TECHNICAL ARTICLE—PEER-REVIEWED

An Analysis of Failures Leading to Fire Accidents in Hospitals; with Specific Reference to India

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Abstract Fire can be especially dangerous when it occurs in hospitals because many patients in any typical hospital are not physically fit enough to quickly respond to emergency measures, especially evacuation calls. The present paper reports an in-depth assessment of the factors which have led to major fire accidents in Indian hospitals. The study reveals that several building safety codes, acts and guidelines are available, not only to prevent accidental fires but also to minimize harm when such fires do take place. However, observance of the stipulations is very lax, and seems to be exercised more in breach than in compliance. The study reveals that hospitals have zones like the intensive care units which are not only more prone to accidents than other zones but can also cause greater loss of lives due to the presence of critically ill patients, or persons who are extremely vulnerable (for instance newborn babies). Special codes and practices need to be framed for such zones. The study has also identified and catalogued a series of measures which must be implemented in future to prevent accidental fires in hospitals. The study is with reference to accidents that have occurred in India from 2010 to the present but is representative of the situation prevailing in most developing countries.

Keywords Accident · Analysis · Episodes · Hospitals

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Introduction

Fire protection in hospital is critically important since it predominantly houses people who are sick, elderly, disabled and need outside assistance for evacuation in case of an emergency [1, 2]. Before 1950, no automatic fire systems had been installed in the Indian hospitals—which was how it was in most of the developing world. It led to several instances when fires caused heavy casualties in hospitals, especially the multi-storied ones [3]. Then, by-and-by, safety systems, codes, and practices were introduced to minimize fire accidents from occurring in hospitals as also mitigate them. Despite this, fire accidents have continued to occur frequently in hospitals across India. Indeed, the worst-ever hospital fire accident in India has happened as recently as in the previous decade. It occurred at one of the AMRI (Advanced Medical Research Institute) group of hospitals in Kolkata in 2011, killing ninety-three persons [4]. It has exposed most poignantly the poor conditions of the Indian hospitals in terms of fire safety. Even though over a decade has elapsed since that disaster, no lessons seem to have been learnt because the frequency with which accidental fires keep breaking out in hospitals has not reduced.

The present study has been carried out to make a quantitative assessment of the causes of hospital accidents in India and the factors which prevented them from being controlled before they had caused serious harm. An attempt has also been made to identify measures with which accidental fires can be prevented in hospitals. The study is with reference to accidents that have occurred in India from 2010 to the present but is representative of the situation prevailing in most developing countries.

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A Past Accident Analysis of Hospital Fires in India

To obtain a quantitative assessment of the number and type of fire accidents that have occurred in Indian hospitals, their extents, and the factors that had triggered or accelerated them, data was acquired for the period 2010-present. It was culled from scholarly articles, other reports, newspaper articles, and various sources available in social media and on the internet. Pie charts were then developed to show the relative frequencies of different causes and effects. A chart was also developed on the fraction of hospitals that had lacked legal non-compliance. A comparison was made between fire accidents occurring in private hospitals and government hospitals.

Given that no bias has been allowed in data acquisition vis a vis locations, categories, causes, and effects, the present study is representative even if it may have missed those instances which were not reported in the media.

Results and Discussion

Results at a Glance

A summary of all the reported hospital fire accidents that have occurred in India since (and including) 2010 is presented in Table 1. The locations of all accidents, the nature of hospital ownership, the accident triggers, the number of casualties, and the aspects of negligence on the part of the hospital management are given in Table 1.

Figure 1 provides an assessment of the frequency with which hospital fire accidents have been occurring in India since (and including) 2010. Even as the number of accidents has been per year fluctuating, the statistical trend line indicates a sharply rising frequency.

Nearly as many accidents have occurred in privately funded hospitals as in the government funded ones (Fig. 2).

Short circuit was the major cause of the fire accidents, contributing to 89% of the total outbreaks. Flammable chemicals were the next biggest trigger, causing 4% of the accidents (Fig. 3).

Half of all the hospitals were not compliant of safety requirements (Fig. 4).

A Summary of Representative Accidents

A study of detailed reports pertaining to representative fire accidents, from among the ones listed in Table 1, brings to light several surprising findings.

The law requires that all hospitals should obtain certificates of compliance from all regulatory agencies on different aspects of safety and disaster management. But the present study revealed that in practice gadgets for fire prevention and control are often installed simply to get the necessary permission to function. Subsequently there is little or no follow-up to keep the gadgets in fully functional condition, nor keep the staff adequately trained [62]. For instance, in PBM (Prince Bijay Singh Memorial Men's) Hospital, Bikaner, a short circuit occurred due to faulty electrical wires which were very old and lacked proper insulation [57]. The aged wires could not carry the load which had been increasing with time. A tripping point reached when indiscriminate use of air conditioners, medical equipment, computers, etc., overloaded the wires because there had been no mandatory inspection of the power supply system.

India's worst-ever hospital fire accident, which occurred at AMRI, Kolkata, in 2011, killing ninety-three people, was escalated by the illegally stored flammable material stored in the hospital's upper basement floor which was originally made for car parking [4]. The centrally air-conditioned hospital did not have the provision for mechanical ventilation. Consequently, several persons were suffocated to death in the smoke that was formed. Other reasons identified which caused the casualties to increase was the poor emergency preparedness of hospital staff. Due to it one and a half hours elapsed before the fire brigade could start its firefighting measures. The malfunctioning and non-functional smoke detectors and alarms contributed to the slowness of the emergency response.

A fire at the ESIC (Employees' State Insurance Scheme of India) hospital in Mumbai, witnessed in 2018, exemplifies the consequences of breach of norms caused when hospital premises are used to keep forbidden inventories. An illegal canteen had stored twenty liquid petroleum gas (LPG) cylinders in the hospital's ground floor [62]. The fire was not only initiated there but escalated quickly due to the illegally stored fuel. Another typical episode of accidental fire involved the intensive care unit (ICU) of Shrey hospital in Ahmedabad, which killed 8 patients [24]. There were no fire extinguishers provided inside the ICU ward and those which were outside the ICU could not be operated by the hospital staff because they were not trained to handle and use the extinguishers.

A reconnaissance by the present authors indicated that the catastrophic fires referred above could have been prevented if there were adequate fire prevention and control facilities in place or if the staff had been trained to enable it to ensure compliance with the codes and standards.

Instances were also found when the license-to-operate of the hospitals had expired, yet the hospitals continued to function, leading to major outbreaks of fire [33].

The study reveals that many hospitals do not even have the basic fire protection measures in place. When fire started in the Murshidabad Hospital in West Bengal, the

Table 1 Past fire accidents in hospitals across India: 2010-present

Year, city/states	Hospital	Government/private	Accident trigger	Negligence identified	Number of deaths (d)	Reference
2023, Dhanbad, Jharkhand	R.C.Hazra Memorial Hospital	Private	Short circuit	Fire safety system not installed "No objection certificate" not obtained No fire alarms	5	[5]
2023, Ahmedabad, Gujarat	Honey Children's hospital	Private	Short circuit	No information available	1	[6]
2022, Hyderabad, Telangana	Sri Vani hospital	Private	Short circuit	No information available	Nil	[7]
2022, Jabalpur, Madhya Pradesh	New Life Multispecialty hospital	Private	No information available	Only one emergency evacuation route – 3.6 m side space for the movement of fire engines was not provided	8	[8]
2022, Mumbai, Maharashtra	Nowrosjee wadia children's hospital	Government	Short circuit	No information available	Nil	[9]
2022, Delhi	Brahm Shakti Hospital	Private	Short circuit	Exit blocked Firefighting system not in working conditions	1	[10]
2021, Hyderabad, Telangana	Gandhi Hospital	Government	Short circuit	No information available	Nil	[11]
2021, Nagpur, Maharashtra	Well Treat Hospital	Private	Short circuit in the AC in ICU ward	No information available	4	[12]
2021, Ujjain, Madhya Pradesh	Patidar Hospital	Private	Short circuit in ICU	Fire hydrant line was redundant Inadequate number of fire extinguishers	Nil	[13]
2021, Delhi	Safdarjung Hospital	Government	Short circuit in ventilator machine inside the ICU	No information available	No information available	[14]
2021, Mumbai, Maharashtra	Sunrise Hospital (Located inside Dreams mall)	Private	No information available	Non-functional firefighting system Insufficient Ducts Fire NOC not obtained	11	[15]
2021, Noida, Uttar Pradesh	ESIC Hospital	Government	No information available	Fire NOC not obtained	Nil	[16]

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Table 1 continued

Year, city/states	Hospital	Government/private	Accident trigger	Negligence identified	Number of deaths (d)	Reference
2021, Cuttack, Odisha	Sardar Vallabhbhai Patel Post-Graduate Institute of Pediatrics (Shishu Bhawan)	Government	Short circuit	No information available	Nil	[17]
2021, Cuttack, Odisha	Sun Hospital	Private	No information available	Fire NOC not obtained	Nil	[18]
2021, Bhandara, Maharashtra	Bhandara District General Hospital	Government	Short circuit in radiant warmer's control panel in SNCU unit (sick newborn care unit)	No firefighting system in SNCU; Fire NOC not procured	10	[19]
2020, Ulhasnagar, Maharashtra	Maxlife Hospital	Private	Short circuit in AC	No information available	Nil	[20]
2020, Rajkot, Gujarat	Uday Shivanand Hospital	Private	Short circuit in ventilator in ICU ward	No fire signs displayed; Sprinkler system not installed; Staff not trained; Fire doors not constructed as per norms	5	[21]
2020, Mumbai, Maharashtra	Apex Hospital	Private	Short circuit in the generator and generator overheating	No information available	1	[22]
2020, Vadodara, Gujarat	Sir Sayajirao General Hospital	Government	Short circuit in ventilator in the ICU ward	No information available	Nil	[23]
2020, Ahmedabad, Gujarat	Shrey Hospital (COVID-19 designated hospital), Ahmedabad	Private	Short circuit in the ICU unit	Illegal construction	8	[24]
2020, Noida, Uttar Pradesh	ESIC Hospital	Government	Batteries in server room at basement caught fire due to short circuit	Fire NOC not obtained	Nil	[25]
2019, Alwar, Rajasthan	Geetanand Children Hospital	Government	Fire in oxygen pipeline connected to radiant warmer due to short circuit	Miniature circuit breaker (MCB) not installed	Nil	[26]
2019, Mumbai, Maharashtra	KEM Hospital	Government	Short circuit	No information available	Nil	[27]
2019, Hyderabad, Telangana	Shine Children's Hospital	Private	Short circuit in refrigerator	No fire safety alarm; Lack of ventilation	1	[28]
2019, Siliguri, West Bengal	North Bengal Medical College and Hospital	Government	Short circuit in ventilator in critical care unit (CCU)	No information available	1	[29]

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Table 1 continued

Year, city/states	Hospital	Government/private	Accident trigger	Negligence identified	Number of deaths (d)	Reference
2019, Delhi	All India Institute Of Medical Sciences (AIIMS)	Government	Short circuit	6 m road space for fire tender movement not available	Nil	[30]
2019, Delhi	Lok Nayak Jai Prakash Narayan Hospital	Government	No information available	NOC not obtained	No information available	[30]
2019, Delhi	All India Institute Of Medical Sciences (AIIMS)	Government	Short circuit due to leakage in oxygen supply pipe behind the manifold	6 m road space for fire tender movement not available	Nil	[30]
2019, Jaipur, Rajasthan	SMS Hospital	Government	Short circuit	NOC not obtained; Firefighting equipment not installed	Nil	[31]
2019, Cuttack, Odisha	SCB Medical college and Hospital	Government	Short circuit in the AC	No information available	No information available	[32]
2019, Noida, Uttar Pradesh	Metro Hospital and Heart Institute	Private	Short circuit in water heater inside recovery room	Occupancy certificate and Fire clearance certificate not obtained	Nil	[33]
2019, Bhubaneshwar, Odisha	Apollo Hospital	Private	Short circuit in the battery room near ICU	No information available	Nil	[34]
2019, Bilaspur, Chhattisgarh	Chhattisgarh Institute of Medical Sciences	Government	Short circuit	No information available	Nil	[35]
2018, Kolkata, West Bengal	Calcutta Medical College and Hospital	Government	Short circuit in refrigerator in laboratory	No information available	Nil	[36]
2018, Mumbai, Maharashtra	ESIC Kamgar Hospital	Government	Short circuit	Sprinkler system and fire detection system not functioning; Fire NOC not obtained	8	[37]
2018, Kolkata, West Bengal	Chittaranjan National Cancer Institute (CNCI)	Government	Short circuit in air-conditioner	No information available	Nil	[38]
2018, Calcutta, West Bengal	Calcutta School of Tropical Medicine	Government	Short circuit in AC	No information available	Nil	[39]
2018, Hyderabad, Telangana	Apollo Hospital, Jubilee Hills	Private	Short circuit	No information available	Nil	[40]
2018, Delhi	Safdarjung Hospital	Government	Overheating of chemical/spirit	Fire NOC not obtained	Nil	[30]
2018, Bareilly, Uttar Pradesh	Sai Hospital	Private	Short circuit in ICU ward	No information available	2	[41]

Table 1 continued

Year, city/states	Hospital	Government/private	Accident trigger	Negligence identified	Number of deaths (d)	Reference
2018, Gorakhpur, Uttar Pradesh	BRD Hospital	Government	Short circuit	No information available	Nil	[42]
2017, Delhi	Metro Hospital and Cancer Institute	Private	Fire started in AC vent	Fire NOC not obtained	No information available	[43]
2017, Lucknow, Uttar Pradesh	Scope Hospital	Private	Short circuit in UPS in the reception area	No information available	No information available	[44]
2017, Lucknow, Uttar Pradesh	King George Medical University Trauma Center	Government	Short circuit in store room	Fire alarm and water sprinklers not functional; No emergency evacuation plan; Mock drills not conducted	Nil	[45]
2017, Coimbatore, Tamil Nadu	Gem Hospital	Private	Short circuit	No information available	Nil	[46]
2017, Ahmedabad, Gujarat	SAL Hospital	Private	Short circuit inside the store room of the hospital	No information available	Nil	[47]
2017, Meerut, Uttar Pradesh	Moolchand Sharbati Devi Hospital	Private	Short circuit in AC in operation theater	No information available	Nil	[48]
2017, Vijayawada, Andhra Pradesh	Sentini Super Specialty Hospital	Private	Short circuit	No information available	Nil	[49]
2016, Bhubaneshwar, Odisha	SUM Hospital	Government	Short circuit	Fire NOC not obtained from fire department	22	[50]
2016, Berhampore, West Bengal	Murshidabad Medical college and hospital	Government	Short circuit in the air conditioner	Main emergency exit gate locked	50	[51]
2016, Ludhiana, Punjab	Mohandai Oswal Cancer Hospital	Private	Chemical reaction at the laboratory in the basement of the hospital building	LPG cylinders stored in the basement	No information available	[52]
2015, Cuttack, Odisha	Sishu Bhavan	Government	Short circuit in the ICU	No information available	Nil	[53]
2015, Cuttack, Odisha	Acharya Harihar Regional Cancer Centre	Government	Short circuit in the dialysis Operating theater	No information available	1	[54]
2015, Mumbai, Maharashtra	Surana Sethia hospital	Private	Short circuit in the AC in the ICU room	Firefighting equipment not functioning properly	Nil	[55]
2013, Mumbai, Maharashtra	Gokul Hospital	Private	Short circuit in the meter box	No information available	1	[56]
2013, Bikaner, Rajasthan	PBM Hospital	Government	Short circuit due to faulty electric wires in nursery ward	Old and faulty electric wires without insulation	Nil	[57]

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Table 1 continued

Year, city/states	Hospital	Government/private	Accident trigger	Negligence identified	Number of deaths (d)	Reference
2012, Delhi	Safdarjung Hospital	Government	Short circuit in the electric box	No information available	Nil	[58]
2012, Pune, Maharashtra	Medipoint Hospital	Private	Short circuit in the store room	Illegal construction of fourth floor which was not sanctioned in the building plan	Nil	[59]
2011, Kolkata, West Bengal	AMRI Hospital	Private	Flammable materials stored in the basement caught fire as a result of electric shock	Illegal storage of flammable material in the basement Fire extinguishers and sprinkler systems not working	90	[4]
2010, Ahmedabad, Gujarat	Vadilal Sarabhai Hospital	Government	Short circuit in the UPS	No information available	2	[60]
2010, Hyderabad, Telangana	Park Super Speciality Hospital	Private	Short circuit	No fire safety measures in place like the emergency exits not available	Nil	[61]

emergency exit gate was closed, the fire alarm and the elevator were non-functional, and hospital lacked the basic firefighting infrastructure like fire extinguishers [51]. The fire that raged in the DGH (District General Hospital), Bhandara, in 2021, burnt to death 10 babies because the hospital did not have the mandatory fire extinguishers and the staff was not trained to use whatever equipment that was available [19]. Sunrise Hospital, which is situated on the 3rd floor of Dreams Mall in Bhandup, Maharashtra, was given provisional occupational certificate to run COVID-19 center. March 2021, the hospital witnessed a fire outbreak which took a toll of 11 people [15]. The audit report of the hospital reveals that major firefighting appliances like riser system, pumps, sprinkler system, underground water storage tanks and hydrant system had been installed but none was functional.

After the DGH Bhandara tragedy mentioned above, 484 government hospitals situated in the Indian state of Maharashtra were assessed for fire safety. It was found that in more than 80% institutions, fire safety audit had never been carried out and less than 50% hospitals had conducted mock drills in past. Barring a few, none had obtained fire safety certificates from the concerned agency [63].

That a general laxity prevails in terms of appreciation of the fire hazard and in taking steps toward risk minimization comes out strongly from these illustrative assessments. One more dimension of the problem has been highlighted by Kodur et al. [64], which relates particularly to the postmodern buildings in which there is liberal use of plastic-based material in lieu of metal or concrete-based systems used earlier. This presents a major hazard, the risk from which is exacerbated by the generally cavalier attitude of the building managers toward fire safety.

It has also been brought out [65], that intensive care units (ICUs) of the hospitals pose special risk due to the presence of greater levels of oxygen in their atmosphere. This happens from the inevitable leaks of oxygen occurring from patients put an oxygen support system. It enhances the flammability of the air in the ICU, enhancing the probability of accidental fires.
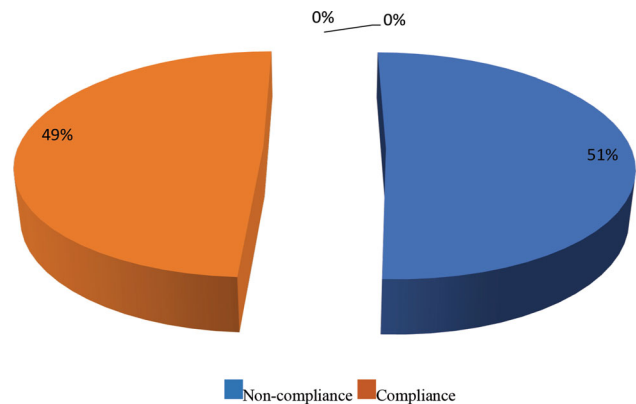
The Major Lacunae in Hospital Safety

Lack of Compliance with the Safety Norms

The problem begins with the hospitals bypassing, in part or full, the norms, codes, and practices relating to fire safety. This leads to serious hazards of (a) ever-present triggers of likely fires; (b) difficulties in the evacuation of patients and staff in the event of fires; (c) presence of substances—used in building construction, furnishings, and hospital practices—in a manner that fire gets escalated and aggravated; (d) delays in beginning the firefighting measures; and (e)
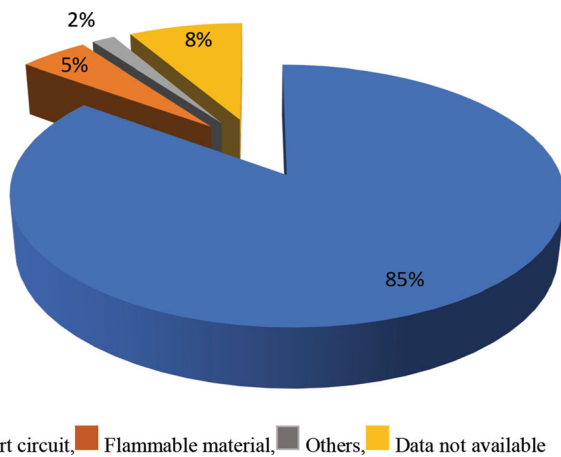
Fig. 1 Number of hospital fire accidents that have occurred since 2010. The figure for 2023 is based on the projection that if two accidents occur per quarter (as happened during January–31 March 2023), there may be eight in 2023
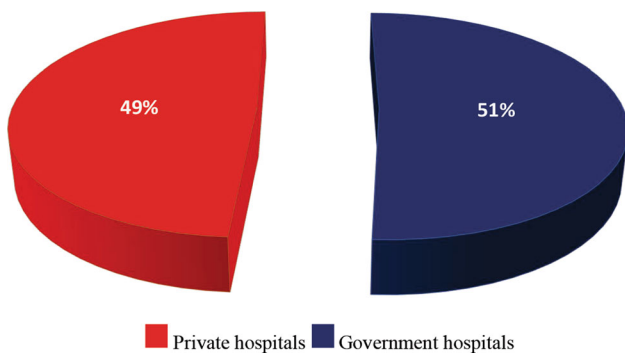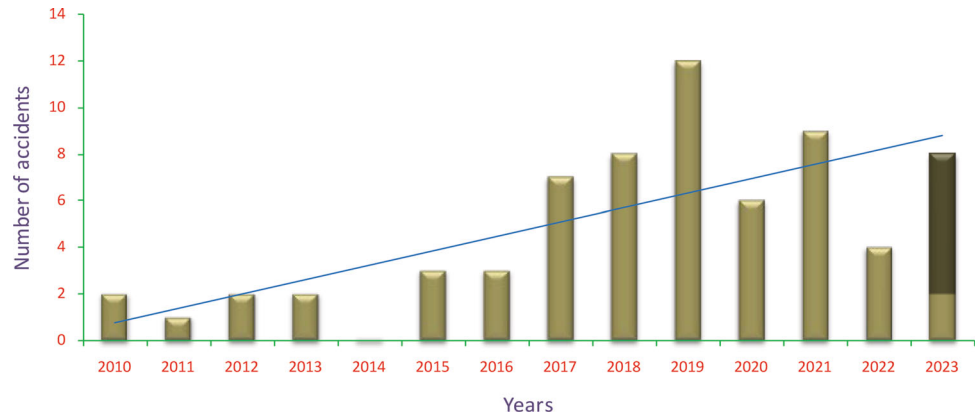
Fig. 2 Proportion of fires in government hospitals in comparison with private hospitals

Fig. 3 Cause of fire incidents in the hospitals

discoordination and lapses in the course of firefighting and evacuation.

Laxity in Surveillance and Control

There is laxity in the surveillance system which fails to serve renewal notices upon hospitals when the hospital's license-to-function has expired. This has resulted in

Fig. 4 Proportion of hospitals that showed legal compliance and non-compliance

hospitals continuing without auditing and renovating their safety equipment and practices—eventually leading to disastrous fires.

Profusion of Inherently Hazardous Substances Specific to Hostels Which Need Special Care

Hospitals use many patient-care items and chemicals which are highly flammable and tend to escalate fires once fires break out. Bedding, PVC (polyvinyl chloride) tubes, paper/plastic disposables, alcohol-based chemicals, and other volatile organics—all highly flammable—are deployed in profusion. Then there are oxygen cylinders which are a part and parcel of patient care, especially in the intensive care units (ICUs). Despite all precautions oxygen dispensers leak oxygen leading to the ICUs having higher concentration of oxygen in the air than elsewhere. In this manner fuels and oxidizers abound in hospital rooms. There is also presence of potential ignition sources or triggers in the form of heated probes, air conditioners, and other appliances prone to generating sparks. Hospitals have been found to even use the highly hazardous open coil heaters to keep the patients warm during winters.

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Apathy of Top Management

Instances have been reported wherein the hospital staff had been conscious of safety concerns and had been urging the top management to provide the required alarms, controls, and emergency response systems. But the top management had not been responsive [8, 10, 15, 21].

Measures Suggested for Preventing Hospital Fires and Managing Them When They Do Occur

(i) All relevant laws, standards, codes, and regulations need to be taken into consideration, without exception, during the design stage of the buildings. There should be unwavering compliance.

(ii) Collaboration between engineers and fire safety professionals is needed during the planning of building design. The structure and the design of the building should be such that it causes minimum damage to life and property in case of any emergency.

(iii) A proper schedule of housekeeping should be maintained. Flammable items like organic chemicals, cotton, bedding, and disposables, should be kept in dedicated storerooms which should be made fire-proof. Flammable or combustible material should not be stored in the basement.

(iv) Firefighting appliances must be in place and must be in always working condition. Alarm system should be kept fully functional round the clock. The staff need to be adequately trained for emergencies. Mock drills and fire safety audits should be conducted at regular intervals.

(v) All corridors and exit routes should be kept free of obstruction.

(vi) There should be standard operating procedures for fire management which must be duly followed.

(vii) Electrical equipment should be well maintained to prevent sparking.

(viii) No building should start operating unless the fire clearance certificate has been obtained from the concerned authority/department. Such certificates should be renewed before they expire. Approval certificates should also be obtained for the electrical fittings and installations in the buildings.

(ix) Proper estimation of the present and projected fire load should be made at the design stage itself and appropriate buffer should be provided before the building starts to function. Too many modifications and changes should not be done in the electric circuit connections. If any change is done, wire capacity should be kept in mind.

(x) Proper emergency preparedness plan should be made, and staff and other occupants should be properly trained as per that.

(xi) Auxiliary power backup should be available when emergency occurs.

(xii) Links should be made with the nearby hospitals to provide quick medical attention to critical patients.

(xiii) Indoor split ACs should not be placed near oxygen cylinders, oxygen lines or any point near the administration of oxygen. Distance of at least 4–5 m should be provided between them. Central air-conditioning should be preferred.

(xiv) Spark producing machines should also be kept 4–5 m away from the point of administration of oxygen. Smoking should be strictly prohibited.

(xv) Proper color coding of wires, simple and clear layout of the electrical wire connections, adequate insulations are among the safe practices that must be followed.

(xvi) Oxygen monitors should be installed.

(xvii) Oxygen and nitrous oxide pipelines should be properly color coded (as per the national standard) and should contain very few joints to prevent leakage. Periodic inspection should be done to check for leakage.

(xviii) An alternative emergency exit door should be made available in each ward.

(xix) Concepts of inherently safe design, accident forecasting, and vulnerably assessment should be employed to minimize the risk [66–72].

Summary and Conclusion

An assessment of hospital fires occurring in India has been presented. It is based on accident data spanning 2010-present. Based on frequency analysis it is seen that electrical short circuit is the most common cause of fires in hospitals; accounting for as many as 89% of the fire outbreaks. Flammable material including chemicals catching fire due to causes other than short—circuiting contributed to 4% of the accidents. A slightly larger fraction (54%) of all the fire accidents occurred in Government hospitals while 46% took place in private hospitals. In at least 50%

of the hospitals, legal non-compliance was reported. It is seen that timely safety audit can help identify the vulnerabilities in hospitals so they can be addressed in time. Imparting proper training and conducting mock drills at regular intervals can help the staff to remain prepared for emergencies. The paper identifies the challenges faced by hospitals from fire hazards and makes recommendations on how to meet those challenges.

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