

# Fire Safety Related Challenges Faced by Existing Hospitals: A Review

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## Abstract

**Background:** Hospital fires are real dangers and have historically caused life and property damages. A review of major research databases like Scopus, IEEE Xplore Digital Library, IET site, PubMed, Cochrane library and ASCE Library was conducted to explore fire safety challenges faced by existing hospitals and possible recommendations made thereof to overcome such challenges.

**Methods:** The review was conducted for key words- “Fire safety”, “Hospital Fire”, “Fire risk” and “Fire safety challenges”. The search found 684 articles in total which were screened for relevance to research area and 27 articles were reviewed in detail.

**Findings:** There is poor enforcement of law by agencies. Retrofitting for conformance to fire safety regulations is difficult. Issue like faulty equipment, improperly kept inflammable material, evacuation difficulties due to higher acuity of patients, operational issues like maintenance of all fire safety equipment and installations, and training of staff, etc. are highlighted.

**Conclusion:** Focussed interventions and an all-encompassing fire safety risk management plan is the need of the hour. Significant insights into critical issue of fire safety is of immense benefit to healthcare professionals as a basis to make hospitals safe places.

**Keywords:** Fires; Hospitals; Maintenance and Engineering, Hospital; Legislation, Hospital; Operating Rooms; Risk Management; Disasters

## Introduction

Statutes, codes and quality programmes govern hospital fire safety. Hospital fire dangers are real, widespread, and ever present.<sup>1</sup> Hospital fires are global pandemic (Table 1). Operating-room fires have potential catastrophic outcomes.<sup>2</sup> In 2011-2015, US fire departments responded to 1,130 hospital fires that left

32 injured and caused damages worth US\$8.8 million.<sup>8</sup> U.S. fire departments responded to an estimated average of 5,650 structure fires in or on health care properties per year. These fires caused an average of four civilian deaths, 160 civilian injuries and \$44.9 million in direct property damage annually. AMRI Hospital fire depicts true picture that exists in India. It had glass façade, lacked windows and mechanical ventilation of centrally air-conditioned building was missing. Fire department had served notice on dangerous use of basement (LPG cylinders, mattresses and wooden boxes). With three months deadline to comply, it did not. Staff didn't inform fire brigade for nearly 1<sup>1/2</sup> hours. Smoke detector and fire alarm system were kept non-operative out of ignorance or oversimplification.<sup>9</sup>

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**Table 1: Hospital Fires**

Hospital	Deaths	Year	Cause
State-Run Hospital, Lahore <sup>3</sup>	4	2012	Short circuit 10
AMRI Hospital Kolkata	95	2011	
Bei-Men, Sinying Hospital, Taiwan, <sup>5</sup>	13	2012	
PBM Hospital, Bikaner	Nil	2013	Faulty electric wiring
Rajendra Hospital, Patiala	5	2013	Short circuit
Moscow Psychiatric Hospital <sup>3,6</sup>	36	2013	
Guru Teg Bahadur Hospital, Delhi	Nil	2013	Fire in A/C unit
Galaxy Care Hospital, Pune		2013	Short circuit
Safdarjung Hospital, Delhi		2013	
Psychiatric Hospital, Luka, Russia <sup>3</sup>	37	2013	
Orthopaedics Hospital, Southern Japan <sup>3</sup>	10	2013	
Shishu Bhawan hospital, Cuttack <sup>4</sup>	Nil	2015	Fire in new-born warmer <sup>11</sup>
SUM Hospital, Bhubaneswar <sup>4</sup>	22	2016	
Murshidabad Medical College Hospital, West Bengal, <sup>7</sup>	3	2016	Faulty electric wiring <sup>7</sup>

Fire safety encompasses beyond building plan. Hospitals fail to incorporate basic components, viz. planning for critical supplies or ways to evacuate patients off-site. By drawing attention to these issues, hospitals can identify weaknesses in current plans and better prepare for a successful evacuation.<sup>12</sup> Catastrophic potential of fires and a tendency of history to repeat itself called for a review of fire safety challenges faced by existing hospital.

### Methods

A review of major research databases like Scopus, IEEE Xplore Digital Library, IET site, PubMed, Cochrane library and ASCE Library was conducted for key words- "Fire safety", "Hospital Fire", "Fire risk" and "Fire safety challenges" to explore fire safety challenges faced by existing hospitals. The search found 684 articles in total which were screened for relevance to

research area and 27 articles were reviewed in detail to examine various challenges faced by existing hospitals and recommendations to overcome them.

## Results

### Challenges

There are problems with law enforcement.<sup>3</sup> Hospitals lack fire prevention measures. No objection certificates (NOC) from fire department were not renewed as it did not entail major penalty.<sup>9</sup> There are no follow-ups with fire department on maintenance of fire alarms/sprinklers.<sup>13</sup> Health facilities do not fully complied with relevant construction codes and compartmentation for movement to safer area to await rescue.<sup>14</sup>

Facilities built on previous standards faced losing license due to new regulations of patient's room size.<sup>15</sup> Equipment sensitive to vibration/moisture, ongoing

patient procedures, and active HVAC systems are critical and cannot be easily shut down. Dust and water, containing bacteria and spores, when dispersed infect patients. Dirt on workers, contaminated carts and materials cause diseases such as aspergillosis. Poor ventilation/filtering of air affect indoor air quality of patient rooms.<sup>15</sup>

Emergency response mechanism did not meet international best practices (fire station every 3 kms). Response time sometimes exceeded beyond 30 minutes (upper limit of 3 minutes).<sup>9</sup> Funds are needed to upgrade fire equipment and manpower skills.<sup>9</sup> Mock fire drills take place occasionally and in metro cities only.<sup>9</sup> A woman died when rope snapped during mock drill.<sup>9,16</sup> Fire station facilities were not acquainted with facilities, its location and specific hazards.<sup>6</sup>

Heavy casualties occurred as patients on life-support couldn't be moved. Small hospitals have transformed into special care environments, ill-equipped to deal fire emergency due to inadequate fire protection facilities, fire safety equipment, and human resources.<sup>5</sup>

There is poor planning and management of fire safety issues.<sup>3</sup> Emergency preparedness plans did not exist, fire risk assessment not conducted and there was no fire safety planning or monitoring. Hospitals lacked "no smoking" policy and fire reporting procedures.<sup>6</sup> Health facilities lacked adequate fire risk assessments.<sup>14</sup> Role of security services is unclear.<sup>3</sup> Emergency contact details are not readily available with hospitals.<sup>6</sup> Fire extinguishers, automatic sprinklers,<sup>3</sup> fire/smoke alarms and sign boards for directing emergency evacuation were not available. Fire exits were either not available or exit signs/routes not illuminated. Electrical switches/circuit breakers were not identified and electrical cords/plugs were not maintained.<sup>6</sup> Combustible material were improperly stored and corridors were not free from clutter. Chemical containers were not labelled as "flammable".<sup>6</sup> Combustible construction material is an issue.<sup>3</sup> Competent persons for managing fire incidents were not deployed and firefighting employees were either not identified or inadequately trained.<sup>6</sup> Performance by hospital staff with respect to fire safety and management is poor.<sup>3</sup>

Newer technologies viz. linear accelerators and robotic surgical tools pose problems as these require

larger space and sometimes located in areas already tight and not specifically designed.<sup>17</sup> Alcohol-based disinfectants are located throughout facilities, including exit corridors.<sup>17</sup> For security of infants, children and psychiatric patients, egress doors are kept locked.<sup>17</sup>

Laser and electrocautery have reintroduced risk of surgical fires.<sup>18,19</sup> Many otolaryngologists (25%) have experienced operating room fire.<sup>20</sup> Most OR fires involve cautery/lasers.<sup>21</sup> Most fires (81%) occurred while supplemental oxygen was in use.<sup>20</sup> Airway fires result from combination of oxygen-rich environment, flammable material, and heat source during surgery.<sup>19, 21</sup> Each healthcare worker owns a part of fire triangle. Fuel source is typically provided by circulating nurse, e.g. flammable prepping agents,<sup>2</sup> tinctures; drapes<sup>2</sup>, other combustibles, GI gases (mostly methane), etc.<sup>21,22</sup> Surgeon supplies ignition source through fibreoptic light sources, sparks from surgical drills/burrs, flexible endoscopes, etc.<sup>21, 22</sup> High fire risk surgeries are oropharyngeal surgeries; surgeries on head or neck<sup>2</sup>, face, cataract; endoscopic laser surgeries; cutaneous/transcutaneous surgery; tracheostomy and burr hole surgery.<sup>20, 23</sup>

Evacuation time draws major attention because of diverse population, mix of patient conditions, and multiple units on one floor.<sup>24</sup> Internal movement challenges included non-functioning elevators, compromised access to stairwells/evacuation routes, and failed lighting and electrical circuits. Finding appropriate transport mode for patients to alternative site were complicated, esp. where multiple evacuations occurred simultaneously.<sup>25</sup> In case of non-functional elevators, vertical evacuation is compromised.<sup>12</sup> Health facilities lacked adequate ability to evacuate.<sup>14</sup>

Communication is the major contributor to evacuation success.<sup>12</sup> Challenges include congested telephone circuits, failure of emergency equipment, and difficulties communicating fire/police agencies. False information about a non-existing tent hospital at evacuation site led to patients being dropped there.<sup>12</sup> Absence of sheltering agreements led to widespread confusion tracing patients following evacuation.<sup>12</sup> A central command post or a pre-arranged transfer agreement facilitated search for appropriate shelter sites.<sup>25</sup> Confusion of roles and no designated decision

Non-availability of medical records has led to rescuing hospital receiving patients without basic identifying information, illness unawareness and mismatch of services, e.g. evacuation of dialysis patients to a hospital not having such services.<sup>12</sup> Failure to maintaining an accurate visitor, patient and staff census during an evacuation can leave hospitals vulnerable to significant disruptions during evacuation.<sup>12</sup> Post evacuation, a system is required to ensure return of equipment.<sup>12</sup>

There is a dilemma about evacuated priority, healthiest or sickest.<sup>12,27</sup> It is difficult to determine evacuation mode if no plan exists.<sup>28</sup> Some evacuated sickest first and others healthiest.<sup>12</sup> Critical patients can only be moved to specific locations. Mix and changing patient acuities pose difficulty in planning evacuation.<sup>28</sup> Impaired patients cannot evacuate without assistance.<sup>17,29</sup>

Functional ability of staff is compromised due to the threat itself. Since continuing care requires resources, it further complicates evacuation.<sup>28</sup> Training is not provided for temporary staff.<sup>30</sup> Weaknesses in unit design with inadequate escape routes, ventilation cut-outs and fire doors; and lack of portable monitoring equipment and emergency drug supplies are reported. Evacuation plans were often limited in scope for e.g. staff expected to remain on floor and plans were not rehearsed.<sup>30</sup> Anxiety impairs evacuees' ability to select appropriate routes.<sup>31</sup> Occupants don't know how to react to a fire alarm. For wayfinding, occupants seek help of staff who should be well trained to instruct patients.<sup>32</sup> Return to a facility that is under repair or missing staff poses different set of challenges.<sup>12</sup>

A systematic review found that strength of evidence was insufficient, and effect for interventions like education, equipment, patient safety course or team training and risk assessments was not estimable.<sup>19</sup>

## Discussion

Lessons from history signify that even old hospitals should comply with existing laws.<sup>3</sup> Knowledge of and implementation of codes/standards are recommended for keeping a hospital fire from becoming a disaster.<sup>1</sup>

Installation and maintenance of automatic fire

systems are critical in fire safety.<sup>1,3</sup> Sprinklers lead to 75% reduction in property damage.<sup>8</sup> Fire alarm systems must be designed for early detection, accurate location announcement, fire department notification, and control of high voltage alternating current system, and elevators.<sup>33</sup>

There should be a strategy for fire prevention and emergency response procedures, including counter-measures for fire risk assessment, management, and emergency response, in order to improve fire safety.<sup>5</sup> More practice implementing plan would be beneficial.<sup>26</sup> Staff should be prepared in handling myriad complexities of evacuation, including ethical considerations. A physician was accused of killing four sickly patients with sedatives.<sup>12</sup> Standardisation as Code Red is recommended.<sup>34</sup> Staff training is critical to fire safety.<sup>3</sup> Conducting frequent drills is recommended.<sup>1</sup>

A unified, centralised command structure, single authority and clearly responsibilities contribute to successful evacuation. Simple, flexible disaster plans with minimum staffing is needed. Development of "fire-safe" elevators to assist evacuation is recommended.<sup>35</sup> Policies should guide order of evacuation.<sup>12</sup> Switching policy is suggested beginning with non-critical (never optimal to split evacuation teams).<sup>27</sup> Robust evacuation planning should address changing patient acuities.<sup>28</sup> For patients unable to evacuate without assistance "defend-in-place" strategy may be developed.<sup>17,29</sup> For vertical evacuations, methods include dragging patients on sheets using mattresses on stairwells, formalised sheet and mattress method, specialised med sleds, plastic sheets, etc.<sup>12</sup> There should be established escape route plans.<sup>3</sup> Effective guidance help reduce negative impacts of anxiety on route choices.<sup>31</sup>

Communication protocols should be established in advance with multiple redundancies (messengers, telephones, portable radios, cellular telephones, satellite communications, runners and volunteer radio operators).<sup>12</sup> Short text messages may be used. Public information officer and liaison with media can avoid miscommunications.<sup>12</sup>

Local NGOs can assist hospitals in evacuations.<sup>12</sup> MoUs with other hospitals and vendors allows smooth evacuations and availability of critical goods/services.

Central log at Incident Command can help

effective tracking and ensuring that medical records are available.<sup>12</sup> Evacuation packs may contain worksheets, phone numbers, medication, transport equipment, and disposable supplies.<sup>12</sup>

Operating room fire safety guidelines have been recommended such as, nonconductive plastic clamp, adjusting setting to avoid sparks, never using cautery to enter trachea, using air or air/oxygen mixtures in anaesthetic gases, avoiding nitrous oxide especially during bowel surgery, avoiding “tenting” of drapes, stopping supplemental oxygen one minute before using cautery on head and neck, etc.<sup>21</sup>

A centralized reporting system should be developed to catalogue events. Standardized root cause analysis will help to elucidate circumstances by which a sentinel event took place.

### Conclusion

Multiple challenges compromise fire safety in hospitals- law enforcement, retrofitting, modifications in facilities, poor preparedness, newer hazards, etc. Hospitals need focussed interventions and an all-encompassing fire safety risk management plan is the need of the hour. Significant insights into critical issue of fire safety is of immense benefit to healthcare professionals as a basis to make hospitals safe places.

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