

Safety Education and Risk Management: Research on the Evolution Mechanism of Fire Accidents in Nursing Homes

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Abstract—Based on fire safety and risk control in nursing home, this work sought a system and mechanism to coordinate efforts and rectify defects based on the catastrophic consequences caused by frequent fire accidents in nursing homes. This work reviewed and analyzed the accident attribution theory and studied the case of "5.25 major fire accident in Lushan nursing home". The elimination of management defects plays a decisive role in cutting off the causal chain of accidents; there is an accidental necessity behind the random fire accident, and the dangerous source evolves along the route of point source, line source and surface source until it is close to the critical point or the mechanism of detonating accident when there is a fuse; the self-strengthening and sunk cost in path dependence inhibit the upgrade of safety management. The fire and rescue institutions should go down to the grass-roots level to carry on the practical training to the nursing home practitioners and the elderly in the residential nursing home; the design loopholes in the law making process and the judicial process need to be repaired urgently; and the emergency management of emergency safety accidents in the nursing home needs to be strengthened.

Keywords—Safety education; risk management; nursing home fire accident; evolution mechanism

I. INTRODUCTION

Safety means that unacceptable risks are effectively controlled. In recent years, there have been frequent fire accidents in nursing homes, resulting in disastrous consequences. Nursing homes are enclosed spaces where the old, the weak, the sick and the disabled live in high density. In case of a fire, the fire will often be intense, resulting in the tragic consequences of mass death and mass injury.

II. REVIEW AND ANALYSIS OF ACCIDENT CAUSATION THEORY

The accident causation theory focuses on clarifying the cause of the accident, tracing the beginning and the end of the accident, evaluating the consequences of the accident, and defining the responsibility of the accident, so that people can be "immunized" from failure.

Representative figures of accident frequency prone theory are Farmer, Chamber, etc. [1]. The statistical distribution of the number of accidents supports the theory. The accidents probability distribution of no individual differences, a small

number of individual accidents occurred frequently and more people are prone to accidents obeys Poisson Distribution, Biased Distribution and Distribution of Unequal Liability. The explanatory power of the theory is limited. Since the employee who caused the accident has no subjective malice, the cause of the accident is mostly lazy, rash and inflexible. To attribute complex accidents to employees' "job adaptability" is to overgeneralize and ignore the nature behind the phenomenon.

Representative figures of accident causal linkage theory include Heinrich, Frank Bir and Edward Adams [2]. The accident linkage theory of "1:29:300" proposed by Heinrich has domino effect, so as long as one of the key cards is drawn; the chain suspension can be cut off. Frank Bir and Heinrich's causal chain of accidents follow opposite logical paths. Heinrich uses the previous "result" summary to prevent the appearance of the latter "result", emphasizing the logic that people should draw lessons from the past and it is never too late to mend. Frank Bir, on the other hand, speculates on the possible "result" based on the "cause" of existence, emphasizing the prevention in advance. Adams puts all kinds of complicated factors causing accidents on a logical line, and clarifies the evolutionary mechanism from "management system to management error to site error to accident to injury". Adams singles out "management deficiencies" to create an "overpass" over the causes of various accidents. In 1966, the Japanese scholar Kitagawa Tozo extended the fault attribution from the technical and management aspects to a larger field, which emphasizes the formation of a "great security concept" based on safety education and covers the whole people with safety awareness.

Representative figures of the modern system security theory include Haddon, Surry and Anderson [3]. Hadden believes that the damage to people caused by accidents is due to energy transfer or accidental release of toxic substances. The Surry model emphasizes the perception, understanding and behavioral response of hazards in the process of hazard composition and hazard release. Anderson adds the "source of risk cues and their detectability" to the Surry model, emphasizing the sensitivity of people in danger to risk signals.

III. CASE STUDY OF FIRE ACCIDENT CAUSAL CHAIN

In practice, some accidents are unexpected, but there is an explicit or implicit causal chain of accidents behind it. This

work took "5.25 Lushan nursing home major fire accident" as the analysis sample, and combed this accident causality chain.

A nursing home in Lushan County, Henan Province burst into fire at 20:00 on May 25, 2015. Among the 44 elderly residents in the fire zone, 38 were killed and 6 were injured. As far as the fire went, only the blackened frames of the tin foam house and the remains of the wheelchair remained [4]. The fire "burned out" the confusion of nursing home safety management and the lack of safety prevention system.

A. Direct causes of accidents

a) Superimposition of unsafe state of the object and unsafe human behavior

The unsafe state of the object. First, the building uses flammable combustible materials illegally as core color steel plate. These colored steel plates are low in fire resistance, so they cannot reach the level 3 fire resistance rating, and they collapse when they burn [5]. According to the Building Design Code for the Elderly, colored steel plates are prohibited as building materials for nursing homes. Second, the safe evacuation passage is narrow and crowded, and there is only one way out of the nursing home's "disabled elderly" area. As the fire spread quickly and blocked the exit, leaving no way to escape. Third, they used inferior cable illegally, and the fire along the wire quickly ignited the connected room.

The unsafe human behavior. None of the 44 elderly people who lived in the nursing zone that night were spared. Therefore, have managers and nurses ever had any effective rescue behavior? It is certain that the rescue of managers and nurses is not in place.

b) The victim died from heat, electrocution and suffocation

The fire of the accident originated from the electrical circuit short circuit, which ignited the wire insulation layer, polystyrene foam, ceiling wood keel and other flammable combustible materials, causing the fire to spread. In the fire accident, the victim suffered from high temperature barbecue, electric shock and chemical burning release of toxic gas asphyxiation and other triple injury.

B. Indirect causes of accidents

The indirect cause of fire accident is mainly due to management defects.

a) Safety education training is insufficient, and the safety awareness is poor, so they lack basic safety education training

The nursing workers and the elderly in the accident did not go through fire training and drills, and there were phenomena such as no alarm, no fire extinguishing, no escape, no evacuation, and delay in alarm timing.

b) Safety technical defects

The distribution room and cable wiring of the nursing home were chaotic. Before the fire accident, there have been many cases of power socket plug contact fault. Due to aging cable,

power failures caused by fuses occur frequently. However, the electrical failure has not caused alarm.

C. The underlying causes of the accident

a) The investigation and management of security risks are not timely

The fire started from the aging of the wire, which involved fire safety responsibility, including who is responsible for maintenance, who is responsible for supervision, and whether the electrician has professional qualifications.

b) Government regulators are responsible

The nursing home was found to have violated regulations on the use of iron sheet foam siding and poor quality cables, as well as arbitrary line loads, inadequate fireproofing, inadequate number of evacuation routes and blocked closures. Additionally, the "annual inspection" and the daily supervision are just formality.

In summary, there are a series of management flaws behind the seemingly accidental fire accident. After the event, there is endless "draw inferences from one case to the other", but there is no way to stop the "again and again" after the event.

IV. THE TRANSMISSION MECHANISM BEHIND THE FIRE ACCIDENT

A. Dynamic evolution mechanisms of hazard sources

a) The quantitative change process of "point source to line source to surface source"

The first step is the point source. At the initial stage of risk exposure, the main risk sources are point sources. This scattered point-like risk source may not only be self-inflicted, but can also accumulate continuously without external intervention to form a "large scattered and small concentrated" distribution of risk patches.

The second step is the line source. Line sources are formed by the connection of dangerous patches. As the boundary of the dangerous patch extends, when its end-to-end junction reaches a certain degree, it will form a line source risk in the form of "continuous strip".

The third step is the surface source. The non-point source risk is formed when multiple line risk sources are intermingled and superimposed on each other until a close-up is reached.

b) The appearance of qualitative critical point or "fuse"

First, when the risk accumulation breaks through a certain critical value, it will break the original delicate balance and lead to safety accidents. If the electrical wire aging causes resistance to a certain extent, it will catch fire at high temperature.

Second, the occurrence of a fuse or the touch of a random variable will also lead to safety accidents ahead of time. For example, when the fire evacuation passage is occupied by combustible items, a discarded cigarette butts will ignite the open fire.

B. Path dependence and its self-reinforcing mechanism

a) Path dependence and behavioral inertia

Path dependence means that people's judgment, decision-making and behavior mode are influenced by the accumulation of memories that can be obtained from the past, and will consciously or unconsciously follow the traditional practice. Path dependence is a mistake of empiricism, turning a blind eye to the exposure of security risks and taking it for granted.

In the Implementation Plan of Fire Safety Standards Improvement Project for Private Nursing Homes issued by the ministry of civil affairs in conjunction with multiple departments in December 2019, "nine types of behaviors are strictly prohibited" are listed. These include illegal charging of electric bikes. The main body of violation is nursing workers in nursing homes. These people think of themselves as "insiders" who do things according to their behavior, either from the ignorance of the law, or from the fortuitous ignorance, or from the recklessness of habit, or from the negligence of nature. This kind of behavior inertia and environmental risk interlock become the dangerous source of fire accident.

b) Sunk cost considerations in self-reinforcing mechanisms

Path dependence itself has a tendency of self-reinforcing. Nursing homes will stick to the original facilities that need money as long as the original facilities can continue to be used. In the meantime, it involves many influence factors such as sunk cost and personal reputation. For example, the establishment of mini-fire stations in accordance with regulations and the implementation of 24-hour on-duty inspections can cause the original investment costs to sink. In addition to accounting costs, marginal costs and opportunity costs, nursing homes will take sunk costs into account when calculating the investment costs of new or renovated fire facilities. Sunk cost is a kind of past investment since nursing homes are not willing to abandon, which reflects the "self-reinforcing" mechanism in path dependence at work.

A considerable number of nursing homes often exclude change based on sunk cost considerations, increasing the safety risk of nursing homes. This analysis is supported by the case of "5.25 Lushan nursing home major fire accident". The accident broke out when the cable was short-circuited. Bad cable is the fire source. The cable consists of three kinds of materials: the price of the outer insulating plastic is cheap; the copper core of the cable needs more than 99.9% pure copper to make and the price is expensive; although the dosage of the anti-aging agent and flame retardant used to prolong the life of the insulating material is small, it is very expensive. As a result, except that it is not illegal to outsource insulating plastic, the cable copper core purity is insufficient, diameter "shrinkage" and anti-aging agent, flame retardant agent added discount. Unqualified cables have high resistance and high heating value after electrification. The service life of insulation layer is only one third of that of qualified cables. It can be said that "small fraud, big hidden danger", and "saving a small amount of money but brewing catastrophe".

V. FIRE SAFETY EDUCATION AND SAFETY MANAGEMENT

A. Fire safety education

The "individual prevention" in the fire risk control of nursing home is far more important than "physical prevention" and "technical prevention". People have subjective initiative, so people may be the most reliable factor in the security prevention system, or the most unreliable factor.

Fire-fighting skills training for nursing home practitioners

First, the training of nursing home practitioners. The training is mainly in the form of centralized teaching, on-site drill and video display for fire rescue organizations to improve the practical operation. From a long-term perspective, the construction of nursing home employees lifelong fire skills training system is necessary.

Second, fire safety and escape skills training for elderly people in nursing homes. The training should focus on how to put out the initial fire, how to call the police, and how to rescue and cooperate with rescue, so as to avoid panic in fire accidents.

Third, nursing homes should carry out fire safety education covering the whole population and promoting the whole media. For example, individuals should develop fire prevention behavior as the foundation; the family should practice the fire prevention safety as a unit; the school should cultivate the fire prevention accomplishment as the focus; the community should build the fire prevention community together as a module; the public welfare organization should create the fire prevention society as the network.

B. Fire safety management

The fire safety and fire risk control of nursing homes have never been foolproof.

a) "Self-control, mutual control, other-control"

The "self-control, mutual control and other control" of fire risk is an organic integrity. The combination of the three is conducive to prolonging the safety cycle. Among them, "self-control" is the basis, which can provide a good security environment for mutual control; mutual control can watch on each other, supervise each other and check for gaps; other control is to fill the gaps and leak, playing a synergistic effect.

First, exposing blind spots and paying attention to detail. It is impossible to eliminate all dangerous sources, but only to eliminate or reduce the risk of existing ones [6]. For example, blind spot becomes the focus of risk management and control through "blind lantern" type exposure risk source. For fire safety in nursing homes, details determine success or failure. The premise of "no accident" is not only to nip all kinds of hidden risks in the bud, but also to implement every link of "behavior chain" management.

Second, rectifying defects and making up for defects. For safety control, rather than the shortest plank determining its water capacity, the weakest synergistic link determines the overall risk management and control capacity. Imagine that if the nursing home was able to enforce fire safety regulations, or

if the regulatory authorities were conscientious, there would be no such tragedy.

b) Emergency management of sudden fire accidents

When a fire breaks out in a nursing home, first, it should call the "119" fire alarm number in the first time, and take the lead in informing the professional departments of fire control, medical treatment, civil affairs, etc., so as to avoid doing "unprofessional" things instead of "professional departments", thus delaying the time of emergency treatment. Second, medical treatment and care for the injured should be actively carried out to prevent the occurrence of secondary disasters, derivative disasters and other coupling events caused by major natural disasters.

C. Accelerating the reform process of fire enforcement in nursing homes

a) Further improving fire inspection procedures

The fire risk control of nursing homes involves technology and system. Among them, technology is related to direct cost, and system is related to transaction cost. Fire review is a combination of technology and system, including substantive review and procedural review. In the past, the fire control review of nursing homes was mainly physical examination. Before the opening of the nursing home, it must go through the administrative examination and approval of fire safety in three links: first, the examination and inspection of the design drawings; second, the acceptance when the construction is completed; and third, and the safety inspection before opening. At present, under the background of "delegating power, streamlining administration and optimizing government services" reform, the administrative license set up by nursing homes has been canceled. However, professional regulatory standards, including fire protection, have not been lifted. From the point of view of policy development trend, the construction of credit system with "informing promise" as the core will become the main way to supervise nursing homes after the event. This work holds that in order to avoid the breakdown of the safety bottom line involving the life and health of the elderly, it is necessary to give higher legal basis to fire law enforcement reform. Additionally, after the occurrence of a major fire accident, in addition to the accountability of the responsible person, it is necessary to revise or repair the loopholes in the relevant law making and judicial process.

b) Strengthening the main responsibility of fire safety in nursing home

The essence of "fire safety notification commitment system" is to require the main body of operation to take full responsibility for its own fire safety, which embodies the basic principles of the legislation of the Fire Protection Law. The main responsibility of fire safety in nursing homes is as follows: first, construction and operation must be carried out in accordance with the relevant laws and regulations, fire fighting and other relevant national technical standards; second, the "fire safety notification commitment system" should be added into the credit management system. According to the nature, severity and social harm of the behavior of the nursing home, they will be divided into different credit rating and announced to the society. A major fire accident in a nursing home is a

major breach of trust, which will be directly included in the "blacklist" of social credit records, "one violation, everywhere restricted", and it will be listed as a key subject of daily supervision or spot check.

VI. CONCLUSIONS AND DISCUSSION

Based on the reality of frequent fire accidents and disastrous consequences in nursing home, this work discussed the accident causality chain and evolution mechanism behind the accident by combing and discriminating the theory of accident attribution and the case analysis of "5.25 Lushan nursing home major fire accident", and sought a kind of fire risk control mechanism of nursing home which can work together to correct the malpractice.

The work drew the following conclusions: seemingly random fire accidents have an accidental inevitability behind them; the dangerous source evolves along the route of point source, line source and surface source until approaching the critical point or detonating the accident when there is a fuse; the self-strengthening and sunk cost in path dependence restrain the upgrade of safety management; the elimination of management defects is decisive to cutting off the accident causal chain; and the strengthening of safety education and risk management in nursing homes is the strategy for long-term stability.

The conclusion of this work shows that it is necessary to further consolidate the main responsibility of nursing home in fire risk control, and put "individual prevention" in a more important position than "physical prevention" and "technical defense". Additionally, the emergency management of emergency fire accidents should be strengthened to prevent the occurrence of secondary disasters and derivative disasters. It is necessary to speed up the reform process of fire law enforcement in nursing homes and improve the fire control examination procedures. Looking ahead, under the background of "delegating power, streamlining administration and optimizing government services" reform, the construction of credit system with "fire safety notification and commitment system" as the core will become the main way for fire department to supervise after the implementation of the incident. Therefore, this work suggests that first, after the cancellation of the administrative license set up by nursing homes, the fire law enforcement reform should be given higher legal basis in order to avoid the breakdown of the safety bottom line involving the life and health of the elderly; second, after the occurrence of major fire liability accidents, it is necessary to amend or repair the loopholes in the relevant laws and judicial process.

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