Safety management in healthcare by means of live working

Viktor Lovrenčić
C&G d.o.o. Ljubljana
Ljubljana, Slovenia
viktor.lovrencic@c-g.si

Boštjan Gomišček
Faculty of Business
University of Wollongong in Dubai,
Dubai, UAE
BostjanGomiscek@uowdubai.ac.ae

Mario Perla
University Medical Centre Ljubljana
Ljubljana, Slovenia
mario.perla@kclj.si

***Abstract*—An interesting parallel has been discovered when studying the sources of quality and safety management in healthcare and carrying out of live working in the maintenance of electrical installations. The awareness and efforts of healthcare professionals focused on the increase in patient safety as well as the electrical profession in carrying out live working have a hundred year tradition. In both fields, the first success was observed in Slovenia in the last decade. Patient safety is the first priority of all the persons involved in the healthcare system. The Slovene health policy started the systematic preparation of supporting documents in 2006 in order to assist the implementation of continuous improvement in quality and safety management in hospitals. In recent years, several medical institutions have started and successfully completed the certification under the quality management standards and many of them efficiently concluded the process of accreditation in accordance with the international standards. Live working was introduced into the Slovene electric power system in 2006 when the discussions about the benefits of preventive maintenance of electrical installations started. In 2009, live working officially began in the Krško Nuclear Power Plant. In 2011, it was started in the Slovene electricity distribution and in the University Medical Centre (UKCL) when a very complex re-connection on the main low voltage panel was required. When reviewing the scientific and professional literature a large gap was discovered in patient safety when the reliable supply of healthcare institutions with electricity is to be provided and high requirements of standards in electrical installation maintenance in healthcare facilities are to be met. The paper presents the connections between live working, patient safety and the valuable Slovene experience in carrying out live working in healthcare. It has to be pointed out that the contribution of live working to the safety management in healthcare is indispensable.**

Keywords—electricity; healthcare; health facilities; maintenance; safety management; total quality management

I. INTRODUCTION

Healthcare includes a wide range of activities that are carried out intensely and continuously [1, 2, 3].

Strict requirements for continuous processes as they can be observed in healthcare cannot be found in any other industry, not even in a nuclear power plant where 24/7 processes can be occasionally interrupted due to curative or preventive maintenance or overhauls.

The safety of healthcare services requires standards that demand the provision of continuous availability of electricity from public or alternative sources in order to meet the basic needs for safe patient care [2, 4].

The Luxemburg Declaration on Patient Safety [5] stipulates that the access to high quality healthcare is a key human right that is recognised and respected in the EU, by all its institutions and the citizens of Europe.

The requirements for providing quality and safety of health treatment and their continuous improvement are considered core activities in the EU states. The internationally accepted principles of quality are therefore taken into account in Slovenia as well: effectiveness of medical treatments, patient safety, timeliness of healthcare, efficiency and equal treatment [1].

Continuous quality improvement in healthcare has been developing slowly for the last 100 years. Nowadays the quality management methods and tools are developed to a great extent. Slovenia has been only at the beginning and only some of the numerous tools and methods of quality and safety in healthcare have been implemented. It has been proved in the literature that measuring and monitoring of quality, feedback, expert judgement, self-assessment, accreditation, as well as monitoring and publication of quality indicators result in the lasting improvements in healthcare [6].

Accreditation standards for healthcare institutions [2, 3, 4] clearly impose requirements for planning and maintenance of infrastructure on the management of healthcare institutions. Live working (LW) was introduced into the Slovene healthcare when the certification and accreditation procedures started, which marked an important step in the quality management and patient safety [7, 8].

LW has a hundred year tradition in the world [9]. As early as in 1913 the first carrying out of LW was documented in the USA [10], in 1933 in Europe, in Poland [11] and in 1963 in France [9].

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The purpose of this paper is to review the sources dealing with the quality of healthcare services, patient safety and LW, especially from the recent period.

There are very few publications about the research of impact of planning and carrying out the maintenance of electrical installations on the quality management in healthcare and patient safety and/or continuous electricity supply that is an indispensable source for continuous and safe care of patients.

The use of LW in the provision of continuous electricity supply to internal customers in different industries and various institutions, with the emphasis on healthcare, was researched in depth.

Additionally some examples of LW in the maintenance of electrical installations are presented in detail on the example of University Medical Centre Ljubljana (UKCL).

II. Framework and Limitations of the Research

The national guidelines on the development of quality of care and patient safety [12] encourage the management in healthcare, healthcare institutions, insurance companies, educational establishments specialised in healthcare, healthcare professionals and other staff, patients, users and other participants to increase quality, set strategic objectives, and strive for the achievement of these objectives. The guidelines stipulate the basic values and the philosophy of quality of care and patient safety.

The development and events in the organisations carrying out LW are monitored by numerous interested parties: management and employees in the companies, owners, potential investors, customers of electricity, suppliers of technology for carrying out LW, tools and equipment, institutions (institutes, training centres), professional civil organisations (standardisation), competitors in the market of LW services, community (ministries of industry and labour, national energy regulators and/or agencies, labour inspectors, trade unions, international civil professional associations) [13].

When reviewing the literature in the field of quality in healthcare services and patient safety a framework and limitation were set for the last ten-year period in the Slovene healthcare sector. Seven "Angela Boškin Days" conferences were organised in the period between 2007 and 2014. An extensive review of 136 papers of all the conferences showed that topics of patient safety presented by healthcare professionals prevailed and only rare papers dealt with the quality management system. There were absolutely no discussions about the maintenance of infrastructure as one of the most important components of high quality healthcare services and patient safety (Table I).

TABLE I. Review of papers published on the occasion of the conferences "Angela Boškin Days" from 2007 to 2014

Year	2007	2008	2010	2011	2012	2013	2014
No. of papers	13	28	20	28	20	11	16
Quality indicators	0	8	4	3	6	3	7
Quality, ISO 9001	0	2	2	3	5	3	2
Accreditation	0	2	2	2	8	3	4
Infrastructure	0	0	0	0	0	0	0

While reviewing the literature we were limited by the public availability of research and statistical data in individual states. The owners of studies and analyses, i.e. mainly Transmission System Operators (TSO) and Distribution System Operators (DSO) and the institutes as performers of the analyses protect their copyrights, which is a serious limitation.

The participants of the International Conference on Live Maintenance - ICOLIM 2014 in Budapest organised by Live Work Association (LWA) received a valuable collection of all the proceedings from 1992 to 2014. An in-depth review of 579 papers of the ICOLIM conferences showed that only two papers discussed LW outside TSO and DSO.

The findings about the lack of research and data in the field of LW/healthcare have encouraged the research and a review of sources outside the environment of electrical power and supplier industry (TSO, DSO) and made us focus on the use of LW in healthcare. The results point out the relevance of LW in the reliable provision of electricity and its impact on safety management/patient safety.

III. Quality of Healthcare Services and Patient Safety

The quality improvement in healthcare services has developed for the last hundred years [6].

In May 2002, the World Health Assembly adopted the resolution WHA55.18 in which it recognised the urgency of paying the closest possible attention to the improvement in patient safety. In May 2006, the Council of Europe adopted the Recommendation Rec 2006 [7] of the Committee of Ministers addressed to the Member States on the management of patient safety and prevention of adverse events in healthcare [14].

The Ministry of Health issued the guidelines on the development of quality of healthcare and patient safety in order to encourage the management in healthcare, healthcare institutions, insurance companies, educational establishments specialised in healthcare, healthcare professionals and other staff, patients, users and other participants to promote quality, define strategic objectives and strive for the achievement of these objectives. Slovenia has considered the principles of quality in healthcare accepted on the international and

European level: efficiency, safety, timeliness, effectiveness, equality, focusing on patients [12].

Kiauta and Tomšič [17] presented positive cases of the hospitals that decided early on a systematic approach to the implementation of a quality management system in accordance with ISO 9001, Splošna bolnišnica Novo mesto in 2002, Bolnišnica Golnik in 2003, UKC Maribor in 2005, Splošna Bolnišnica Jesenice in 2007 and Splošna Bolnišnica Celje in 2008 (Kiauta reported that only four hospitals had no certificate in 2015).

Accreditation represents an important step in the development of the quality culture in healthcare and patient safety. At the beginning the accreditation (1917) was focused on the voluntary continuous improvement in quality in the USA, from where the Joint Commission model spread to the English-speaking countries. From mid 1990 the existing and new accreditation programmes focused also on the responsibility to the public, policy makers/regulators and payers as well as on the continuous improvement in quality and safety of healthcare, which became mandatory [18].

Šilar [20] described the course of an accreditation evaluation and she is one of the rare authors who mentioned the quality of infrastructure.

The requirements of the standard [3] emphasise the relevance of maintenance of electrical installations and maintenance methods. When introducing LW the maintainers of electrical installations in hospitals are familiar with the fact that many hospitals have effectively implemented the accreditation in accordance with the requirements of AACI, ACI and DIAS-DNV. On the basis of publicly accessible data of the Ministry of Health a table of effectively completed accreditations in Slovenia was prepared (Table II).

TABLE II. ACCREDITATION OF HEALTHCARE INSTITUTIONS IN THE PERIOD MARCH 2011 – JANUARY 2015
(Source of data: http://www.mz.gov.si/si/delovna_podrocja/kakovost_in_varnost/vodenje_kakovosti_in_akreditacije/)

Institution/Standards	AACI*	ACI**	DIAS – DNV***	Total
Hospital	4	3	17	**24**
Healthcare centre	1		1	**2**
Specialist out-patient clinic	3	15		**18**

*AACI – International Accreditation Standards for Healthcare OrganiSations
**ACI – Accreditation Canada International
***DIAS - DNV International Accreditation Standard for Hospitals - Det Norske Veritas

The electrical profession strictly follows the requirements of healthcare and/or international standards [2, 3, 4] for the provision of supply without interruptions at the stage of design, construction and maintenance of electrical installations. These requirements are met by following the provisions of the Companies Act [21], TSG-12640-001:2008 [22] and SIST HD 60364-7-710 [23] as they regulate the content and dynamics of the maintenance of electrical installation and/or plants. Standard SIS EN 50110 [24] regulates the safety and health at work of electricians, work in a de-energised state and LW.

IV. LIVE WORKING IN INDUSTRY AND HEALTHCARE

LW is considered each work where a worker knowingly touches live parts with the parts of the body or a tool, equipment or devices, or comes close to the LW area [24].

There are three recognised methods of work distinguished by the position of a worker with respect to the live parts and by the equipment used for the protection against an electric shock and short-circuit. They are [24]:

- Hot stick working,
- Insulating glove working,
- Bare hand working.

In 1913, the event when a fitter used a raw wood stick (disconnect stick) in the medium voltage network in Ohio, USA or the use of the insulation wood stick (hot stick) marks the official beginning of LW in the literature [10, 25].

Researchers and experts from various fields have searched for arguments for the implementation and use of LW as a tool of preventive maintenance of electrical installations at all voltage levels for the last one hundred years [25].

LW with insulation gloves or “in contact” that has been developed as practically the only method for work on LV electrical installations [26] has been taken over by the Slovene electricity industry on the basis of the contract concluded between C&G d.o.o. Ljubljana and the Croatian specialised training centre HEP NOC in 2007. The maintenance of LV electrical installations by LW started in Slovenia in January 2009 in the Krško Nuclear Power Plant, when the first Slovene maintainers obtained all the necessary licences for LW on LV installations [7] and in 2011 for LW in the Slovene distribution [8] after a year of detailed introduction to the LW system and training.

On the basis of the data and the review of maintenance of electrical installations in UKCL [27] LW was carried out on LV for the first time in a Slovene healthcare institution in 2011 (Fig. 1).

The world and Slovene experts and professionals who research, carry out and use various kinds of maintenance tools and procedures consider the maintenance a function that is gaining importance and often plays a decisive role in the organisations [28].

Maintenance is a combination of all technical and administrative activities including inspections, monitoring and supervision over the products, machines or processes with the

aim to keep or re-establish such conditions that help us achieve their required functionality [29].

Fig. 1. Carrying out of live working in UKCL [27]

LW can be defined as a tool of preventive maintenance of electrical installations; the fundamental objective of LW is the maintenance of electrical installations and/or equipment without the interruption in electricity supply of households, healthcare institutions, industry or internal customers [8].

The analysis of Slovene experience in carrying out LW on LV in different environments (a nuclear power plant, thermal, hydroelectric or solar power plant, in transmission and distribution, in paper industry, production of pharmaceuticals or UKCL) shows that several different organisational forms with a varying number of human resources, equipment, scope of maintenance and/or priorities in providing reliability and safety of continuous electricity supply have been developed [7, 8, 30, 31, 32].

The impact of LW on the quality of electricity can be measured by the satisfaction of external customers (e.g. uninterrupted supply of electricity to UKCL by its distributor) or internal customers (e.g. uninterrupted supply of electricity to UKCL by maintainers of electrical installations and/or UKCL infrastructure) [7, 8, 30].

V. LIVE WORKING IN UKCL – CASE STUDY

The studies on investments and maintenance of electrical installations in University Medical Centre (UKCL) considered the possibilities of introducing and carrying out LW on LV in UKCL as soon as the first experience in LW was gained in the electrical environment. The management of UKCL could choose between the introduction of LW and engaging their own (in-house) maintainers or contractual partners (outsourcing) [7, 8]. Due to the limited financial and human resources for the introduction of LW on LV in UKCL they decided on external services [8].

The efficient beginnings of LW on LV in UKCL date back to the year 2011 when 15 work orders were carried out (Table III). Some of the projects were technologically very complex and demanded a detailed and accurate preparation of work that could be carried out by external contractors, electricians with extensive experience and licence for LW on LV under the supervision of electrical maintainers of UKCL [27].

We have closely studied the documentation [27] describing the preparation of individual activities for carrying out work orders for LW on LV in UKCL. Work orders No. 1-6 and 15 (Table III) are of vital importance, as the effects of LW deserve special attention.

From August to October 2011 a by-pass of supply LV cables from the old LV panel to a new one was made for lines of lighting and power supplying the main hospital building with electricity.

LW was carried out in the afternoons when the load was slightly lower than during the mornings.

It has to be emphasised that the carrying out LW was especially complex:

- The circuits with so high currents under voltage (exceeding 200 A) were bridged for the first time in Slovenia,
- Each step of work had to be described in detail as the contractors were aware of the responsibility for the patients and the staff carrying out LW.

In this case LW was the only possible solution that enabled the uninterrupted supply of electricity as it prevented temporal disconnections of separate outlets.

Positive economic effects were negligible in this case when compared to other benefits of LW for the undisturbed healthcare treatment processes in UKCL.

The extremely complex project (Table III, No. 15) in the Paediatric Clinic in spring 2014 could not be implemented without disconnecting electricity for several hours. The construction of a new extended LV branch GN3-12 was the challenge of another project (Fig. 2).

Fig. 2. Room for the extension of the new LV cabinet by the live working method in the Paediatric Clinic (Source: Paediatric Clinic)

The contractors had to connect the equipment to the existing LV panel. A problem arose as there were no free connecting points.

Two methods were available to the contractors:

- Disconnection of the whole clinic for some hours, without the possibility of full use of other emergency sources or
- Carrying out of LW on LV [27].

Stopping the work for 6 to 8 hours in several wards of the new Paediatric Clinic would be an alternative to LW on LV. What would this mean from the aspect of quality of healthcare and safety of patients? Most probably moving of patients to temporary rooms would be required (which were not available, so transfer to other hospitals in Slovenia would be necessary).

TABLE III. SCOPE OF CARRYING OUT LIVE WORKING ON LV IN UKCL IN THE PERIOD 2011 – 2015

	DATE	DESCRIPTION OF WORK	PLACE OF WORK
1.	22 August.2011	By-pass of supply cables (2X NYY-J 4X70) for the line - lighting in the B Wing – from the old to the new LV panel	The main transformer station in UKCL
2.	23 August 2011	By-pass of supply cables (2X NYY-J 4X70) for the line – lighting in the C Wing - from the old to the new LV panel	The main transformer station in UKCL
3.	24 August 2011	By-pass of supply cables (2X NYY-J 4X70) for the line – lighting in the A Wing - from the old to the new LV panel	The main transformer station in UKCL
4.	30 Sept. 2011	By-pass of supply cables (2X NYY-J 4X70) for the line – power in the C Wing - from the old to the new LV panel	The main transformer station in UKCL
5.	1 Oct. 2011	By-pass of supply cables (2X NYY-J 4X70) for the line – power in the A Wing - from the old to the new LV panel	The main transformer station in UKCL
6.	1 Oct. 2011	By-pass of supply cables (2X120) for the line – power in the B Wing - from the old to the new LV panel	The main transformer station in UKCL
7.	25 Oct. 2011	Removal of a temporary connection between 4NF00/31 and switch 4SQCM on the old panel	The main transformer station in UKCL
8.	6 Sept. 2012	Extension of the fuse base	Haematology
9.	20 Feb. 2013	Replacement of a switch control box on the line – C Wing/ground floor	Haematology
10.	21 Feb 2013	Replacement of a switch control box on the line – B Wing / ground floor	Haematology
11.	12 March 2013	Assembly of an additional branch point in block LM-1KD (unit)	Haematology
12.	12 March 2013	Assembly of an additional branch point in block LM-1KD (grid)	Haematology
13.	13 March 2013	Dismounting of the old equipment, assembly of new branch points	Haematology
14.	8 April 2013	Dismounting and re-assembly of LV bus bars	Transformer station in the Neurological Clinic
15.	25 April 2013	Extension of an additional field GN3-12 in the new Paediatric Clinic	Transformer station in the Paediatric Clinic
16.	11 Dec. 2015	Extension of the grid and aggregate power supply in the Gynecology Clinic for IVF “in vitro laboratory”	Transformer station in the Gynecology Clinic

Both LW projects mentioned above prevented the complete disconnection of a part of hospital for several hours. The workers carrying out LW enabled uninterrupted supply of electricity and supported health staff in the quality and safe care of patients in both cases.

UKCL has a long-term contract with the utility Elektro Ljubljana (EL) for maintenance of MV objects, TS 10/0,4 kV. In September 2015, after the inspection of the location TS Eye Clinic and the safety assessment (EL – C&G – UKCL), the companies agreed to start the first pilot project for cleaning with the LW method on MV. EL successfully carried out the LW cleaning of TS Eye Clinic and minimised the interruption of the grid network.

We have successfully completed 16 projects on LV and 1 project on MV, in the future we will therefore also use the LW method with maintenance services in UKCL.

VI. CONCLUSIONS AND FUTURE RESEARCH

One hundred years of challenges in providing patient safety and carrying out LW have proved its added value in the Slovene healthcare institutions.

The successful certification and accreditation of Slovene healthcare institutions in compliance with the international standards has opened up possibilities of greater patient safety and stronger competitiveness in the market of healthcare service providers.

A review of Slovene healthcare literature sources draws our attention to the fact that authors have dealt with the quality of health services and patient safety mostly from the aspect of healthcare providers and employees.

It can be found out in the proceedings of the conferences that the profession mainly reports on LW in transmission and distribution of electricity. A huge gap is observed in the discussions of introduction and carrying out LW and its advantages outside electric industry, i.e. in industry, institutions [hospitals, infrastructure] and households. Slovenia is a rare exception as carrying out of LW on LV initially started in industry and production of electricity in 2009, only shortly later in transmission and distribution and in the largest healthcare institution (UKCL) in 2011.

The case study of LW use on LV in UKCL has showed an exceptional contribution to patient safety. While carrying out LW in the Paediatric Clinic in spring 2014 it became evident

that new devices/apparatuses could practically not be connected without this method.

It is of vital importance that the research is continued as it should give answers to the following questions:

- Does the maintenance of electrical installations by the LW method have an impact on the satisfaction of customers of electricity and a higher level of quality of electricity in healthcare?
- Does the maintenance of electrical installations by the LW method contribute to better effectiveness and efficiency when carrying out preventive maintenance of electrical installations in healthcare?

The results of the research in progress where we focus on the benefits of upgrading the processes of maintenance with the LW method to improve quality, compliance with the requirements for safety and health at work as well as effectiveness and efficiency in the maintenance of electrical installations might be of interest to the LW as well as healthcare community.

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