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USE OF EPIDEMIOLOGY IN THE PUBLIC SPACE: RECONSTRUCTION OF A TRAIN FIRE IN INDIA

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ABSTRACT

This account is the outcome of an independent investigation into the burning of a coach of the Sabarmati Express in February 2002 in Northwest India. In this fire, 59 occupants were charred to death and the initial official reports suggested that some arsonists deliberately burnt the coach. The propagation of this information and associated events resulted in large-scale violence in the state of Gujarat in India when over one thousand citizens lost their lives. This paper presents the results of a study done two years later using all the epidemiological tools available and shows that earlier reports are probably wrong and how scientific investigations can help in preserving community harmony. Epidemiological methods can be used to reconstruct events in a more reliable way than hearsay and anecdotal techniques used by laypersons. The results of the indicate that: (i) It is highly unlikely that the fire could have started on the aisle floor outside the toilet by throwing of inflammable fluid (as claimed in official reports). (ii) The resultant dense and high temperature smoke spread along the ceiling of the carriage and eventually resulted in a flashover when the fire engulfed the entire coach. (iii) Over a hundred passengers attempted to escape through a narrow exit away from the fire. Those who were not overcome by the toxic fumes of the fire could get away. The rest probably became unconscious before they could escape and were subjected to dense and toxic fumes and radiative heat, resulting in asphyxiation and death.

KEYWORDS

Train, fire, epidemiology, India

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INTRODUCTION

The Sabarmati Express was on its way to Vadodara (India) in the early morning of 27 February 2002. It stopped en route at a small town called Godhra at about seven in the morning. According to newspaper reports, there was an altercation between some train occupants and food vendors at the station. This developed into more violence and stone throwing by people along the tracks and as the train attempted to leave it was halted by people on the train pulling the chain and activating the emergency brakes (UNI 2002; Lakshmi 2002). According to reports there was a longer period of stone throwing at the train and then the S-6 coach caught fire. Before the tragic event could be brought under control, 58 persons had perished on the spot. Television stations the same day and newspapers contained reports which were similar to the reports below:

“As the train left Godhra station, one of the miscreants who had boarded it pulled the chain alarm after some time to halt the train a km away. It was here that a large number of stone-pelting miscreants set the coach ablaze by throwing acid bombs and dousing it with kerosene and petrol” (UNI 2002).

“An angry mob attacked a train full of Hindu activists today in western India and set fire to four cars, killing 57 people and injuring at least 43, local officials said. When the train started to pull away, attackers described by state officials as

local Muslims swarmed the cars containing the activists, the official said ... Those killed in the ensuing melee included 25 women and 15 children, officials said. The victims were members of the Vishwa Hindu Parishad, or World Hindu Council, returning from the northern Indian city of Ayodhya ... ‘It is clear from the statements of survivors that the attack was carried out by local people belonging to the Muslim community and, for this reason, because of chances of retaliation, we have already

instructed our police officers to arrange special security cover for the Muslim population,’ Zadaphia said” (Lakshmi 2002).

The newspaper reports were supported by police evidence and politicians’ accounts. The next few days witnessed mounting communal violence against Muslim citizens in the state of Gujarat, especially in Ahmedabad city. Over 2,000 citizens (predominantly Muslims) were murdered and tens of thousand made homeless. The after effects of this violence still remain.

The Government of the state of Gujarat and the Federal Government of India have instituted official enquiries to investigate the causes and associated vents leading up to the violence. The official reports have not yet been submitted. However, the public perception remains that the main trigger for the violence was the wanton burning of the train carriage by Islamic “terrorists”. Even this claim has not been legally substantiated yet.

Almost 32 months after the event, a civil society organisation, The Hazards Centre (Delhi) undertook an investigation into the probable causes of the fire. The study was initiated because of increasing concern over the manner in which previous investigations had been conducted and the absence of an explanation consistent with the facts as recorded. Hence, the Hazard Centre set up a multi-disciplinary group of professionals to investigate the event with help from several other individuals from different fields, as well as the Railway authorities.

The group members analysed the documents available from previous investigations, visited the railway workshops at Matunga and Jagadhri, viewed video footage of the Sabarmati Express S-6 coach, and observed the burnt coach at Godhra. Other coaches, not belonging to the Sabarmati Express and which have caught fire at other places and times, and now parked at Indian Railway workshops at Gandhinagar and Jagadhri, were also examined to learn more about the broader processes and results when such coaches burn. After several consultations, a report was

submitted to the Indian Railways and released for public discussion in January 2005 for wider public discussion and debate (Roy et al. 2005).

METHODS

The team investigated facts concerning: (i) the construction and evidence of fire in the coach; (ii) the origin and spread of the fire in the coach; (iii) details of evidence given by 41 surviving passengers and other witnesses to the police and courts; (iv) post-mortem reports of 27 passengers who died in the fire; (v) the injuries to 56 survivors as reported to medical professionals soon after the event. All information used is in the public domain.

The coach

The burnt Coach-6 at Godhra was physically observed 2½ years after the incident (hereafter referred to as the Godhra coach). Therefore, allowance had to be made for the passage of time and the changes that may have been brought about by exposure to weather, investigating teams, and curious onlookers. However, the team was able to view video footage of the coach taken two months after the burning incident, and the visual evidence suggests that the essential features of damage to the coach remain the same.

The observations of six other coaches (burnt at other locations) presently parked at Gandhinagar (one) and Jagadhri (five) were very useful for comparing the fire patterns across coaches in order to understand the manner in which the flames spread. The team discovered that one coach kept at Jagadhri was very similar to the burnt coach at Godhra. This coach (16526 GSCN – hereafter referred to as the Delhi coach) caught fire while under maintenance in the washing line of Delhi Junction Station on 21 November 2003.

The fire

The Godhra coach was examined to ascertain the extent of damage to different parts of the coach lengthwise and in height, both inside and outside. Damage to different structures was recorded. A similar examination was done for the Delhi coach and details obtained regarding the burning characteristics of different materials from the railway authorities. Mechanisms of fire initiation and propagation in different situations were studied with special reference to scientific evidence from house fires, fires initiated by cigarettes, gases and fumes emitted by different materials, and time periods involved in different processes.

Evidence of surviving passengers and other witnesses

The statements made by several passengers and railway, police, and fire brigade employees to the police and enquiry committees are available on record and provide some important insights into the incident. After careful screening, it was found that there were 41 passengers, some bona fide and others not so, whose statements had some bearing on the pattern of the fire. Of these, about half could provide some idea of which seat they were occupying at the time of the incident.

Post-mortem reports

A total of 27 post mortem reports were made available to us. Out of 27 reports, 26 are for those who died on 27 February 2002 and one for an individual who died on 3 April 2002.

Injury details of survivors

A total of 56 injured victim reports are available with us. Out of 56 reports, 48 (86%) were examined on the 27th of February and 8 (14%) on the 28th February 2004.

RESULTS AND DISCUSSION

The coach

Heat marks were clearly visible on the sides of both the Delhi and Godhra coaches where the paint was scorched and peeled or vaporised off. The heat marks on the left and right side of both the coaches are roughly similar and more severe on the upper half of the coaches. The patterns are also very similar, indicating that the heat was greater at one end of the coach in both cases. In the case of the Delhi coach it is also known that no materials were thrown from outside (Figure 1).



Figure 1. Damage to the Godhra coach (under investigation, left) and Delhi coach (comparison coach right)

The crinkling of the steel body and the roof was also similar and took place in the middle section but more towards the end where the scorch marks are more pronounced. The pattern of heat marks on the outside of the coaches is clearly correlated to the conflagration inside. In both the coaches almost half the plywood floor crumbled in one half where the fire presumably originated, although the under-floor remains intact. The vinyl and foam berths and partitions have been completely destroyed in this half and the steel is mangled. As the distance from the centre of the fire increases, the aluminium frames and reinforced fibre shutters slowly begin to reappear, as do scorched remains of the seats. The damage to the ceilings indicates that in the regions of high temperatures, the asbestos ceiling crumbled, the fan blades have got warped. In the Godhra coach, the aluminium water tank above the luggage compartment next to seats 68-70 displayed a large hole towards the inner side indicating that the heat was greatest in the upper portion of this end of the compartment.

For the Delhi coach, there was no evidence of anyone throwing inflammable fluid on the coach, the heat marks on the outside must have been caused by the heat inside. Any inflammable fluid thrown from the outside could not have produced such heat marks on the top end of the carriages unless the coach was on fire throughout its length inside. It was reported for the Delhi coach that the fire was initiated, without the use of any inflammable fluid on the floor inside, between the first

and second cabins and the seats burnt first. It took about 15-20 minutes for the fire and smoke to spread throughout the coach from the time the smoke was first noticed.

Therefore, in the case of the Godhra coach it is possible that the fire originated in the region between the last two cabins and started by burning the lower berth first. The resultant dense and high temperature smoke spread to the top of the carriage and then moved along the ceiling and between the ceiling and the roof through the length of the coach. The radiative and convective heat generated eventually resulted in a flash over when the fire engulfed the entire coach towards the top.

Hence, in the Godhra coach, it is highly unlikely that the fire could have started on the floor of the passage or the floor outside the toilets. Inflammable plywood and foam in three tiers of seats would not be available for the fire to burn in this area. If the fire was started by an inflammable fluid on the floor, the flames would have been noticed right away in a very crowded carriage, precluding the possibility of a long smouldering source.

The fire

The floor, ceiling, wall and partitions in the coach were constructed with fire-retardant materials. In the coach, the most flammable material was the latex foam in the seat. This was, however, protected by a plywood base and a vinyl cover. The next most flammable material was the plywood base itself and if this is exposed to a source of ignition it will rapidly catch fire and, in turn, set the foam on fire too. The plywood can be set on fire by clothes and other materials stored by passengers below the seat. These materials can be set on fire by cigarettes, matchsticks or cigarette lighters that are still burning. If there is any cooking equipment with fuel stored below the seat, this can worsen matters.

The latex foam creates enormous clouds of hot, dense, asphyxiating, black smoke and this itself becomes the source of ignition for other materials as the temperature rises to flash point. The total combustible mass per seat was about 10 kg. If this drops to the floor while it is burning, it will also ignite other berths, partitions, panels, and the vinyl flooring. Other materials in the coach that will melt and vaporise are the vinyl fabric cover (rexine) of the seat, laminated plastic partitions (sunmica) and vinyl flooring (linoleum). All these materials jointly produce hydrogen cyanide, isocyanates, carbon monoxide and dense smoke.

The luggage carried by a typical passenger in a coach varies between 5-10 kg, and almost all luggage will carry clothes that are highly flammable. Any smouldering or lighted particle can set the luggage on fire, if it remains in contact long enough to raise the temperature for flammable materials to catch fire. For materials like cloth, plastics, paper, etc. to smoulder and set the plywood on fire it can take 10-20 minutes. Then the foam in the seat can be completely on fire within 5-10 minutes. Cigarette induced house fires have similar characteristics (Kransky 1987).

The depositions of the passengers suggest that very few escaped from the side of the cabin where the fire probably originated. The damage in the Godhra coach is similar to the Delhi coach. In the Delhi coach the fire is said to have originated on the 9th cabin side (Seat No 72, See Figure 2). These two pieces of evidence suggest that the fire must have originated

If the fire originated around the 8th and 9th cabin, then the passengers only in these cabins would have a chance to escape from the 9th cabin end and all the passengers in cabins 1-7 and some of those in 8 would move toward cabin 1 to escape. This is also suggested by the testimony of the witnesses.

The available evidence for the Godhra coach strongly suggests that the fire initiated in the luggage below the seat in the 8th or 9th cabin and then spread through radiative and convective heating from the overhead smoke. It is possible that the material below the seat and the plywood smouldered for 10-20 minutes or more before the smoke was noticed. Heavy smoke is not likely to have appeared immediately after the initiation of the fire.

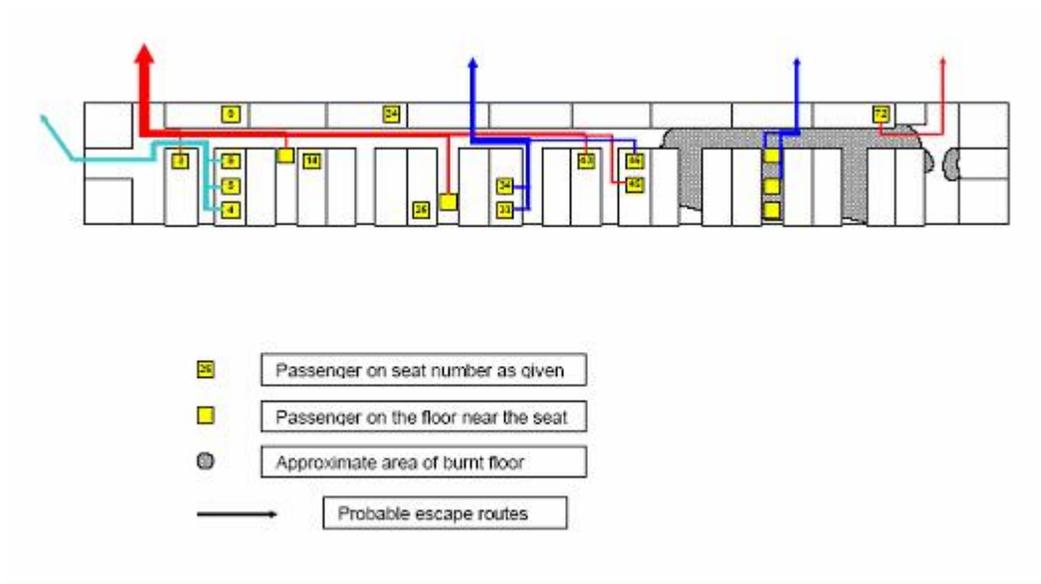


Figure 2. Schematic diagram of the Godhra coach. The fire probably originated near seat 72, forcing most passengers to attempt escape from the left end (in figure) of the coach.

Evidence of passengers who survived

The statements made by several passengers and railway, police, and fire brigade employees to the police and the High Level Committee are available on record and provide some important insights into the incident. After careful screening it was found that there were 41 passengers, some bona fide and others not so, whose statements had some bearing on the pattern of the fire. Of these, about half could provide some idea of which seat they were occupying at the time of the incident. Based on the statements given by those 19 passengers who could recall their position or exit mode, we have made an attempt to map the possible escape routes from the burning coach. The interpretation has been based both on what the passengers stated as well as an observation of which window bars were broken and the area of intense heat in which the floor was burnt.

Of the 11 passengers who made statements in this regard, only 1 said that the fire began towards the seat 1 end of the coach. The rest were unanimous that the fire began from rear end (near seat 72). The limited information available from the statements suggests that the time taken for the fire and smoke to spread could vary between 10 to 20 minutes. All these statements have been made by passengers who were further away from the origin of the fire.

Twenty three passengers said that some inflammable substance was flung into the coach. Ten of these even specified that this was in the form of a burning rag, burning torch or petrol and acid were thrown from outside. All these 10 passengers were in the 5th or 6th cabin from the front but did not mention their specific seat numbers. Four passengers said some liquid was thrown into the lavatory. Of these, three belonged to one family who were located in the 1st cabin. Four passengers claimed that they noticed some liquid on the floor and all of them were in the 5th cabin.

Seventeen passengers said they had escaped out of the door and they all specified that this was toward the seat 1 side. Thirteen other passengers escaped out of windows. The mapping exercise indicates that all those passengers who were between seat 1 and 48 probably escaped out of the door on the yard side of the front end (seat 1) of the coach. Only one person escaped from the other door on the same side because he was sitting on berth 72 closest to the door. Three others of one family in the 1st cabin said they had forced their way out from the space between the connecting vestibules on their side. Two windows from which some of the bars were broken appear to have been the exit route for six other passengers.

Those passengers with easy access to the door appear to have made their way quickly through it as soon as the first signs of smoke began appearing. Others who were further away from the door and closer to the origin of the fire had to break their way out through the windows or wait in the narrow aisle to get their turn to move toward seat 1. The huge majority (16/23) of those who said that inflammable substances were thrown from outside could not specify which seat they were in or what was their reserved berth. Of the remaining seven, only three were located near where the fire began. Hence, the evidence points to the fact that the fire could not have been ignited by pouring petrol on the floor and setting it ablaze.

Post mortem reports

Eight doctors performed the post-mortems and all except one were conducted in the railway yard. The reported time taken for the post mortems ranged between 20 to 75 minutes with an average of 38 minutes. All the 8 doctors record almost exactly the same details for injuries and reported all body parts charred/roasted/burnt including internal organs and contents. For all cases, the diagnosis recorded was that the burn injuries were “ante mortem”. For all cases, the cause of death was recorded as “shock due to burns”. The estimated age of all victims ranges from 4 to 45 years. Only 3 persons were estimated to be less than 10 years old.

The post mortem reports can be considered unscientific and unreliable for the following reasons:

1. Twenty-six were conducted in the yard without adequate equipment and support needed for a scientific post mortem.
2. Time taken (average 38 minutes) for the post mortem is far too little for obtaining details of injuries, preserving relevant tissues, etc.
3. It is not possible that 26 bodies will have almost identical injuries.
4. In most cases it is recorded that almost all body tissues, including internal ones, were roasted/charred/burnt.
5. In all cases the burns are recorded to be “ante mortem” and death caused by “shock due to burns”. There is no indication how all the doctors have arrived at this conclusion.

It is highly unlikely that every one who died would have very similar burn injuries and would be charred completely, if they were moving around and trying to escape. Therefore, the possibility those who got charred completely were dead or unconscious before they got burned.

It appears that those passengers, who were located at the rear end of the crowd and were from cabins 5-8 waiting to escape from the seat 1 end, never got a chance. They probably fell unconscious and/or died from asphyxia before the fire burnt them completely. In this case, the fire would have released isocyanates, hydrogen cyanide and carbon monoxide. With the presence of these gases people can fall unconscious and die within minutes depending on the concentration of gases. This may be why all the passengers who died are reported to have been charred completely.

Injury details of survivors

Details of injuries are given in Table 1. A majority of patients (68%) reported trouble in breathing due to smoke and heat inhalation. Almost half of these victims had no other problems except breathing trouble. Soot marks were largely on the face, head and upper body, at times on the hands. This indicates that soot-laden smoke was only on the upper half of the carriage in the region where these victims spent their time before escaping.

Burn patients comprised only 12% of the patients treated. Of all the burn patients, 83% had facial and head burns and 58% had upper limb burns. Only 3-4 patients had more than superficial burns. This indicates that:

1. Among these survivors, it is unlikely that any of them faced the full impact of the heat generated by the carriage fire. They probably managed to escape while the fumes were still in the upper regions of the compartment.
2. The fumes and the heat were localised in the upper half of the compartment where they were gathered before escaping.

Table 1. Details of injuries among survivors.

No	Injury type	Number	Percent
1	Smoke & heat inhalation injuries, Total	38	68
	Only inhalation	17	30(45% of total)
2	Burns, total	12	21
	Scalp and facial burns	10	18(83% of burns)
	Upper limb	07	13(58% of burns)
	Lower limb	03	05(25% of burns)
	Torso	02	04(17% of burns)
3	Injuries, total	12	21
	Fracture(lower limb)	02	04(17% of inj)
	Lower limb injury	07	13(58% of inj)
	Upper limb injury	04	07(33% of inj)
	Torso	04	07(33% of inj)
Total is greater than 56 as one person can have more than one injury type			
Total will be greater than 100 as one person can have more than one injury type			

Only 21 percent of the survivors comprising this sample suffered physical injuries. Only 2 injuries include fractures of the hand. Most of the injuries were to lower limbs and could have been sustained while escaping and falling from the compartment. The height of the compartment floor from the ground was more than 1.5 m. A fall from this height hands first can fracture an ulna. Falling head first from this height can produce serious head injury, especially among older

people. If someone jumps feet first, fractured ankles, sprains, and bruises to knees etc. are very likely. Very few injuries to the upper body parts are recorded, indicating that they might not have been subjected to violence from others.

The injury information supports the understanding that the fire initiated from the 8th or 9th cabin (seat 72 side) after smouldering for a while. The initiation is unlikely to have been noticed by any one and therefore it is unlikely that any burning material was thrown from outside as they would have then taken action before it smouldered.

It is unlikely that there was any fire on the floor as long as these survivors were in the compartment. If the evidence given by some passengers from the 5th–6th cabin that some inflammable substance was flung into the coach and that there was fuel on the floor is correct then this fuel would have caught fire and burnt the lower parts of passengers' bodies. Since this is not true for a vast majority of the cases, it is unlikely that there was any inflammable fluid on the floor in any significant quantity.

When the fire started and gave out a great deal of smoke, the occupants in the region of seats 64-72 (approximately) would have been taken by surprise and moved away. Most of them would have tried to escape from the exits on the seat 72 side. The occupants on seats 1-64 (approximately) side would have tended to move toward seat 1 to escape.

In the above circumstances, 150 or more people must have gathered between seats 1 and 50 or so trying to escape. These passengers must have been subjected to dense and toxic fumes emanating from the roof and upper levels of the compartment and radiative heat as the ceiling heated. At this time it is unlikely that there was anyone left between seats 48-64 where the smoke and fire would have been intense.

Most of the survivors are likely to be those who were in the region of the seats 1-40 and managed to get ahead. These survivors are those who sustained the injuries mentioned above as they escaped the debilitating effect of the fumes.

CONCLUSIONS

1. The fire probably originated in the region between the last two cabins (8 & 9) and it is highly unlikely that it could have started on the floor of the passage or the floor outside the toilets by throwing of inflammable fluid.
2. The resultant dense and high temperature smoke spread along the ceiling of the carriage and eventually resulted in a flash over when the fire engulfed the entire coach from the top.
3. In the above circumstances, people must have gathered trying to escape and been subjected to dense and toxic fumes and radiative heat, resulting in asphyxiation and death.
4. Systematic recording of the evidence and scientific investigation of the case has been marked by its absence. Specific procedures need to be developed for mapping the damage and interviewing the witnesses.
5. Procedures for scientifically collecting and analysing samples also need to be pursued in line with modern approaches in forensics and medical investigation.
6. Serious thought needs to be given to the design of doors and exits and emergency escape designs for Indian carriages, considering the high passenger load per compartment.
7. There is no conclusive evidence that the fire in the railway coach was set deliberately by arsonists or criminals.

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