Dedication

To the spirit of my father,
As well as my mother, wife,
brothers, sisters and My SON.

I dedicate this Research

Acknowledgments

Thanks and gratitudes to those who cooperated to complete this study,
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Abstract

The Importance of this study is presented in discussing the availability of electrical safety requirements at the healthcare facilities according to the directions and recommended standards by organizations and associations in field of electrical safety such as NFPA, IEC, NEC, and AMMI, because the not available of electrical safety

requirements and absence of awareness, and knowledge about the electrical safety lead to electrical hazards (burns, electrical shock, misdiagnosis, inadequate therapy) which effect on patient, medical equipment, and medical staff.

The main purpose of study is evaluation of electrical safety implementation in medical departments (ICU, operating room, medical imaging, and hemodialysis) in Khartoum Hospitals, and investigates if the level of safety is different between departments according to the priority. The number of surveyed departments is 41 in 15 Hospitals (state, military, and non- state).

The data was collected by many methods which include direct visits to Hospitals, visual inspection for electrical installations by using electrical safety checklist, as well as making interviews with engineers and technicians. SPSS program is used to analyze the results.

The results indicated that the level of electrical safety in Khartoum Hospitals was middle in terms of power system and power distribution, grounding system, and application of electrical safety program. The level of electrical safety was low and may be absent in terms of using testing and protective devices, and the safety level was high in terms of electrical cords and extension cords. Also, the results revealed that the level of electrical safety doesn't differ between the medical departments in Khartoum Hospitals according to the priority.

المستخلص

تأتي أهمية هذه الدراسة كونها تناقش توفر متطلبات السلامه الكهربـائيه فـي مرافق الرعاية الصحية بناءً على التوجيهات والمعـايير العـالميه الموصـى بهـا NFPA , من قبل المنظمات والجمعيـات فـي مجـال السـلامه الكهربيـه مثـل IEC, NEC, AMMI، حيث ان عدم توفرها وغياب الوعي والمعرفه ينتج عنه أضرارواخطار كهربائية (حروق , صعقات كهربيه, تشـخيص خـاطىء, والعلاج غيـر المناسـب) والـتي تـؤثر سـلباً علـى كـل مـن المريـض والجهـاز الطـبي والعاملين في المستشفى .

الغرض من هذه الدراسه هو تقييم تطـبيق السـلامة الكهربـائيه فـي الاقسـام الطـبيه (العنايـة المكثفـه, العمليـات, التصـوير الطـبي, والغسـيل الكلـوي) بمستشفيات ولاية الخرطوم, والتحقق فيما اذا كان مستوى السلامه الكهربيه متفاوت فيما بين الاقسام الطبيه بالمستشفى حسب الاولويه للقسم. وقد تم مسح 41 قسم من الاقسام الطبيه أعلاة في 15 مستشفى حكـومي وخـاص بولاية الخرطوم.

اسـتخدمت أدوات لجمـع البيانـات تمثلـت فـي الزيـارات الميـدانيه الـى المستشفيات والقيام بالفحص المرئي للتركيبات الكهربيـه وجمـع المعلومـات عن السلامة الكهربائية بإستخدام قائمة فحص من تصميم الباحث, إضافة الى اجراء بعض المقابلات الشخصيه مع المهندسين والتقنيين والموظفين. وقد تم تحليل النتائج بإستخدم البرنامج الاحصائي SPSS.

اوضحت النتائج ان مستوى السلامه الكهربيه كان متوسطاً فيما يتعلق بأنظمة الطاقه الكهربيه وتوزيعها ونظام التأريض وتطـبيق برنامـج السـلامه الكهربيـه في الاقسام الطبيه بالمستشفيات. وكان المستوى ضعيفاً ويكاد يكون معدوماً بالنسبه لإستخدام ادوات الحمايه الكهريبه وادوات اجـراء اختبـارات السـلامه. بينما كان المستوى عالي ومقبولاً فيمـا يتعلـق بالاسـلاك والوصـلات الكهربيـه ولكن ليس بالشكل المثالي, و أوضحت النتائج ان مسـتوى السـلامه الكهربيـه لا يتفاوت بين الاقسام الطبيه في مستشفيات الخرطوم حسب الاولويه ونـوع الاجراءات الكهربائيه في القسم الطبي.

Abbreviations

Abbreviation	Complete words
ANSI	American National Standards Institute.
AWG	American Wire Gauge.
ANOVA	Analysis of Variance.
AAMI	Association for the Advancement of Medical Instrumentation.
ATS	Automatic Transfer Switch.
CCU	Coronary Care Unit.
CI	Confidence Interval.
DF	Degree of Freedom
ESPIME	Electrical Safety Priority Index for Medical Equipment
ECG	Electrocardiogram.
EPSS	Emergency Power Supply System.
FDA	Food and Drug Administration.
GFCIs	Ground Fault Circuit Interrupters.
IEEE	Institute of Electrical and Electronics Engineering.
IPEM	Institute of Physics and Engineers in Medicine.
IMD	Insulation Resistance Monitoring Device
ICU	Intensive Care Unit.
IV	Intravenous.
IPS	Isolation Power Systems.
IT	Isolation Transformer.
JCAHO	Joint Commission on the Accreditation of Healthcare Organizations.
kVA	Kilovolt-ampere.
LIMs	.Line Isolation Monitors
mA	Milliampere.
MCBs	Mini Circuit Breakers.
NEC	National Electrical Code.

NEMA	National Electrical Manufacturers Association.
NFPA	National Fire Protection Association.
NC	Normal Condition.
OSHA	Occupational Safety and Health Administration.
PPE	Personal Protective Equipment.
RCD	Residual Current Device.
SELV	Safety Extra Low Voltage.
SFC	Single Fault Conditions.
SPSS	Statistical Package for the Social Sciences.
IEC	The International Electrotechnical Commission
UL	Underwriters Laboratory.
UPS	Uninterruptible Power Supply.
UK	United Kingdom.
U.S	United State.

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