

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

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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, CO₂ and O₂, 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 August. This study found that these outpatient clinics do not satisfy the criteria of auditory, visual and seasonal perception analyses.

Keywords Bioharmology, Bioharmological Conformity Assessment, Hospital, Polyclinics, Particulate Matter, 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].

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, heat, air, etc.), the number of users and air conditioning can be potential contaminants [4]. These contaminants include many visible or invisible particles and microorganisms in an enclosed space. These particles are a serious threat to people [5]. 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 [6].

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, 7]. Bioharmology is a field of study that includes all the units of construction and suggests a 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, 7, 8].

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, 7]. This study will contribute to determining effective parameters for building construction, their implementation and achieving healthy outcomes.

3. The Experimental 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 August. 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 (Triaxial ELF Magnetic Field Meter) was used. To measure O₂, CO and CO₂, 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, 7, 8, 16].

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. Selected airborne particulate cleanliness classes for cleanrooms and clean zones [9]

ISO Classification Number (N)	Maximum concentration limits (particles/m ³ of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with 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	1 000	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	2 930
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 [7 and 10]

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 [11]

Corrosion/Damage Type		Preservation Indices		
Natural Aging		≥ 75	75 - 45	≤ 45
		Good	OK	Risk
Metal Corrosion		≤ 7	7,1 - 10,5	$\geq 10,6$
		Good	OK	Risk
Mechanic Damage		$\geq 5 - 12,5 \leq$		OK
		$\leq 4,9 - 12,6 \geq$		Risk
Mold Risk		$\geq 0,5$		Mold is formed
		$\leq 0,5$		Mold does not occur
MD	Mold Day	EMC	Equilibrium Moisture Content (%)	
PI	Preservation Index			

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. BCA Summer Term Results for Hospital-1 [1]

Bioharmological Properties	Unit	Obstetrics-Gynecology Clinic	Chest Clinic	Eye Clinic	Children's Clinic	ENT Clinic
CO	ppm	0	0	0	0	0
CO ₂	ppm	0,10	0,05	0	0,05	0,05
O ₂	%	20.7	20.7	20.7	20.7	20.6
Relative Humidity	%RH	31.1	30.9	33.6	32.8	31.1
Temperature	°C	24.2	23.3	23.9	23.5	23.7
Light (General)	Lux	134	56	115	86	73
Levels of Noise from Living Beings-C	dB(A)	70.1	74.8	70.2	75.4	69.5
Levels of Mechanical Noise-A	dB(A)	54.3	47.7	43.1	43.3	45.5
Electromagnetic Field (mG)	μT	1.3	0.3	1.3	0.9	1.0
Number of Particulates-Particles	0,3μm	5.45x10 ⁷	5.41x10 ⁷	1.02x10 ⁸	5.60x10 ⁷	5.54x10 ⁷
Number of Particulates-Particles	1μm	8.00x10 ⁵	7.20x10 ⁵	1.00x10 ⁶	7.49x10 ⁵	1.16x10 ⁶
Number of Particulates-Particles	5μm	9.01x10 ⁴	8.12x10 ⁴	7.77x10 ⁴	1.24x10 ⁵	9.18x10 ⁴
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 Summer Term Results for Hospital-2 [1]

Bioharmological Properties	Unit	Obstetrics-Gynecology Clinic	Chest Clinic	Eye Clinic	Children's Clinic	ENT Clinic
CO	ppm	0	0	0	0	0
CO ₂	ppm	0.08	0.15	0.10	0.15	0.15
O ₂	%	20.6	20.6	20.8	20.5	20.6
Relative Humidity	%RH	23.9	24.0	24.8	24.1	24.3
Temperature	°C	30.1	30.3	30.8	30.4	30.1
Light (General)	Lux	362	266	292	240	265
Levels of Noise from Living Beings-C	dB(A)	69.7	69.2	69.7	69.9	74.2
Levels of Mechanical Noise-A	dB(A)	51.6	40.9	54.1	45.6	53.9
Electromagnetic Field (mG)	μT	0.3	0.3	0.7	0.6	0.6
Number of Particulates-Particles	0,3μm	5.31x10 ⁷	4.17x10 ⁷	4.48x10 ⁷	4.23x10 ⁷	4.01x10 ⁷
Number of Particulates-Particles	1μm	5.68x10 ⁵	8.09x10 ⁵	6.91x10 ⁶	5.30x10 ⁵	7.17x10 ⁵
Number of Particulates-Particles	5μm	4.24x10 ⁴	4.24x10 ⁴	2.69x10 ⁴	1.77x10 ⁴	3.88x10 ⁴
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. Summer Term BCA and IPI Preservation Metrics for Hospital-1 [1, 11]

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	24,2	31,1	6	Natural Aging	OK	PI	45	Suitable	Dry Air	Comfortable Space
				Mechanical Damage	OK	EMC (%)	6,3	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	6,3	Nonexistent		
Chest Clinic	23,3	30,9	5	Natural Aging	OK	PI	50	Suitable	Dry Air	Comfortable Space
				Mechanical Damage	OK	EMC (%)	6,3	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	6,3	Nonexistent		
Eye Clinic	23,9	33,6	7	Natural Aging	Risk	PI	41	Not suitable	Dry Air	Comfortable Space
				Mechanical Damage	OK	EMC (%)	6,7	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	6,7	Nonexistent		
Children's Clinic	23,5	32,8	7	Natural Aging	Risk	PI	42	Not suitable	Dry Air	Comfortable Space
				Mechanical Damage	OK	EMC (%)	6,6	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	OK	EMC (%)	6,6	Nonexistent		
ENT Clinic	23,7	31,1	6	Natural Aging	OK	PI	45	Suitable	Dry Air	Comfortable Space
				Mechanical Damage	OK	EMC (%)	6,3	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	6,3	Nonexistent		

Table 7. Summer Term BCA and IPI Preservation Metrics for Hospital-2 [1, 11]

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	30,1	23,9	7	Natural Aging	Risk	PI	26	Suitable	Dry Air	Highly Offensive
				Mechanical Damage	OK	EMC (%)	5	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	5	Nonexistent		
Chest Clinic	30,3	24,0	7	Natural Aging	Risk	PI	26	Suitable	Dry Air	Highly Offensive
				Mechanical Damage	OK	EMC (%)	5	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	5	Nonexistent		
Eye Clinic	30,8	24,8	9	Natural Aging	Risk	PI	22	Not suitable	Dry Air	Highly Offensive
				Mechanical Damage	OK	EMC (%)	5,2	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	5,2	Nonexistent		
Children's Clinic	30,4	24,1	7	Natural Aging	Risk	PI	26	Not suitable	Dry Air	Highly Offensive
				Mechanical Damage	OK	EMC (%)	5	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	5	Nonexistent		
ENT Clinic	30,1	24,3	7	Natural Aging	Risk	PI	26	Suitable	Dry Air	Highly Offensive
				Mechanical Damage	OK	EMC (%)	5	Nonexistent		
				Mold Risk	Good	MD	No risk	Nonexistent		
				Metal Corrosion	Good	EMC (%)	5	Nonexistent		

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 August (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 /	Hospitals	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	**	**	**	**	**	**	**	**	**	**
<i>Notasyon</i>		*** Appropriate		** <i>Should be improved</i>		* <i>Threatening to Vibrant Health</i>					

Table 9. BCA Global Assessment

Bioharmological Properties		Examined Polyclinics									
		Obstetrics-Gynecology Clinic		Chest Clinic		Eye Clinic		Children's Clinic		ENT Clinic	
BCA	Hospitals	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		**	***	**	**	**	**	**	**	**	**
<i>Notation</i>		*** Appropriate		** <i>Should be improved</i>		* <i>Threatening to Vibrant Health</i>					

6. Conclusions 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 [12]. 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 [13]. A deficient air-conditioner and air conditioning system may also preclude good hygiene [14]. 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 [15].

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, 7, 8]. Bioharmological solutions developed to overcome problems are becoming more important in today's world.

Note

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