

A Public Health Report on

Injuries Related to the
West (Texas) Fertilizer Plant Explosion
April 2013

Waco-McLennan County Public Health District
In collaboration with the
Texas Department of State Health Services



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TABLE OF CONTENTS

	<i>Page Number</i>
1. Acknowledgements	3
2. Introduction	4
3. Methods	4
• Objectives	4
• Institutional Review Board Review	5
• Criteria for Inclusion	5
• Data Collection	5
• Medical Record Review	6
• Survivor Interviews	6
4. Results	7
• Medical Surge	8
• Fatal Injuries	9
• Non-Fatal Injuries	9
• Location of Injured Patients	10
• Survivor Interviews	12
5. Limitations	13
6. Discussion	14

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- McLane Children's Hospital Scott & White (Temple)
- Methodist Dallas Medical Center (Dallas)
- Parkland Memorial Hospital (Dallas)
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INTRODUCTION

On April 17, 2013 a fire broke out at the West Fertilizer Company plant in West, Texas. West is a rural community in McLennan County of about 2800 residents located in central Texas along the Interstate 35 corridor. The plant was located at northeastern edge of the town. In close proximity to the plant on the west and south were residential areas, a nursing home, two schools and an apartment complex building; to the north and east were agricultural fields, ranches, and sporadic homes. The plant had reserves of ammonium nitrate. This fire subsequently caused an explosion that killed 15 individuals and directly injured at least an additional 252 individuals. The explosion caused extensive damage to the homes, businesses, and schools near the plant. The explosion was registered as 2.1 on the Richter magnitude scale and left a 10 feet deep and 90 feet wide crater at the site. After the explosion, residents of the neighborhood surrounding the plant were ordered out of their homes for up to 10 days. The explosion drastically affected the residents and visitors of the city of West.

Explosions of this magnitude are rare events, but can inflict severe damage to a community and its residents. The knowledge about the injuries and deaths resulting from explosions is limited, particularly in residential communities. In an effort to understand the types and characteristics of injuries and healthcare resources that were used during and after the explosion, an investigation team was formed to gather this data. This team had members from the the Waco-McLennan County Public Health District (WMCPHD), Texas Department of State Health Services (DSHS) (Health Service Region 7 and Central Office).

METHODS

The investigation team consisted of trained epidemiologists, public health nurses and physicians, preparedness professionals and a geographer. The team had extensive experience in data collection, medical record review and patient interviews. The multidisciplinary team role was vital in the development of the investigation.

In addition, the team consulted with experts on blast and disaster injuries from the Centers for Disease Control and Prevention (CDC) and the Oklahoma State Department of Health, the latter having investigated the Oklahoma City bombing in 1995. They gave insights and suggestions which were incorporated in this investigation.

Objectives

The objectives of this investigation were:

1. To describe the characteristics of fatal injuries caused by the explosion
2. To describe the physical injuries of survivors of the explosion

3. To describe risk factors associated with injuries caused by the explosion, including location at the time of the blast, timing of injury, and demographic characteristics
4. To quantify the number of acutely injured patients who sought medical care
5. To describe the medical care received by the injured

Institutional Review Board Review

The investigation protocol and participant consent process was reviewed and approved by the DSHS Institutional Review Board (IRB).

Criteria for Inclusion

We included the patients who were fatally or non-fatally injured in West, Texas when the fertilizer plant exploded in the evening of Wednesday, April 17, 2013 who met the following criteria:

1. Fatal injuries: patients who died in McLennan County within one week as a result of injuries sustained in blast
2. Non-fatal injuries: patients who sought medical treatment for injuries related to the explosion, identified through medical records
 - Injury treated at any hospital, emergency room, or urgent care facility in McLennan or Hill County within 5 days with cause and timing of injury consistent with being related to the blast.
 - Injury treated at a Texas hospital known to have received injured patients between Wednesday, April 17, 2013 and Friday, May 17, 2013 and identified by that hospital as being related to the blast.

Data Collection

The investigation team developed a medical record data collection tool and a survivor survey. The survey and data collection tools were also based on several existing survey instruments including questionnaires used during investigations of the 1995 Oklahoma City bombing and 2012 Alabama tornado outbreak, as well as a blast injury form developed by CDC. The data collection tools were designed to collect information related to the description of where the person was at the time of the explosion, how and what type of injuries were sustained.

A two phase approach was used to collect data as described as:

1. Record review
 - Hospital medical records
 - Urgent care clinic medical records

- Mobile medical unit records
 - Medical examiner reports
2. Survivor interviews

Medical record review

From September to December 2013, medical records were reviewed for all patients identified by any Texas hospitals reported by the Heart of Texas Regional Advisory Council (HOTRAC) as having seen patients with injuries related to the explosion.

Additionally, hospitals and urgent care facilities in McLennan and Hill counties were asked to provide any records of patients with medical codes relating to specific injuries who were treated in the five days after the explosion. The medical record information was abstracted by trained personnel using a standard questionnaire. The purpose of medical record review was to obtain information on mode of arrival at the health care facility, types of injuries sustained, and the types of medical resources utilized at the treatment facilities. The disposition information was also recorded during medical record review such as patients were treated and released, admitted, or transferred to another facility. Death certificates and medical examiner reports were reviewed to collect injury characteristics on deceased patients.

Survivor interviews

From December 2013 through February 2014, eligible injured patients identified through medical records were contacted to participate in a survivor survey. After excluding nursing home residents and anyone of age less than 18 years, attempts were made to reach 149 patients. We sent notification letters to eligible survivors, alerting them that investigation staff would be calling them to answer a telephone survey a week later. We attempted to contact survivors twice during business hours and once after business hours or during weekends. If patients were unreachable by telephone, a copy of the survey with a postage-paid return envelope was mailed. The survey was also mailed if that preference was indicated by the patient during a telephone call. The survivor survey had a total of 52 questions but depending on the location of the person at the time of blast (outside, inside home, in car etc.) the actual number of questions varied. The survivor survey was designed to take approximately 15 minutes. For this part of the investigation, we established and documented verbal consent prior to conducting the telephone. A written consent document was also included with the mailed survey. The purpose of survivor interviews was to further understand the mechanism, exact location and the timing of injuries.

RESULTS

The investigation team reviewed 654 patient records at 14 facilities, including 11 hospitals and three urgent care facilities (Table 1). Of these, 308 patient visits by 288 unique patients were determined to be related to the explosion. Twenty patients presented either to two medical facilities or the same facility at different times. A total of 252 patients had non-fatal injuries directly related to the explosion; an additional 10 patients had injuries indirectly related to the explosion. Of those injured directly by the explosion, 56 (22%) were admitted to a hospital. An additional 15 patients died of injuries sustained in the explosion. The injury fatality rate for this explosion was 5% (15 fatalities of 277 injured patients). Among the 2831 residents of the city of West, 10 residents were fatally injured and 197 residents were non-fatally injured. The injury rate among West residents was 7%.

The four hospitals located in Hill (Hill Regional Hospital and Lake Whitney Medical Center) and McLennan (Hillcrest Medical Center and Providence Hospital) Counties received 250 (81%) of the patient visits for medical care related to the explosion. The remainder of the visits occurred at hospitals in Dallas (4), Fort Worth (3), or Temple (6), at urgent care facilities in McLennan County (22), or at the Mobile Medical Unit temporarily established in West (23). We were not able to review records at three urgent care clinics in McLennan County, all of which reported not treating any patients for explosion-related injuries.

Table 1. Medical Visits Related to the West Fertilizer Plant Explosion by Facility

Location	Facility	Total Visits	Admissions	Injury Visits
McLennan Co	Hillcrest Medical Center	114	26	104
	Providence Hospital	89	19	82
Hill Co	Hill Regional Hospital	46	1	41
	Lake Whitney Medical Center	1	0	1
Dallas	Children's Medical Center	1	1	1
	Methodist Hospital	1	1	1
	Parkland Hospital	2	2	2
Fort Worth	JPS Hospital	3	3	3
Temple	McLane Children's Hospital	2	2	2
	Scott & White – Temple	4	3	3
Urgent Care in McLennan Co	Central Texas Urgent Care – Hewitt	1	NA*	1
	Central Texas Urgent Care - Lacy Lakeview	18	NA	15
	Concentra	3	NA	3
West	Mobile Medical Unit	23	NA	21
Total	Total	308	58	280

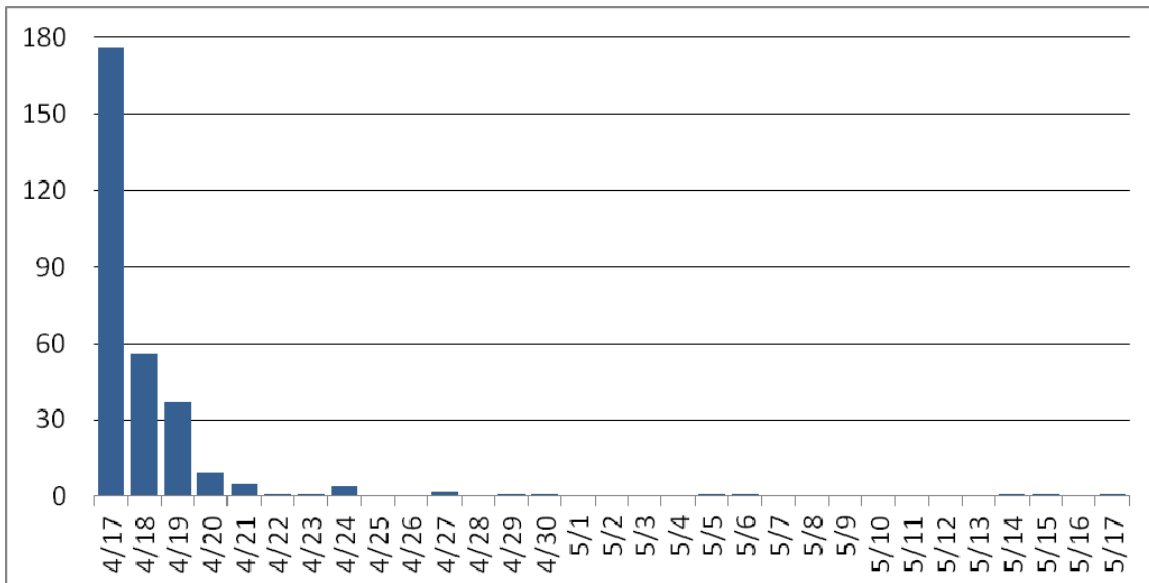
*NA means not applicable

Medical surge

The majority of patients arrived at medical facilities for treatment within hours of the explosion (Figure 1). On the night of April 17th, 176 (of 308; 57%) of all patient visits occurred. By the end of the day on April 18th, 232 (75%) of patient visits occurred.

Of the 308 visits to hospital emergency rooms and urgent care facilities that were identified as being related to the explosion, 280 visits were for treatment of an injury. Non-injury visits included patients who needed medications or who wanted to be evaluated for possible injuries. Patients arrived at the medical facilities for treatment by several different modes. Walk-ins (via private vehicle, bus from the field triage location, law enforcement vehicles, other) accounted for 57% of all visits. Others were brought to the hospital by ground ambulance (21%), air/helicopter (3%) and mode of arrival was unknown for 19% patients.

Figure 1 – 308 Patient Visits related to the West Fertilizer Plant Explosion, by Day of Visit



The majority of patients were treated and released upon their initial visit to a medical facility (220/288; 76%). A total of 58 patients were admitted to the hospital. Fifty-two patients were admitted to hospital after their initial visit. Five additional patients were transferred to a higher level acute care facility and subsequently admitted. One patient was initially discharged, then returned eight days later and was admitted. No one who reached a medical facility for treatment subsequently died.

A variety of medical resources were utilized to treat injured patients (Table 2), including imaging studies such as X-rays, CT scans, ultrasounds, or MRI scans (57% of visits),

blood products (3%), and endotracheal intubation (2%). More patients who were admitted for treatment of their injuries received these medical resources.

Table 2. Medical Resources by Patient Visit

	Injury Visits (n=280)	Injury Admissions (n=56)
Blood products	9 (3%)	9 (16%)
Endotracheal intubation	5 (2%)	4 (7%)
Imaging studies	160 (57%)	54 (96%)
X-ray	146 (52%)	52 (93%)
Computed Tomography (CT)	83 (30%)	41 (73%)
Ultrasound	6 (2%)	3 (5%)
Magnetic resonance imaging (MRI)	5 (2%)	5 (9%)

Fatal injuries

Fifteen patients were killed by injuries directly as a result of the explosion. Fourteen died at the time of the explosion; one died a short time later. All fatalities resulted from fractures, blunt force trauma, or blast force injuries sustained at the time of the explosion. Ten firefighters and two civilians responding to assist were killed. Two residents of a nearby apartment complex and one resident of the nursing home also died. The decedents ranged in age from 26 to 96 years; 14 were males.

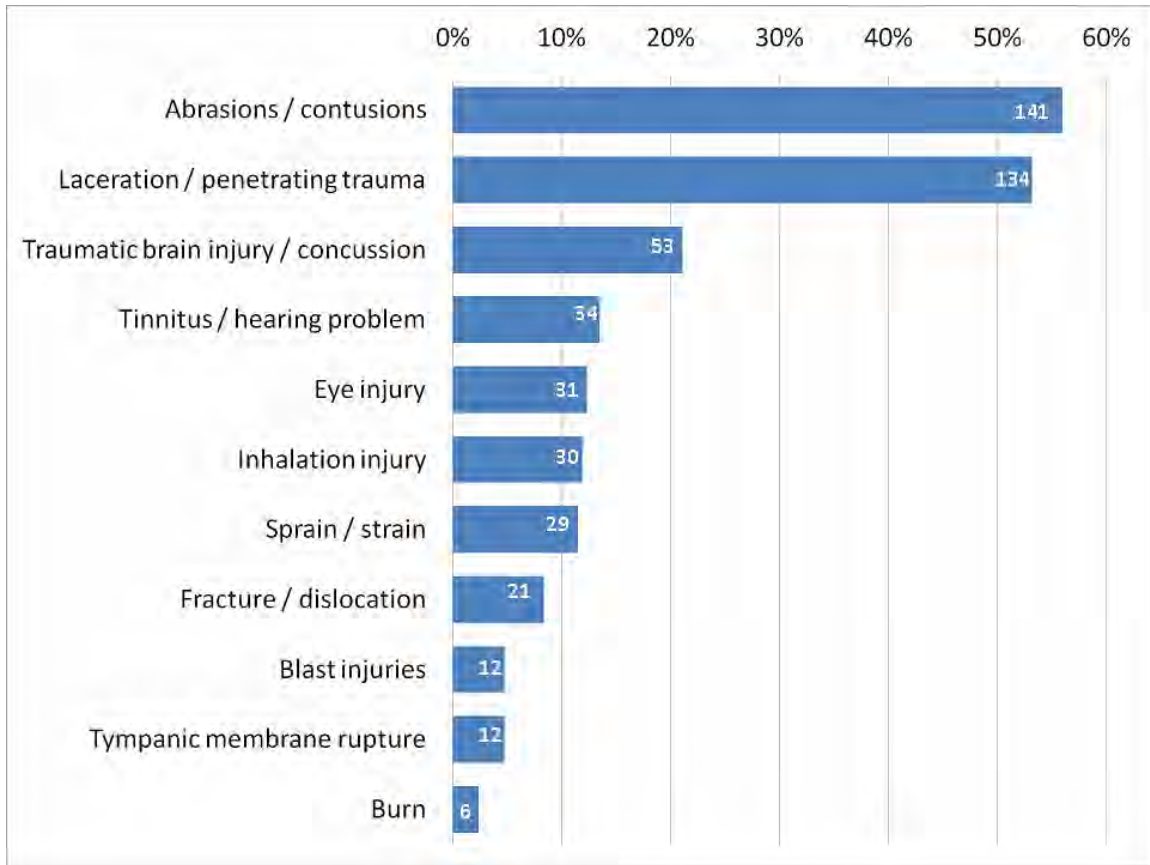
Non-fatal injuries

Of the 262 patients with non-fatal injuries, 61% were women. Average age was 53.6 years, with a range of less than 1 year to 98 years. Over one quarter (72; 28%) of the injured patients were residents of the West Rest Haven nursing home. The nursing home census at the time of the explosion was 130 people; therefore the explosion led to injuries in 55% of the residents.

There were 252 patients directly injured by the explosion; the remaining 10 patients were injured after the explosion during clean-up or by debris in the neighborhood. Over half of the 252 patients injured directly by the explosion had documented abrasions/contusions and lacerations/penetrating trauma (Figure 2). Fifty-three (21%) of injured patients had traumatic brain injuries or concussions. Other common injuries included tinnitus/hearing problems (14%), eye injuries (12%), and inhalational injuries (12%). Eleven percent of patients had sprain/strain; eight percent had fractures/dislocations. Tympanic membrane ruptures were documented in 5% of injured patients. Blast injuries, including pneumothorax, blast lung and blast abdomen injuries were seen in 5% of patients. Burns were observed for 2% of patients. Patients injured

indirectly by the blast, such as during clean up, had a variety of injuries, including abrasions/contusions, lacerations/penetrating trauma, sprains, and inhalational injuries. Patients sustained between 1 and 9 types of injuries as listed in Figure 2.

Figure 2. Types of Non-fatal Injuries Sustained by 252 Directly Injured Patients



Location of injured patients

Using information from survivor interviews and medical record notes, the location of each of the 252 patients directly injured by the explosion at the time of the blast was determined, if possible. For 191 (76%) patients, we could determine if they were inside a structure, outside, or in a vehicle. We were able to determine the approximate geographic coordinates of their locations for 172 (68%) of injured patients.

Over half (55%) of injured patients reported being inside a structure, 13% reported being outside, and 8% reported being in a vehicle (Table 3). All 72 injured residents of the West Rest Haven nursing home were classified as being inside at the time of the explosion. The types of injuries sustained by patients inside were different than those who were outside or in a vehicle. People who were inside were over twice as likely to

have abrasions/contusions and lacerations. People who were outside or in a vehicle were over eight times as likely to have hearing loss/tinnitus, tympanic membrane rupture, or inhalational injury. People who were inside and outside or in a vehicle were equally likely to have eye injuries or traumatic brain injury/concussion.

Table 3. Location of Patients Non-fatally Injured Directly by Explosion (n=252)

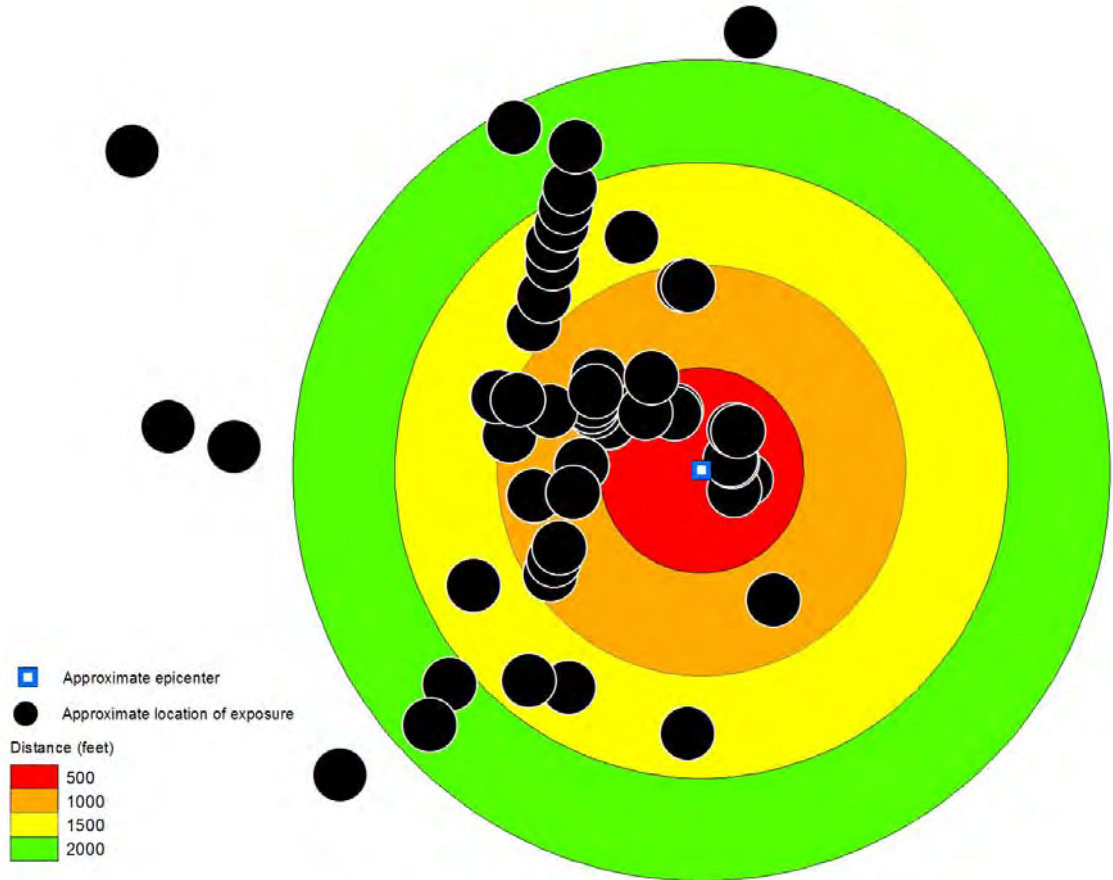
Location	N	%
Inside	138	55
Outside	33	13
In vehicle	20	8
Unknown	61	24

The median distance from the blast epicenter of the 172 directly injured patients with geocoded location at the time of the blast was 825 feet. Over three-quarters (134/172; 78%) of these injured patients reported they were within 1000 feet of the blast, a radius that included the nursing home and apartment complex (Table 4). All patients who were admitted to the hospital were no more than 1500 feet away when the explosion occurred. Those who were closer to the epicenter were more likely to be hospitalized than those who were farther away. The types of injuries sustained from the explosion were similar regardless of the distance from the blast. Figure 3 is an illustration of approximate injury exposure locations of non-fatally injured patients within a mile of the approximate blast epicenter; each dot does not necessarily represent an individual person.

Table 4. Distance from Blast for Patients Injured Directly by the Blast (n=252), by Admission Status

	Total N (%)	Admitted N (%)	Not admitted N (%)
Total	252	56	196
<500 feet	9 (4%)	3 (5%)	6 (3%)
500-999 feet	125 (50%)	47 (84%)	78 (40%)
1000-1499 feet	18 (7%)	3 (5%)	15 (8%)
1500-1999 feet	6 (2%)	0	6 (3%)
2000-2499 feet	5 (2%)	0	5 (3%)
2500-2999 feet	1 (<1%)	0	1 (<1%)
3000-3499 feet	3 (1%)	0	3 (2%)
>=3500 feet	5 (2%)	0	5 (3%)
Unknown	80 (32%)	3 (5%)	77 (39%)

Figure 3 – Map of Approximate Exposure Locations of Non-fatally Directly Injured Patients within a Mile of the Approximate Blast Epicenter



Survivor interviews

We interviewed 58 survivors, 53 of whom were directly injured by the explosion. Of those directly injured by the blast, 45 (85%) heard the explosion. Using a noise intensity scale from 0 (no noise) to 10 (very intense), the mean score given by those who heard the explosion was 9.7.

Thirty-eight (of 53; 72%) directly injured survivors were aware of the fire at the fertilizer plant prior to the explosion. They found out about the fire in numerous ways, including directly from a friend or relative (19; 50%), by seeing the fire (15; 39%), from a person of authority (7; 18%), by hearing the fire (3; 8%), or from TV (1; 3%). Six (11%) injured survivors were told to evacuate from their location prior to the explosion; 5 of 6 were located within 1000 feet of the epicenter.

LIMITATIONS

Our analyses have several limitations. This investigation only identified injured people who sought medical care at a hospital or urgent care facility immediately after the explosion. We also collected data on those with injuries who were treated at the mobile medical unit set up in West two days later. We did not identify those who sought medical care at private physician offices, at other medical facilities, or those who were treated later in time. We are likely to have identified the most severely injured patients, requiring more immediate treatment at a nearby medical facility or at a facility known to the HOTRAC, who was tracking this information during the emergency. The injured patients who were not identified during this investigation were thought to have less severe injuries.

Medical records may not have included complete information that could have been useful in this investigation. Patients were treated during an emergency situation with treatment as the primary focus, so data such as demographics, contact information, past medical history, detail of circumstances, and minor injuries may have not been noted or recorded. We also may have failed to identify some injuries due to miscoded injury diagnoses or codes. At the time of the fire, nursing home staff conducted a horizontal evacuation of residents, moving them within the facility away from the side of the building nearest to the fire. Residents who subsequently needed medical treatment after the explosion were transferred quickly and many arrived at the emergency room without documented medical history or medication lists.

Some injuries, particularly ear injuries as well as traumatic brain injury, may not have been identified at the time of medical treatment immediately after the explosion, particularly in the presence of more acute and life-threatening injuries. About a third of survivors of the Oklahoma City bombing in 1995 reported tinnitus or hearing loss in the year after the explosion; only 12% of injured patients in our study reported this type of ear injury. Among survivors of the World Trade Center attack on September 11, 2001, a medical record review of 35 hospitalized patients demonstrated that over half of patients with probable traumatic brain injury were not diagnosed during their hospital stay.

We conducted interviews with survivors several months after the explosion. Some participants may not have remembered everything that happened or remembered it differently than they would have if interviewed shortly after the explosion. Additionally, the survivors who did agree to take the survey and provide responses may be different than those who do not agree to take the survey or did not ever answer the phone. We also did not interview anyone of age less than 18 years or the residents of the West Rest Haven nursing home, whose experiences may have been different than the adults we were able to interview.

This investigation focused only on the apparent acute physical injuries associated with the explosion as noted above. The results will help inform whether future investigations related to the West, Texas fertilizer explosion are practicable or useful. Any future

investigations would need to have a clear public health purpose; would require the availability of relevant data and resources; and should be designed to reveal issues that could be addressed with appropriate public health interventions. Any future efforts would also require the support of local authorities, and could potentially be undertaken by entities other than WMCPHD or DSHS.

DISCUSSION

It is our hope that this investigation will assist the people in the West community to better understand the public health impact of acute injuries sustained in this tragedy. We believe this investigation will also be useful to medical providers and public health professionals in learning about the types of injuries that may occur and the medical/public health resources needed to plan for and respond to a similar emergency incident.

This investigation makes the following recommendations and observations:

General Public Recommendations:

1. Anyone in a similar emergency incident that might be experiencing certain types of symptoms related to injuries (e.g., ear injuries/hearing problems, traumatic brain injuries/concussions) such as trouble sleeping, headache, dizziness, memory problems, difficulty in concentration, balancing problems etc. should consider early medical evaluation. For more information on blast related injuries visit : <http://www.bt.cdc.gov/masscasualties/blastinjuryfacts.asp>
2. Families should develop a family emergency plan in case a disaster occurs in their community, and share this plan with family and neighbors. A family emergency plan would consist of such things as a communication plan (a list of designated out-of-town contacts), designated meeting place in case you cannot return home, copies of important documents in a safe location, and planned multiple routes away from your home in case evacuation is necessary. For more information visit: <http://www.dshs.state.tx.us/Prepare-for-an-emergency.aspx> or <http://emergency.cdc.gov/preparedness/>
3. While developing an emergency plan, individuals should be aware of locations in their community with explosive potential such as industrial and chemical facilities and transportation corridors. For more information on facilities that pose a potential hazard in your community contact your local fire department.
4. Citizens should heed warnings and instructions from local officials particularly regarding evacuation and shelter in place notifications.

Medical Community Recommendations:

1. This report provides information which may help the medical (e.g., hospitals, urgent care facilities, mobile medical unit) and first responder communities predict and plan for the types of injuries that might be expected in a similar emergency incident, and when and how those patients might be arriving to the medical facility which may improve medical recognition and management of those injured.
2. While examining apparent physical injuries, medical providers should also screen for ear and brain injuries which may result from similar emergency incidents. For more information on these and other blast injuries visit:
<http://www.bt.cdc.gov/masscasualties/blastinjuryfacts.asp>
3. The medical community should explore communication strategies to address patients with potential ear injury or hearing loss from a similar emergency situation.
4. Long term care facilities (e.g. nursing homes, assisted living facilities) should review their processes to gather patient medical records when evacuating or moving patients in a similar emergency situation.
5. Encourage nursing homes and assisted living facilities to exercise their evacuation plans regularly.

Public Health Recommendations:

1. Use this investigation as a model for collaboration between local, regional, state, and federal agencies.
2. Share the investigation plans (e.g., IRB proposal), tools, and lessons learned with other epidemiologists to build capacity to do these types of investigations across the state.
3. Share this report with colleagues in public health, trauma, emergency management, law enforcement, fire, architecture, engineering, and other stakeholders who may be able to use these results to inform potential recommendations within their fields of expertise.
4. Share the field report with those local health departments and medical facilities that may have fertilizer plants within their jurisdictions so that can be aware of the type of injuries and deaths that might occur.

5. Develop a tabletop exercise with these specific incident data and challenges to help epidemiologists improve their capacity to conduct these types of investigations in the future.
6. Public health should be involved in the reentry and recovery phases of a similar emergency situation to make public health recommendations at the time of reentry and recovery.