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Original Research Article

Critical analysis of fire incidents and self-assessment of fire safety program in a tertiary care hospital of India: an observational study

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ABSTRACT

Background: Self-assessment of fire safety provides valuable insights for framing a robust fire safety program for hospitals by identifying gaps and taking corrective measures. The study was performed to (i) critically analyse fire incidents which occurred in the hospital and (ii) assess fire safety program of the hospital.
Methods: A critical analysis of 3 fire incidents which occurred in hospital was performed. Further review of records regarding all fire incident reports was performed for last 4.5 years and analysed for cause, site, timing, triggering factor and firefighting. For the second objective, fire safety mechanisms in hospital were compared with national accreditation board of hospital checklist and national building code 2016 part 4 "fire and life safety" guideline.
Results: It was found that a total of 44 incidents of fire occurred over a period of four and a half years from January 2019 to July 2023, of which 42 were minor, confined fires while two were major and non confined fires. Electrical cause was found in 48.84% of fire incidents, 37% occurred in external areas, 41% in the morning shift hours and in 51.16% incidents clean agent was used for extinguishing the fire. In 93.18% incidents, trained hospital security extinguished the fire. Average reporting time was 1.23 minutes and mean time taken to act and extinguish the fire completely was 10 minutes.
Conclusions: Critical analysis of fire safety using records of fire incidents and comparison with guidelines helps hospitals in self assessment of their fire safety plans and guides in filling lacunae.

Keywords: Critical analysis, Fire audit, Fire safety, Incidents, Incident reporting, Hospital fires

INTRODUCTION

Hospitals are classified as type 1C occupancies according to the national building code of India 2016 part-IV "Fire and life safety".[1] Fire safety encompasses building plans and beyond. In general public perceives hospitals as highly secure facilities but the number of medical fire disasters across the globe shows otherwise.[2]

Since out-break of COVID-19 pandemic, many fire incidents have been reported around the world. Many incidents directly related to rapid increase in ventilator use in hospitals. Catastrophic potential of fires calls for review of fire safety challenges, weaknesses and plans to be improved for a better safety of all occupants of the hospital. No hospital correctly foresees the number of patients it would get, number of machines to be installed and number of security and fire safety checks it would need at time of licensing of the hospital. This situation is worse in government hospitals where sheer numbers of patients overwhelm the resources present, every hour and every minute.[4]

Add to this human factor such as carelessness, negligence and lack of fire safety awareness which have served as a

trigger to some of the leading causes of the hospital fires.[5-7] Besides, safety issues fire also has ethical and legal issues, since any damage caused by fire incidents invites not only legal actions but also costs a lot to pay for damages, blood money (restitution), costs of personal disability due to injuries and replacing damaged equipment.[8]

The studies available on fire safety in literature have mostly been collected from media reports.[9]

Very few studies are based on actual hospital incident reporting system like one study done in PGIMER Chandigarh.[10] Only major fires with loss of life and/or huge loss of property make news. Most of the fire incidents in hospitals are not reported within the hospital itself, leave alone media.

In our study there is a combination of critical analysis of fire incidents and reporting system available in the hospital which will provide insight into the lacunae present and will help the management to fill in the gaps. The incident reporting system helped the hospital to plan and upgrade its fire safety mechanisms. This study was done for a period of four years and a half, from January 2019 to July 2023. It is hoped that the study will help other institutions to devise robust fire incident reporting system, analysis of which will help them plan fire safety in a better manner.

Objectives

Objectives were to conduct critical analysis of fire incidents that took place at a tertiary care hospital of India and to do an assessment of the fire safety plan in the hospital.

METHODS

study design/study period/study place

A descriptive records study of fire incidents in a tertiary care, one hundred and fifteen (1015) bedded public hospital of the North India was performed out of which three incidents were critically analysed. Review of records regarding all the fire incident reports was performed for four and half years beginning January 2019 to June 2023.

Study type

A descriptive analysis including frequency, cause, site, timing, triggering factor and firefighting response was performed.

Selection criteria

All the major and minor fires that took place during the study period were included in the critical analysis.

Procedure

Cause of fire was divided into electrical, cooking, trash, oxygen leaks and unknown. Trigger factor for the fires was also explored for example negligence, smoking etc. Site of fire was divided into four areas namely patient care area, service area, external area and residential area (hostels, residential quarters etc.). Timing of the incidents was divided as per the shift duty system of the hospital namely, morning shift (8:01 AM to 2:00 PM), evening shift (2:01 PM to 8:00 PM) and night shift (8:01 PM to 8:00 AM). The firefighting measure utilized was also studied as per the type of extinguisher used to control the fire. Time taken from reporting of fire to complete control was also noted to test the robustness of the firefighting measures.

For second objective of fire safety plan assessment, safety mechanisms in the hospital were compared with national accreditation board of hospital checklist and national building code 2016 part iv “fire and life safety” guideline. A scoring system was used to assess the preparedness as per checklist and NBC guideline. A score of one was allotted to each point in the checklist. Half a mark was awarded to partial fulfilment of a statement in the checklist and 0 for none.

Statistical analysis

Data was compiled and analysed in Microsoft excel and descriptive statistics like frequency, percentages were used to obtain the results in the form of graphs and tables.

Besides, authors also visited all areas of the hospital to directly observe the fire safety systems of the hospital, studied records available in the office of the nodal officer of fire safety. Records regarding fire safety committee meetings, fire audits, trainings and drills were also analysed. Availability of fire exit routes, emergency illumination, assembly points and SOPs for evacuation in the disaster manual were studied.

RESULTS

Results for objective 1

Critical analysis of three fire incidents was performed, to know the strengths and weaknesses of our fire safety programme and opportunities for addressing lacunae in the program.

Fire incident 1: Technicians room of haemodialysis unit

Control room received a call from staff of ward 3P (colorectal surgery ward) at 9:10 PM on 27 may 2021 about smoke entering their ward. They immediately called fire safety officer (Hospital security officer) who along with his team was taking a round of hospital premises and reached the incident site within 2 minutes. The blaze was full. They could not enter initially due to

smoke. Fire station was called who arrived with their fire tender and Sky lift within minutes. Smoke had spread to the colorectal ward from the hemodialysis technician's room on the other side through a broken window pane. Horizontal evacuation of the patients was done instantly. Patients were evacuated to ward 3 and 3A located in the same floor, but were then transferred back after around 30 minutes.

A heat convector was found as the source of the fire. Technicians on duty had left their room for dinner after keeping the appliance 'ON'. There was some combustible material like a mattress and junk in the room which fuelled the fire and the smoke spread to adjacent corridors and ward.

Table 1: Fire incidence.

Weaknesses	Strengths and opportunities
Staff had left heat convector ON unattended.	Control room quickly activated the action plan on receiving information.
Broken window pane (Compartmentation compromised)?	Trained firefighting team *24/7. Prompt response.
Fire detection an alarm lacking.	Fire station within premises is an advantage
Staff of adjacent ward raised an alarm but did not act (Lack of training and drill)	Extinguishers and hydrant system were available and used. Fire suits and breathing apparatus were expedited after the incident for fire fighters.
Items for condemnation including defunct equipment stored in the room. Not disposed timely	Department requested for training and was held the next day.

Fire incident no. 2: Local area network (LAN of IT) office and server room

At 7:30 AM on 4th march 2022 a security attendant on duty near the entrance of ward block noticed smoke and flame in the LAN office. He immediately called control room who activated the incident plan. Security supervisor on duty rushed to the spot with his team. Fire was a confined one. Wires from the display board installed near the round park had heated. Plug and switch socket supplying the board and installed in LAN had sparked and burned. Long curtains used for decor were touching the socket and had caught the flame and fed the fire. Fortunately, the fire was suppressed quickly using dry powder extinguishers. The room is panelled and polished. Its adjacent compartments house IT servers of the SKIMS, running networking and backup systems of the hospital.

Table 2: Fire incidence.

Weaknesses	Strengths and opportunities
Highly combustible material in the form of curtain present, behind which sockets and electric wiring lay	Control room activated response promptly on receiving information.
Fire detection and alarm, automatic sprinkler system lacking though the area houses the major servers forming the back bone of networking of hospital and backup of (HIS)	The main hall outside LAN office is always covered by security 24*7 so a prompt response could be delivered. Fire extinguishers were installed in the area.
Polished wood lining of the walls- high flame spread surface finishes used for interior decor.	Administration took a decision of using only low flame spread material for surfaces like ceramic tiling or concrete walls with fire retardant paint

Fire incident no. 3: fire in ICU corridor

On 7th august 2021 at 12:10 pm a student technician was preparing to shift a patient. She brought a medium sized oxygen cylinder from Neuro ICU to the surgical ICU and at the junction of two ICUs tried to check the regulator. As she turned it on a sudden fire broke out. The sanitary attendant on duty quickly brought the installed fire extinguisher and used it on the fire. Fire was suppressed quickly. Fortunately, no loss of life or damage to property occurred.

Table 3: Fire incidence.

Weaknesses	Strengths and opportunities
Fire exit plan/drawing lacking.	Trained sanitary attendant with a good presence of mind prevented a devastation.
Lowest category of staff trained, but higher cadres lacking in use of firefighting cylinder and evacuation.	Trained firefighting team available *24/7 at the ICU entry. Prompt response.
Automatic fire detection and alarm lacking	Prompted involvement of department for training and drill including evacuation drill.
Automatic sprinkler system lacking	Automatic detectors and automatic sprinklers to be included in new detailed project proposal on fire safety.

Table 4: Depicting description of each fire incident.

Fire incident site	Type of area	Date	Time	Shift	Reason of fire Incident	Controlled with	First responder	Time in minutes (action/ control)
Substation near hostel	External area	03.01.2019	12:30 PM	Morning	Exhaust fan (El)	Clean agent extinguisher	Hospital security	05 min/10 min
College of nursing	External area	01.01.2019	12 PM	Morning	Heat convector left unattended (E and N)	Not recorded	Hospital security	01 min/15 min
Pharmacy store	Service area	28.01.2019	12 PM	Morning	Short circuit (E)	Not recorded	Hospital security	01 min/05 min
Barbers room	Service area	25.04.2019	7:15 PM	Evening	Negligent burning of fire (N)	Water and foam	Hospital security	02 min/05 min
Garbage carrying tractor at incinerator yard	External area	28.04.2019	11:45 AM	Morning	Trash (unknown)	Water	Firemen at fire station	01 min/10 min
Substation	Service area	20.12.2019	1:45 PM	Morning	Exhaust (E)	Clean agent extinguisher	Hospital security	01 min/05 min
Biochem office room	Service area	20.12.2019	1:30 PM	Morning	Short circuit in AC (E)	Clean agent extinguisher	Hospital security	
Attendant shed at maternity hospital	External area	25.06.2020	4:10 AM	Night	Short circuit, fire caught by electric cable (E)	Not recorded	Hospital security	01 min/05 min
Transport yard	External area	10.07.2020	4:20 PM	Evening	Oil filters thrown in dustbin, cigarette butt (S and N)	Water	Hospital security	01 min/05 min
Incinerator plant	External area	30.07.2020	6:00 PM	Evening	Trash (N)	Foam and water	Security and fire men	01/10 min
Incinerator plant	External area	17.09.2020	1:30 PM	Morning	Overheated electric cable (E)	Clean agent extinguisher, dry powder	Security	01 min/05 min
Nuclear medicine facility (waiting room)	Patient care area	10.11.2020	12 PM	Morning	Heat convector short circuit (E)	Water	Security	01 min/10 min
Electricity receiving station near hostel	Service area	17.11.2020	9:10 PM	Night	Electric cable overheated (E)	Clean agent extinguisher	Staff on duty	01 min/05 min
Technicians room dialysis near ward 3P	Patient care area	27.05.2021	9:15 PM	Night	heat convector left unattended (E and N)	Clean agent extinguishers and water	Security and fire men with fire tender	01 min/30 min
Linen, laundry old store	Service area	15.07.21	3:45 PM	Evening	Spark during welding (N)	Water	Hospital security	01/05 min
Theatre sterile supply unit (TSSU) 1st floor	Service area	10.06.2021	12:53 PM	Morning	Short circuit (E)	Clean agent	Hospital security	01 min/10 min
Sub-station	Service area	20.07.2021	2:00 A.M	Night	Electrical overload(E)	Clean agent	Staff on duty	01 min/05 min
Surgical ICU	Patient care area	07.08.2021	12:10 PM	Morning	Fire in oxygen cylinder (O_2 leak)	Clean agent extinguisher	Staff and hospital security	01 min/05 min
Gyne and obst OT	Patient care area	22.08.2021	7:00 P.M	Evening	Short circuit in OT (E)	Sand	Hospital security	01 min/05 min
Gardners shed	External area	31.08.2021	10:45 A.M	Morning	Cooking (E)	Clean agent extinguishers	Hospital security	01 min/20 min
Guest house pantry	Service area	08.09.2021	3:50 P.M	Evening	Cooking (E)	Water	Hospital security	01 min/05 min
Residential quarter no. D-14	Residential area	24.10.2021	05:45 P.M	Evening	Heat convector (E and N)	Clean agent extinguisher water	Hospital security and fire tender	01 min/25 min

Continued.

Fire incident site	Type of area	Date	Time	Shift	Reason of fire Incident	Controlled with	First responder	Time in minutes (action/ control)
CVTS ICU	Patient care area	28.10.2021	10:45 AM	Morning	Short circuit in infusion pump (E)	Clean agent extinguisher	Hospital security	01 min/10 min
Dressing room ward 5P	Patient care area	15.11.2021	11:30 P.M	Night	Short circuit in heat convector (E and N)	Nil	Hospital security	01 min/5 min
New library	Service area	18.11.2021	12:30 P.M	Morning	Fire in electric panel due to short circuit (E)	Clean agent extinguisher	Library staff	1 min/2 min
Emergency theatre No. 3 anesthesiology	Patient care area	02.12.2021	02.30 PM	Evening	Loose plug-in switch socket (E and N)	Clean agent extinguisher	hospital security	30 sec/2 min
Gardners shed in maternity hospital	External area	13.01.2022	12.10 pm	Morning	Cooking (E and N)	Clean agent extinguishers	hospital security	05 min/15 min
LAN office of IT department	Service area	04.03.2022	7:35 AM	Night	Short circuit (E)	Dry powder	hospital security	01 min/ 07 min
Ward 6A washroom	Patient care area	09.05.2022	09.20 PM	Night	Cigarette butt thrown in trash bin (N)	Water	Hospital security and staff	01 min/02 min
Cutout near bio-engineering and radiotherapy	External area	02.07.2022	11:10 AM	Morning	Dry grass (cigarette butt) N	Clean agent extinguisher	Hospital security	02 min/5 min
Park opposite near infectious disease block	External area	01.07.2022	11:50 PM	Night	Tin shed (E)	Fire extinguishers: CO_2, foam, dry pwder	Hospital security	02 min/05 min
Kitchen of outsourced canteen	Service area	05.08.2022	03:13 PM	Evening	Leakage in cooking gas (C and N)	Clean agent extinguishers	Hospital security	01 min/10 min
Habba Khatoon nursing hostel	External area	13.09.2022	12:08 AM	Night	Cigarette but thrown on dry grass (S and N)	Clean agent extinguishers	Hospital security	01 min/05 min
Ward 7A ramp side	External area	10.10.2022	9:00 PM	Night	Trash (negligently thrown) and smoking (S and N)	Clean agent extinguisher	Hospital security	02 min/ 05 min
Ramp side between shelter shed, canteen	External area	28.12.2022	7:00 PM	Evening	Trash (negligently thrown) and smoking (S and N)	Water and sand	Hospital security	
Ward 1	Patient care area	13.01.2023	12.15 AM	Night	cigarette butt thrown on cleaning dusters (S and N)	Water	Hospital security	
Ward 2A	Patient care area	09.02.2023	5:45 PM	Evening	Trash negligently thrown in shaft (S and N)	Clean agent and water	Hospital security	
Outside ramp area near MRD office	External area	22.02.2023	12:45 AM	Night	Cigarette butt on trash thrown negligently (S and N)	Water	Hospital security	
Scrub room cath lab	Service area	31.02.2023	6:30 PM	Evening	cigarette butt thrown negligently (S and N)	Clean agent extinguisher	Hospital security	
Outside new central Store	External area	17.03.2023	5:30 PM	Evening	some unknown persons had burnt log of wood	Water	Hospital security	
Doctors hostel near washroom	Residential area	20.03.2023	11:30 AM	Morning	Short circuit (E)	Clean agent extinguisher	Hospital security	
Shafts of ward 2A	Patient care area	20.03.2023	7:30 PM	Evening	Trash thrown carelessly (S and N)	Water	Hospital security	
Pathology lab 1228	Service area	06.04.2023	12 PM	Morning	Short circuit (E)	CO_2 extinguisher	Hospital security	
Shaft of ward 1A	Patient care area	04.06.2023	09:50 AM	Morning	Trash (N)	Water	Hospital security	

Note: E-electrical cause. N-negligence, S-smoking, C-cooking, two major and non-confined fires are shown in bold font.

Number of fire incidents

Number of fire incidents shown in the Figure 1 below.

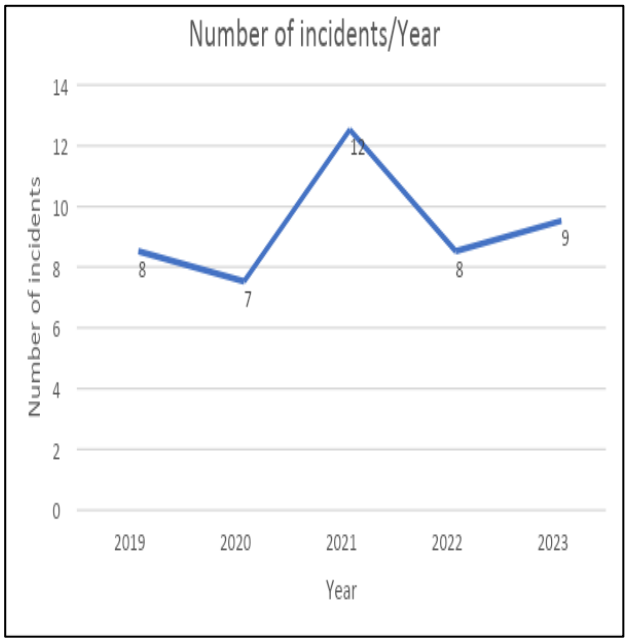

Figure 1: Number of fire incidents from 2019 till June 2023.

Spread of fire

It was observed that out of 44 incidents of fire 42 (95.45%) were confined while two were non-confined.

Cause of fire incidents

It was observed from the record study that 21 (48.84%) incidents of fire were due to electrical causes, 14 incidents (32.56%) were ignited in trash. Cooking caused 4 incidents (9.30%). Oxygen leak attributed to 1 incident (2.33%), and cause of one incident (2.33%) remained unknown. An amount of negligence was present in 22 (50%) fire incidents. Smoking and throwing cigarette butts carelessly triggered fires in 11 incidents (25%).

Site of fire incidents

The records revealed that 16 incidents, (37%) of fire occurred in external areas, 14 (32%) occurred. In service areas, 11 incidents (26%) happened in patient care areas. Two (5%) incidents happened in residential areas.

Timing of fire incident

Observation of records revealed that 18 incidents (41%) of fire occurred during morning shift (8:01AM-2:00PM), followed by 14 (32%) in evening (2:01 PM-8:00 PM) and 12 (27%) during night shift (8:01 PM-8 AM).

Firefighting and suppression

In 21 incidents of fire (51.16%) clean agent was used to extinguish and control the fire followed by water in 7 (11.63%), foam and carbon dioxide in 2 each (4.65%) and dry powder in one incident (2.33%). Water under pressure by Fire tender and fire hydrant system was used in two non-confined fires. No extinguisher was required in 11 cases of fire (25.58%).

Hospital security extinguished the fire in 41 incidents (93.18%) of cases, while other staff on duty acted in three cases (6.82%). In two major, nonconfined fires fire tenders were required to control the fires completely. Evacuation was required in one fire due to spread of smoke to an adjacent ward due to a broken window pane (breach of fire compartmentation).

Time taken to extinguish the fire

Records revealed that data of time taken to extinguish the fire was available for 22 fires only. Average time for reporting the fire to control room was 1.23 minutes and time taken to completely extinguish the fire was 10 minutes with a minimum of 5minutes and a maximum of 30 minutes in case of non-confined fire.

Results for objective 2

A checklist issued by NABH was used to assess the existing fire safety mechanisms in the hospital. A score of one was allotted to each point in the checklist. Half a mark was awarded to partial fulfilment of a statement in the checklist and 0 for none. Findings in the checklist are presented below (Table 5).

The hospital is a high rise building major portion falls in the category of type 1C more than 15 m and less than 24 m hight. The firefighting installations were compared with the standards laid down in “fire and life safety” requirements of NBC-2016. A score of one was allotted to each requirement fulfilled 0.5 to partially filled requirement and 0 for none. The results are shown in Table 6.

Table 5: NABH fire safety checklist and its status in the hospital.

NABH fire safety checklist	Remarks	Score
Firefighting equipment like wet riser, hydrants, auto sprinkler, fire alarm system, fire extinguishers of all types and sizes should be available as per table below (adapted from NBC 2016).	Wet riser and hydrants available. Fire extinguishers of all types and sizes available. Old detection and sprinkler system non-functional. New detection system tendered out. Sprinkler system being installed.	0.5

Continued.

NABH fire safety checklist	Remarks	Score
Operational and maintenance plan for firefighting equipment including refilling of extinguishers	Available	1
Up to date fire drawings to be available. Where applicable, the fire drawings should also specify the location of fire dampers.	Not available. Discussed in fire safety meeting. Civil engineering department given the responsibility.	0
Fire detection and smoke detectors exist across all floors. The detectors shall be tested for functionality at regular intervals, and records maintained.	Technical specification meeting held. BOQ prepared. To be tendered out.	0.5
Central fire alarm system is installed at a location which is staffed 24/7	Under tendering process	0.5
Fire exit plan for each floor. Exit door should be openable and free from any materials which will obstruct way	Exits are regularly checked by the fire safety team. All clear.	1
Fire exit signage on all floors well illuminated/ self-glowing, as per NBC guidelines	Available	1
Emergency illumination system in case power goes	Available	1
Designated place for assembly of patients and staff in case of fire.	Available	1
Mock fire drill records and schedule of conduct of drills.	Available	1
Total score		7/10

Table 6: Minimum requirements for fire-fighting installations NBC 2016.

Type of hospital	Wet riser	Automatic sprinkler	Manually operated electric fire alarm	Auto detection and fire alarm system	Underground water storage	Terrace tank
Hospitals less than 15 meters in height with plot area more 1000 square metres	Required	Required	Required	Required	100,000	20,000
Availability in our hospital	Available	Installation going on	Intercom facility available for communication with fire control room	Under tendering process	Available	Available
Score	1	0.5	0	0.5	1	1
Total score	4/6					

In order to plan and implement a robust fire safety program the hospital has a fire safety committee in place comprising of following members: medical superintendent-convenor, members-chief engineer, faculty incharge security and fire (nodal officer fire safety program)-member secretary, superintendent engineer mechanical, executive engineers civil, mechanical, electrical and it departments, chief nursing officer and security officer (fire safety officer).

The committee meets regularly once every 3-6 months for reviewing the fire safety. After deliberations and recommendation of the committee recently an upgradation project for fire safety was finalized and first phase realized with civil, mechanical, electrical and IT components.

Observations after hospital-wide visits

Hospital has a control room (Incident command center) which also functions as a fire control room. Evacuation protocol is specified in detail in the disaster manual of the hospital. Fire exit stair cases and ramps and designated assembly points are detailed out. Separate evacuation routes and assembly unit is designated for intensive care unit and high dependency unit patients in a separate building within the hospital premises. An added advantage of Fire station within the hospital premises exists, which came to the rescue within few minutes of major fire incidents. More equipment has been procured and at present following strength of firefighting equipment is available in the hospital (Table 7).

Table 7: Current firefighting equipment in the hospital.

Equipment	Quantity
Clean agent HFC 227 extinguishers	500
Carbon dioxide (9 and 6.5 kg) extinguisher	105
Foam type extinguisher	5
Dry chemical powder extinguisher	55
Fire pick axe	12
Fire sealing hooks	12
Fire shovel	12
Fire delivery hose	25
Fire short branch	10
Fire special branch jet fog nozzle	12
Fire rope	5
Search light	12
Fire suit	5

A valid CMC also exists for a period of five years. Periodic re-filling of empty cylinders is under-taken under the rate contract.

Trainings and drills

A number of trainings were given to staff posted in various areas of the hospital for example operation theatres, ICUs, wards, laboratory blocks etc (Table 8). These staff members were well trained to combat any fire exigency. Evacuation drills are held but the frequency needs to be increased.

Table 8: Number of staff trained.

Staff trained	Number
Security personnel	266
Paramedical and nurses	210
Doctors	50

DISCUSSION

By critical analysis of Fire incidents that took place in the hospital, an insight was obtained regarding weaknesses in the fire safety plan. The biggest weakness was the lack of fire detection and alarm system, which was started as phase one of fire safety upgradation plan post audit. Also, decision on avoidance of decor and interior finishing was reviewed and decision taken against use of high flame spread material in line with NBC guidelines.[11] Trainings of staff in all departments were carried out and frequency of drills increased. Strengths of the fire safety plan such as prompt action by trained security staff and quick activation of the plan were recognised and encouraged. In the first critically analysed fire incident defunct equipment and an old mattress kept in the staff room served as combustible material and added to the flare. Condemnable material should have been disposed off, at an earliest. As pointed out by Sodhi et al that condemnations are delayed in hospitals and at times have led to serious consequences like Fire at AMRI hospital due to obsolete material dumped in their basement.[12]

Fire occurred at an ESI hospital in Mumbai 2018 due to illegal storage of twenty LPG cylinders in canteen, breaching norms of holding of forbidden inventories.[13]

The third incident, where oxygen leak was the cause, was an eye opener and could have been potentially devastating. It occurred near the ICU where most vulnerable patient group is housed. It has been brought out that ICUs pose a major risk of fire out-breaks due to inevitable oxygen leaks. It enhances flammability of air, enhancing probability of accidental fire.[11] A similar incident took place in neonatal ICU at Royal university hospital, Suskatoon where fire broke out near the oxygen port.[14] Further a definite rise in fires in hospitals was seen during COVID-19 pandemic many of them being due to oxygen enriched environment in the inpatient areas of hospitals. One such incident which occurred in intensive care unit of a hospital in Baghdad, Iraq left 82 dead and 110 injured.[15]

Only few hospitals in India conduct a fire safety self-audit, Jawaharlal institute of postgraduate education and research Puducherry (JIPMER) being one such, has developed a Fire Safety audit checklist for self-assessment.[16] However, fire services departments in many states have recently paid keen attention to conduct of fire safety audits in hospitals. An audit of 527 hospitals was conducted in the year 2022 in the state of Maharashtra and recommendations laid down.[17] In a recent fire audit conducted by Fire department in Gautam Buddha Nagar of Uttar Pradesh it was observed that out of 170 audited hospitals, 85 were flouting fire safety norms. Initially 108 were not compliant but upon fire hazards being pointed out some hospitals corrected their flaws. Thus, the audit resulted in immediate improvement in these hospitals.[18]

While doing the descriptive analysis of fire incidents at our hospital various aspects were studied in detail with regards to number of fire incidents, whether it was a confined or a non-confined incident, site of the incident, timing, triggering factors, causes of the fire and time and various measures taken to control the fire. Also, data was analysed regarding training programs held for the staff.

A total of 44 fire incidents occurred during these four and a half years, highest number being in 2021. However, greater number of incidents in that year was not attributable to COVID-19. Majorly our studied showed electricity to be the main cause of fire (48.84%). Similar findings were revealed in studies like that of Wood et al and Sharma et al.[13,19] Juyal et al found electric cause in 89% fire accidents in hospitals.[5] As against this PAHO report in 2018 suggested cooking equipment failure (52%) to be the main cause of hospital fires.[2] The electricity load on the day of commissioning the hospital almost doubles from the time the facility is designed which increases to 25% annually. No hospital correctly,

estimates this. To worsen the safety are loose hanging wires or ill- fitting and incompatible switch sockets, lost insulation compounded by negligence like leaving the appliances unattended and inadequate equipment maintenance. The situation is worse in government hospitals.[13]

Human factors such as carelessness, negligence and lack of fire safety awareness are some of the leading causes of these fire outbreaks. 50% of cases were triggered by acts of negligence like leaving heating appliances on, in absence of one's physical presence. In eleven cases (25%) triggering agent was use of cigarette butt thrown negligently, in the trash or un-attended hospital waste. Although, stringent health policies are in place in our country, there is a lack of rigorous compliance to health laws. Section 4, 5 and 6 of COTPA (Cigarette and other tobacco products act) necessitates the need for implementation of prohibition on smoking in public places.[20,21] In spite of proper display of no smoking signages lacunae could be seen which lead to minor fire incidents in the hospital.

About 27% of the fires that took place in our hospital were from the patient care areas, while majority happened in external areas. This is quite an alarming situation considering the dependence the patients have on the staff during hospital stay. This calls for vivid evaluation of the control measures in place and the gaps to be filled in order to waver off any such mishap in future. Fires have happened in intensive care units of hospitals including neonatal ICUs in India and other countries. Patients are most vulnerable in these areas, besides there being an oxygen enriched environ. In some sinister incidents of hospital fires, although fire started in a service or supportive area but it soon engulfed the whole hospital like the infamous AMRI Hospital incident.[6]

About 41%incidents (18) took place during morning shifts. The main reason which could be attributed to this is heavy work-load and equipment usage in early morning hours. National Fire Incident Reporting system (NFIRS 5.0) from USA reveals 60% of fire incidents to be happening in morning hours[16]. In India about 39.39% of incidents occurred in morning hours in one of the studies conducted by Satpathy et al.[22]

The various control measures that were taken to combat these fire incidents mainly included the usage of clean agent (51.16%) followed by water (11.63%), dry powder and CO_2. Clean agent fire extinguishers were used in majority of incidents, as they leave no residue and are environment friendly. In 11 cases (25.58%) no extinguisher was needed. The study of Yar Mohammadian, 2016 stated that in place sound firefighting management based on scientific principles is always the key to prevent fires and its impacts.[23] Fire safety strategy should be a continuing process such that fire safety systems are regularly checked and maintained.

For the second objective NABH check list was used to assess the fire safety program which is in-place within the hospital under study.[24] A simple scoring system was used and 7 out of 10 points scored for meeting the requirements in checklist. 4/ 6 points were scored in the NBC requirement for high rise buildings standard requirements. The hospital has a robust system of fire extinguishers in house whose dates of expiry and functionality is regularly checked and a comprehensive maintenance contract (CMC) is in place for the equipment. Due to this, prompt control could be achieved and although a number of fire incidents happened but no loss of life or property was reported. Besides, other firefighting equipment like fire suits with oxygen packs, ropes, searchlights, fire hook, fire pick axe etc are available for trained security personnel who serve as a team of firefighting men deployed in each duty shift. However, there is a need for automatic fire alarm and detectors for which tendering process has already been started. Also, installation for automatic sprinklers is under way. Sprinklers lead to 75% reduction in property damage.[25] Fire alarm system must be designed for early detection, accurate location, annunciation and control.[26]

There are certain building bylaws which have been laid down for newly constructed structures with the objectives to protect public health. In India national building code 2016 standards need to be followed while constructing buildings including hospitals. Fire safety can be achieved by strictly implementing these standards for example, type of materials to be used, provision of fire extinguishers, installation of detectors and fire alarms, and provision of emergency fire exits, underground and terrace tank water storage etc.[1,25,26] Emergency fire exits and their signages are available in the hospital. Drawings displaying escape routes on each floor are deficient but have been included in the fire safety plan, which is under process as phase 1 plan. Electric and diesel pumps, yard hydrants and wet risers are available as per standards in the hospital as shown in Table 3. A dedicated fire safety committee headed by the medical superintendent is available, which focuses on implementation of fire safety programs, regular mock drills and training of the staff.

Training programs are conducted in almost all the departments of the hospital including ICUs. Theatres, accident/ emergency and wards. Staff, especially concerned with round the clock patient care are trained to handle any fire mishap. Around 520 staff members have been trained and further more are in the pipe-line to be trained in future. It could be seen that not many doctors attend these sessions owing to their busy working schedules. Performance of the staff with regards to fire safety and management is not up to the mark. In spite of regular drills and trainings they lack promptness in taking control of the situation if it arises. This is comparable to a study done by Chowdhary et al at AIIMS, Delhi in 2020 in which they analysed various fire safety challenges faced by the hospitals.[24] Innocent Meki observed that

knowledge gap existed among 60% health care workers regarding fire safety in one study.[27]

In one hospital of Nigeria Ukegbu et al found that only 35% of health care workers knew how to operate a fire extinguisher and only 42% knew about their location. Overall, 65.5% had a poor knowledge score on fire safety.[28]

Last but not the least the hospital has an advantage that a fire station is located within the hospital premises, which is the reason that two major fires were dealt with in a short time without any loss of life, and only minor damage to physical facility.

Limitations

During the period of study staff of various areas were given trainings to combat any fire incident. However, their knowledge with regards to fire safety protocols, types of extinguishers and their usage was not assessed. A further work needs to be done to assess the KAP (knowledge, attitude, practice) of the staff after all the trainings given to them.

CONCLUSION

Self-assessment or audit of fire safety in a hospital plays a vital role in identifying lacunae in fire safety plan and filling the gaps. We used a combination of critical incident analysis, fire incident report analysis and comparison with standard guidelines. The gaps were discussed with top management and upgradation of the fire safety plan proposed and approved subsequently. Health care facilities must have in place fire incident reporting system, however small the incident be to critically analyse and ensure filling of gaps for better fire safety.

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