion/Damage type	Preservation indices		
Natural aging	≥ 75 Good	75 - 45 OK	≤ 45 Risk
Metal corrosion	≤ 7 İyi	7,1 - 10,5 OK	≥10,6 Risk
Mechanic damage	≥5 - 12,5 ≤ ≤ 4,9 - 12,6 ≥		OK Risk
Mold risk	≥ 0,5 ≤ 0,5		Mold is formed Mold does not occur
MD Mold Day PI Preservation Index	EMC Equilibrium Moisture Content (%)		

4. Findings

Tables 4 and 5 show the data obtained from the experimental study of the outpatient clinics. Tables 6 and 7 show BCA and IPI preservation metrics.

Table 4. BCADecember term results for hospital-1 [1]

Bioharmological properties	Unit	Obstetrics-gynecologyclinic	Chest clinic	Eye clinic	Children's clinic	ENT clinic
CO	ppm	0	0	0	0	0
CO_2	ppm	0.10	0.05	0.05	0.05	0.15
O_2	%	20.8	20.7	20.9	20.8	20.8
Relative humidity	%RH	28.7	29.3	24.1	26.3	26.4
Temperature	^oC	30.9	29.7	31.0	30.6	31.3
Light (general)	Lux	101	154	95	88	116
Levels of noise from living beings-C	dB(A)	77.6	77.1	73.3	78.4	84.2
Levels of mechanical noise-A	dB(A)	63.0	64.2	63.3	65.1	67.0
Electromagnetic field (mG)	µT	1.9	0.3	3.6	0.8	2.3
Number of particulates-particles	0,3µm	$5.85x10^8$	$5.56x10^8$	$5.50x10^8$	$5.13x10^8$	$6.01x10^8$
Number of particulates-particles	1µm	$5.83x10^6$	$5.49x10^6$	$5.53x10^6$	$6.46x10^6$	$6.61x10^6$
Number of particulates-particles	5µm	$2.58x10^5$	$2.54x10^5$	$1.84x10^5$	$1.44x10^5$	$3.21x10^5$
Space volume	m^3	37.85	37.85	37.85	37.85	37.85
Space area	m^2	14.02	14.02	14.02	14.02	14.02
Number of users	Person	2+1	2+1	2+1	2+1	2+1
Unit volume per user	m^3	12.62	12.62	12.62	12.62	12.62
Unit area per user	m^2	4.67	4.67	4.67	4.67	4.67

Table 5. BCA December term results for hospital-2 [1]

Bioharmological properties	Unit	Obstetrics-gynecologyclinic	Chest clinic	Eye clinic	Children's clinic	ENT clinic
CO	ppm	0	0	0	0	0
CO_2	ppm	0.10	0.10	0.10	0.05	0.20
O_2	%	20.7	20.6	20.4	20.7	20.5
Relative humidity	%RH	36.7	32.8	32.5	32.4	33.9
Temperature	^oC	21.9	23.5	22.4	24.8	24.6
Light (general)	Lux	85	132	127	100	86
Levels of noise from living beings-C	dB(A)	73.6	71.2	73.7	72.7	76.2
Levels of mechanical noise-A	dB(A)	53.7	48.4	49.1	57.1	58.1
Electromagnetic field (mG)	µT	0.5	0.4	0.5	0.8	0.8
Number of particulates-particles	0,3µm	$5.01x10^8$	$4.48x10^8$	$5.56x10^8$	$5.09x10^8$	$4.88x10^8$
Number of particulates-particles	1µm	$4.80x10^6$	$3.52x10^6$	$4.48x10^6$	$4.15x10^6$	$4.02x10^6$
Number of particulates-particles	5µm	$1.41x10^5$	$1.98x10^5$	$1.31x10^5$	$1.77x10^5$	$1.41x10^5$
Space volume	m^3	107.94	42.17	44.35	46.40	39.96
Space area	m^2	38.55	15.06	15.84	16.57	14.27
Number of users	Person	2+1	2+1	2+1	2+1	2+1
Unit volume per user	m^3	35.98	14.06	14.78	15.47	13.32
Unit area per user	m^2	12.85	4.69	5.28	5.52	4.76

Table 6. December term BCA and IPI preservation metrics for hospital-1 [1,13]

Thermal comfort conditions of space				Image Permanence Institute (IPI) preservation metrics						BCA	
Place	Temperature (°C)	Humidity (%)	Dew point temperature (°C DP)	Corrosion type	Analysis of environment	Preservation metrics	Preservation Index result	Preservation constituents	Dew point temperature of respect		Physical effect
Obstetrics-gynecology clinic	30,9	28,7	11	Natural aging Mechanical damage Mold risk Metal corrosion	OK OK Good Good	PI EMC (%) MD EMC (%)	20 5,8 No risk 5,8	**Not suitable** Nonexistent Nonexistent Nonexistent	VCA		CS
Chest clinic	29,7	29,3	10	Natural aging Mechanical damage Mold risk Metal corrosion	OK OK Good Good	PI EMC (%) MD EMC (%)	23 5,8 No risk 5,8	**Not suitable** Nonexistent Nonexistent Nonexistent	VCA		CS
Eye clinic	31,0	24,1	8	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good Good	PI EMC (%) MD EMC (%)	23 5 No risk 5	**Not suitable** Nonexistent Nonexistent Nonexistent	DA		CS
Children's clinic	30,6	26,3	9	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good OK	PI EMC (%) MD EMC (%)	22 5,3 No risk 5,3	**Not suitable** Nonexistent Nonexistent Nonexistent	VCA		CS
ENT clinic	31,3	26,4	9	Natural aging Mechanical damage Mold risk Metal corrosion	OK OK Good Good	PI EMC (%) MD EMC (%)	22 5,3 No risk 5,3	**Not suitable** Nonexistent Nonexistent Nonexistent	VCA		CS

VCA=VeryComfortableAir , CS=Comfortable Space, DA=DryAir,

Table 7. December term BCA and IPI preservation metrics for hospital-2 [1, 13]

Thermal comfort conditions of space				Image Permanence Institute (IPI) preservation metrics						BCA	
Place	Temperature (°C)	Humidity (%)	Dew point temperature(°C DP)	Corrosion type	Analysis of environment	Preservation metrics	Preservation index result	Preservation constituents	Dew point temperature of respect		Physical effect
Obstetrics-gynecology Clinic	21,9	36,7	7	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good Good	PI EMC (%) MD EMC (%)	49 7,2 No risk 7,2	Suitable Nonexistent Nonexistent Nonexistent	DA		HO
Chest clinic	23,5	32,8	7	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good Good	PI EMC (%) MD EMC (%)	42 6,6 No risk 6,6	**Not suitable** Nonexistent Nonexistent Nonexistent	DA		HO
Eye clinic	22,4	32,5	5	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good Good	PI EMC (%) MD EMC (%)	54 6,6 No risk 6,6	Suitable Nonexistent Nonexistent Nonexistent	DA		HO
Children's clinic	24,8	32,4	7	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good Good	PI EMC (%) MD EMC (%)	38 6,4 No risk 6,4	**Not suitable** Nonexistent Nonexistent Nonexistent	DA		HO
ENT clinic	24,9	33,9	8	Natural aging Mechanical damage Mold risk Metal corrosion	**Risk** OK Good Good	PI EMC (%) MD EMC (%)	36 6,7 No risk 6,7	**Not suitable** Nonexistent Nonexistent Nonexistent	DA		HO

DA=DryAir, HO=HighlyOffensive

5. Analysis of the Findings

Tables 8 and 9 show the general analysis derived from comparing the findings of the experimental study done in the hospitals H-1 and H-2 in December (Tables 4, 5, 6 and 7) with IPI, BCA and the measurements in Tables 1, 2 and 3.

Table 8. IPI global assessment

IPI preservation metrics		Examined polyclinics									
		Obstetrics-gynecology clinic		Chest Clinic		Eye Clinic		Children's clinic		ENT clinic	
IPI		H-1	H-2	H-1	H-2	H-1	H-2	H-1	H-2	H-1	H-2
Environment assessment	Natural aging	***	*	***	*	*	*	*	*	***	*
	Mechanical damage	**	**	**	**	**	**	**	**	**	**
	Mold risk	**	**	**	**	**	**	**	**	**	**
	Metal corrosion	**	**	**	**	**	**	**	**	**	**
Notasyon			***				**				*
		Appropriate		*Should be improved*				*Threatening to vibrant health*			

Table 9.BCA global assessment

Bioharmological properties	Examined polyclinics									
	Obstetrics-gynecology clinic		Chest Clinic		Eye Clinic		Children's clinic		ENT clinic	
BCA	H-1	H-2	H-1	H-2	H-1	H-2	H-1	H-2	H-1	H-2
CO	***	***	***	***	***	***	***	***	***	***
CO_2	**	**	**	**	**	**	**	**	**	**
O_2	***	***	***	***	***	***	***	***	***	***
Relative humidity	*	*	*	*	*	*	*	*	*	*
Temperature	*	*	*	*	*	*	*	*	*	*
Light (general)	**	**	**	**	**	**	**	**	**	**
Levels of noise from living beings-C	*	*	*	*	*	*	*	*	*	*
Levels of mechanical noise-A	*	*	*	*	*	*	*	*	*	*
Electromagnetic field (mG)	**	**	**	**	**	**	**	**	**	**
Number of particulates-particles	*	*	*	*	*	*	*	*	*	*
Number of particulates-particles	*	*	*	*	*	*	*	*	*	*
Number of particulates-particles	*	*	*	*	*	*	*	*	*	*
Space volume	**	**	**	**	**	**	**	**	**	**
Space area	**	***	**	**	**	**	**	**	**	**
Number of users	**	***	**	**	**	**	**	**	**	**
Unit volume per user	**	***	**	**	**	**	**	**	**	**
Unit area per user	**	***	**	**	**	**	**	**	**	**
Notation		***				**				*
	Appropriate		*Should be improved*				*threatening to vibrant health*			

6. Conclusion and Recommendations

To conclude, it is crucial to analyze the engineering and architectural, as well as IPI and BCA properties of hospitals. The hospitals analyzed in this study may be seen as highly suitable constructions and hospitals from a panoramic view with the naked eye. However, when they were analyzed using IPI and BCA principles, significant deficiencies were recognized. It is obvious that this may negatively affect users' quality of health care, as well as worker satisfaction.

Every department of a hospital has its own particularity. Therefore, the hospital design process needs to consider their different needs. The materials selected should have high resistance to the deformations caused by heat, temperature and exposure to air. Information about the materials to be used and hygiene documents should be obtained, and the most suitable air conditioning system should be used [14]. The quality of products used for

cleaning, such as water, detergent or enzymatic stain removers, needs to be considered. Dry sweepers should not be used to clean floors to avoid spreading the dust and bacteria that accumulate due to the lack of air movement [15]. A deficient air-conditioner and air conditioning system may also preclude good hygiene [16]. Air conditioning systems should be cleaned and checked frequently. The norms and standards required for its cleaning and maintenance should be provided.

Children are more sensitive to dangerous air contaminants. It is well known that as the concentration of contaminants in the air in buildings and the duration of users' presence there increase, more serious health problems emerge [17].

Human health is a very important issue. Studies such as this one should be considered at every stage of construction to prevent building-related health problems [1, 8-9]. Bioharmological solutions developed to overcome problems are becoming more important in today's world.

Note

- *This study was inspired by and is an extension of NurdanBaykus' M.A. thesis supervised by Dr. CevdetEminEkinci, which was submitted to Firat University's Institute of Science.*
- *The results of the August term of this experimental study is presented as an oral presentation in Japan in ICNSE2015 conference by this article authors [*18*].*

References

[1] Baykuş N.Hastaneyapılarınınbiyoharmolojikuygunlukdeğerlerinindeneyselolarakincelenmesi. T.C. FıratÜniversitesi, Fen BilimleriEnstitüsü, YayımlanmışYüksekLisansTezi, 2012, [In Turkish].

[2] Kırbaş C. Hastanelerdemimari-mekanikprojetasarımıveuygulamaesasları, *TesisatMühendisliği*, Sayı:127, ss:15, 2012, [In Turkish].

[3] Carr RF. Outpatient clinic. WBDG. http://www.wbdg.org/design/outpatient.php (Resource Access Date: March 25, 2015)

[4] http://www.hurriyet.com.tr/saglik/7657786.asp (Resource Access Date: December 10, 2014), [In Turkish].

[5] Menteşe S. Materyalanaliziveodadeneyleriileiçortamkirleticilerinintespiti. *IX. UlusalTesisatMühendisliğiKongresi,*2009, [In Turkish].

[6] Özçelebi S.Hastaneiklimlendirmesistemlerinegenelbirbakış. *VI. UlusalSterilizasyonDezenfeksiyonKongresi, 2009,* [In Turkish].

[7] Köksal Y.Kapalımahallerdehavakalitesininiyileştirilmesi. *V. UlusalTesisatMühendisliğiKongresiveSergisi*, 2001, [In Turkish].

[8] Ekinci C.E. Yaşamalanlarınınbiyoharmolojikuygunlukdeğerlerininbelirlenmesivestandardizasyonu .*TSE Standard- EkonomikveTeknikDergi,* Yıl:50, Sayı:591, ss:92-106, 2011, [In Turkish].

[9] Ozan SS.Sağlıkyapılarınınbiyosüreçvebiyoharmolojiaçısındanincelenmesi: Fırat tıp merkeziörneklemi. FıratÜniversitesi, Biyomühendislik AnaBilim Dalı. YüksekLisansTezi, 2006, [In Turkish].

[10] Türkmen B. Temizodastandartlarıvelaminerhavaakışlıtavansistemleri. *TTMD Dergisi*,Sayı: 13, 2001, [In Turkish].

[11] ISO. Cleanroomsandassociatedcontrolledenvironments-Part 1: Classification of aircleanliness (ISO 14644-1:1999), (Resource Access Date: March 20, 2015).

[12] Vikipedia. Dew point. http://en.wikipedia.org/wiki/Dew_point (Resource Access Date: March 20, 2015).

[13] www.dpcal.org. (Resource Access Date: December 20, 2014).

[14] Alyüz B. Veli S.İçortamhavasındabulunanuçucuorganikbileşiklervesağlıküzerineetkileri.*Trakya Univ. J.Sci*, 7(2): 109–116, 2006, ISSN 1305–6468. DIC: 205BAKT720612060107.

[15] Özyurt M.Hastanelerdetemizlik, dezenfeksiyon, sterilizasyonvetıbbiatıklarınyokedilmesi. *HastaneİnfeksiyonlarıDergisi,* 3: 175-183, 1999, [In Turkish].

[16] Anıl BO.Mobedi M. Özerdem BM.Hastanehijyenikortamlarıiçinklimavehavalandırmasistemleritasarımparametreleri. *VIII. UlusalTesisatMühendisliğiKongresi,* 2007, [In Turkish].

[17] Vural MS. Balanlı N.Yapıürünkaynaklıiç kava kirliliğive risk değerlendirmedeönaraştırma. *YTU Arch.Fac. e-Journal*, Volume:1, Issusue:1, pp:28-39, 2005, [In Turkish].

[18] Ekinci CE. Baykus N. An experimental analysis of the bioharmological properties of polyclinics at hospitals in august, *International Congress on Natural SciencesandEngineering*, 7-9 May, 2015, Kyoto-Japan ICNSE 2015, (In Press).