

Spine surgery in Nepal: the 2015 earthquake

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At noon on Saturday, 25 April 2015, a 7.8 magnitude earthquake struck Nepal. It was centered in the Himalaya northwest of Kathmandu, the capital of over 1 million people. The violent tremors were felt as far away as New Delhi, India 1,000 km from the epicenter, but the worst of its destructive force was experienced in the heavily populated Kathmandu valley and in the remote mountainous villages of the Himalaya. Ancient temples crumbled; poorly constructed buildings collapsed; men, women, and children were trapped and injured, sometimes fatally. Avalanches killed mountain climbers, Sherpa guides, and porters at Everest base camp (EBC). The death toll to date exceeds 8,600 with as many as 20,000 injured. Spinal Health International (SHI), a nonprofit volunteer organization, has been active in Nepal in past years and responded to requests by Nepali spine surgeons for assistance with traumatic spine injury victims following the earthquake. SHI volunteers were present during the 2nd major earthquake of magnitude 7.3 on 12 May 2015. Past and current experiences in Nepal will be presented.

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Introduction

In Nepal, Saturday is a time for rest after a busy six day work week from Sunday through Friday. On Saturdays, children are not in school, offices are empty, hospital procedures and clinics are at a minimum, and village agricultural workers are in the fields tending crops. This is fortunate for Nepalis, and was a particular blessing just before noon on 25 April 2015, because the Indian tectonic plate shifted beneath the Asian (Eurasian) tectonic plate releasing prodigious amounts of energy. The sudden movement of the earth's crust sent shock waves in all directions for a thousand kilometers resulting in a massive earthquake of 7.8 magnitude (*Figure 1A,B*)

The epicenter was located in the foothills of the Great Himalayan Mountain Range within the Lamjung district not far from Kathmandu, the capital city of Nepal (*Figure 2A*).

Nepal is located in Asia between Tibet (China) and India (*Figure 2B*). The population is over 30 million (2015 estimate) and its size is 147,000 square kilometers. By comparison, Nepal is just over half the size of the state of

Victoria in Australia or the country of New Zealand. Nepal is considered an underprivileged country with a GDP (gross domestic product) of USD \$20 billion and an average income of USD \$700 per capita. Twenty five percent of the population lives below the poverty line. Literacy, defined as the ability to read and write by 15 years of age, is low. Sixty five percent of the population is considered literate (male 75%, female 50%). Life expectancy is 67.5 years (male 66 years, female 69 years) which ranks 166th of the world's just over 200 independent nations. Infant mortality is 40 deaths per 1,000 live births which ranks 53rd in the world (*Table 1*). Life expectancy and infant mortality are considered indicators of the general health of a population.

The risk of infectious disease in Nepal is high. Water and food borne illnesses include diarrhea, hepatitis, and typhoid. Vector diseases include encephalitis, malaria, and dengue fever. Airborne tuberculosis is common and often affects the spine with serious consequence including deformity, paralysis, and death. Sexually transmitted disease is present with HIV/AIDS in intravenous drug users and female sex workers. The risk of HIV/AIDS in Nepal was considered

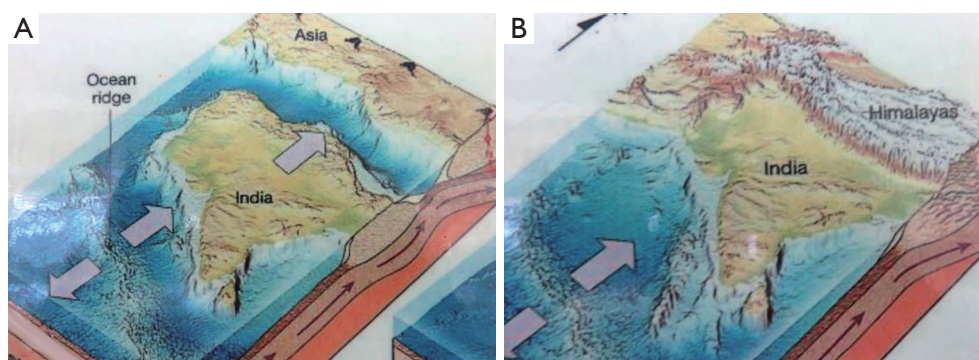


Figure 1 (A) Plate tectonic movements over 50 million years ago; (B) plate tectonic movements leading to the formation of the Himalaya.

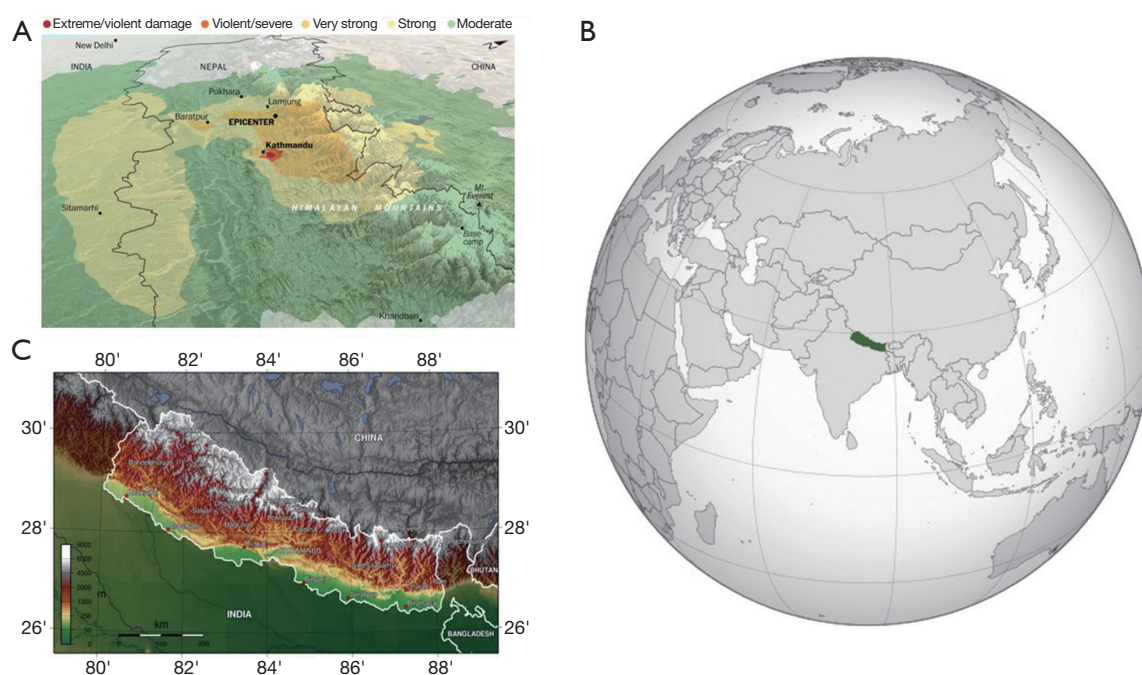


Figure 2 (A) Severity map of the Nepal Earthquake, 25 April 2015; (B) world map demonstrating location of Nepal; (C) topographical map of Nepal.

low prior to 2000, but has increased over the past 15 years. Cannabis grows in rural and urban areas and marijuana and hashish can be purchased illegally. Transport of opiates through Nepal is a recognized problem from countries of origin and production such as Afghanistan and Pakistan. Travelers to Nepal are advised to educate themselves about health matters, immunization, food and water preparation, and the rest prior to their visit.

However, it should be noted that the crime rate in Nepal is low compared to industrialized nations. According

to INTERPOL data, the index rates for murder, rape, robbery, assault, burglary, larceny, and motor vehicle theft are lower for Nepal than the industrialized nations of Japan (low crime rate) and USA (high crime rate). The people of Nepal overall are friendly, congenial, honest, and well behaved. In particular, tourists and foreigners move about freely and safely. The exception to this general rule might occur during periods of civil unrest or political protest. In practice, caution should always be observed.

Topographically, Nepal consists of three regions

Table 1 Comparison of infant mortality for select countries

Countries	Infant mortality (deaths/1,000 live births)
Afghanistan (#1)	117/1,000
African nations (#2-24)	59/1,000-104/1,000
Pakistan (#25)	57/1,000
Nepal (#53)	40/1,000
USA (#169)	6.2/1,000
New Zealand (#184)	4.6/1,000
Australia (#190)	4.4/1,000
Norway (#222)	2.5/1,000
Japan (#223)	2.1/1,000
Monaco (#224)	1.8/1,000

(Figure 2C). The Tarai is the lowland in the southern area which includes floodplains of the Ganges River. This region is on the border with India and is hot and humid. The foothills are the largest region and have a somewhat temperate climate. The largest cities of Kathmandu and Pokhara are located in the foothills. To the north are the mountainous regions which border Tibet (China) and exhibit environmental extremes of cold, wind, and altitude. Eight of the world's ten highest mountains are in Nepal. And the absolute highest is Mt Everest (Chomolungma-Tibet, Sagarmatha-Nepal) at 8,848 m (29,028 ft) above sea level (Figure 3A).

Indeed, the Great Himalayan Mountain Range was formed over eons past, beginning 50 million years ago as the Indian tectonic plate collided with the Asian (Eurasian) plate. This geologic event creates the Himalayan Frontal Thrust and a multitude of fault lines in the earth's crust (Figure 3B). The result is a relatively young mountain range with Mt Everest gradually increasing in height (approximately 1 cm every 3 years) and drifting to the northeast at a rate of 4 cm/year. In addition, earthquakes in Nepal are frequent and at times, severe. The last major geologic event was the Bihar Earthquake of 1934 with 10,700 deaths.

The earthquake of 25 April, 2015 originated at a depth of 15 km (9 miles) below the earth's surface (Figure 3C). By GPS seismic station monitoring, it was calculated that the location of Mt Everest had shifted to the southwest by 3 cm and the height of the summit did not change. Multiple aftershocks followed in subsequent hours and days, the worst occurring the very next day on Sun 26 April at

6.7 magnitude.

The earthquake damage zone extended throughout Nepal and into India and Tibet (China). The historic cities of Kathmandu, Patan, and Bhaktapur were built on an ancient lake bed. During the earthquake, the silty soils undergo a process of liquefaction and violent extreme movements occur resulting in severe structural damage (Figure 3D).

The ground movements at Mt Everest were moderate, but because of the mountainous terrain the effects were dramatic. Everest base camp (EBC) for the southside Nepalese route is situated on the Khumbu Glacier at 5,500 m (17,600 ft) elevation. EBC is located at the base of the Khumbu Icefall which is the first obstacle posed by Mt Everest and must be traversed many times during attempts to climb the mountain. The icefall is considered to be one of the more dangerous parts of the ascent. In 2014, the climbing season came to an abrupt halt due to a major avalanche in the Khumbu Icefall which killed 16 Sherpa climbers (Figure 4A). This was the worst single event on Mt Everest since the tragic disaster of 1996 when a sudden storm trapped climbers and their guides at high altitude in extreme conditions and claimed 8 lives. The story was told in Jon Krakauer's book "Into Thin Air" (1997) and the recent film "Everest" (2015).

The location of EBC was chosen because of its relative safety from hanging glaciers, avalanches, rockfall, and landslides. However, during the 25 April, 2015 earthquake a massive avalanche originating near Pumori 7,161 m (22,915 ft) struck EBC killing 19 people and becoming the worst single event in Everest history (Figure 4B). Climbers were trapped high on the mountain above the Khumbu Icefall. This dramatic scene initially commanded the worldwide news media, but the worst tragedy by far occurred in the cities and villages throughout Nepal.

I have been climbing and trekking in Nepal for the past decade and during my various adventures, I would introduce myself to local orthopaedic and neurological surgeon colleagues. I would seek out those that were performing spine surgery and would volunteer to assist in surgery, demonstrate operative techniques, and give occasional lectures.

In 2009, I founded Spinal Health International (SHI), a nonprofit volunteer organization which was utilized as a conduit for corporate donations to support spine surgeons and their patients in underprivileged countries. In 2010, SHI organized NASCON (The Nepali American Spine Congress) in Kathmandu and hosted surgeon faculty from

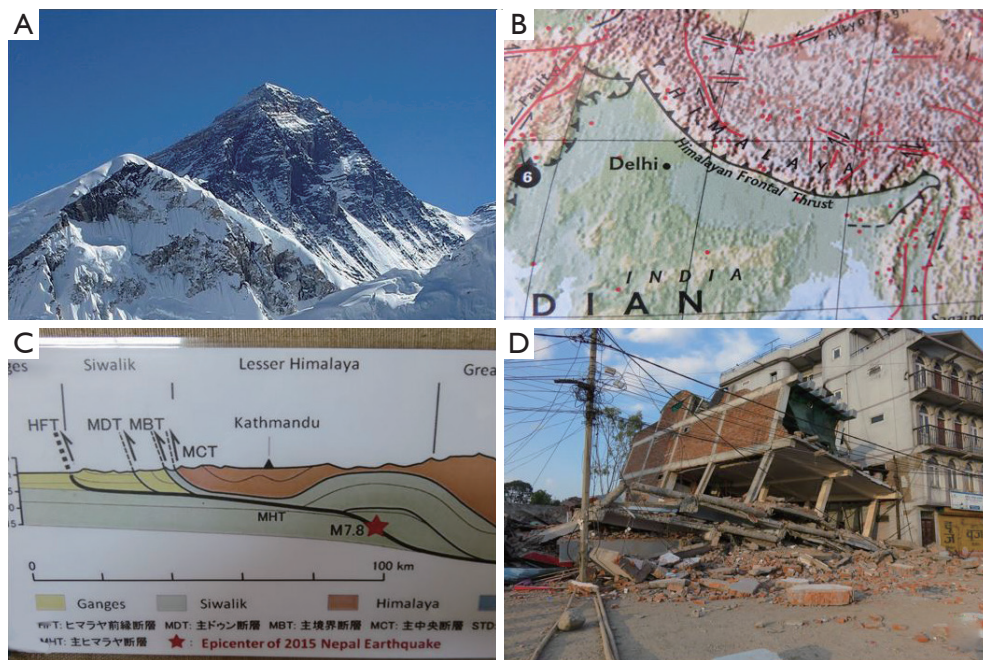


Figure 3 (A) Mount Everest, showing the south side from Kala Patar; (B) Himalayan Frontal Thrust and accessory fault lines; (C) epicenter depth of the 25 April 2015 Nepal Earthquake; (D) structural failure in Kathmandu.

the University of Florida to present papers and demonstrate surgical techniques in theatre.

I have been to Nepal many times, and the majority of cases I've attended involve tuberculosis (TB) of the spine, deformity, and occasional traumatic injury in pediatric, adolescent, and adult patients.

When the 7.8 magnitude earthquake struck Nepal on 25 April, 2015, I immediately began to receive text messages from friends and family in Australia, New Zealand, and USA. In turn, I contacted friends and surgeon colleagues in Nepal, as well as climbers and guides on Mt Everest and in the USA. Kathmandu is an urban area of 1.4 million population and the damage was severe. Office buildings, schools, and world heritage temples collapsed killing thousands and injuring orders of magnitude more (Figure 4C). Longtime friends and colleagues Binod Bijukachhe MD of Grande International Hospital and Ram Krishna Pokharel of Icefall Productions and Icefall Adventures indicated the urgent need for surgeon support and spinal implants and instruments.

Industry did not hesitate to assist SHI in disaster relief efforts. By the time the first week had past, I was in Kathmandu assisting in surgery. I had done cases with Dr Bijukachhe in GIH and Professor Giri, of the Orthopaedics

Department at Bir Hospital when the second major earthquake of 7.3 magnitude wreaked further havoc on Tuesday, 12 May, 2015. The epicenter was located between Kathmandu and Mt Everest (Figure 4D). But once again, the devastation in Kathmandu, Patan, and Bhaktapur was severe. Hospitals sustained further damaged and spine surgeries were cancelled to care for more immediate acute injuries, open fractures of long bones and cerebral, thoracic, and abdominal trauma.

The following select cases are typical of the many traumatic spinal injuries that occurred during the Nepal earthquakes of 2015. The history for each is the same "*The building fell on me!*"

Case 1

Dr. Bijukachhe at GIH had a healthy female in her 30's whose cervical spine was injured by a flexion-lateral bending mechanism resulting in 3 level disc damage and ligament disruption, kyphosis, and incomplete spinal cord injury (SCI). She had signal change within the spinal cord on magnetic resonance imaging (MRI). The surgery consisted of 3 level discectomy, interbody fusion, and anterior plate fixation which restored alignment and decompressed the

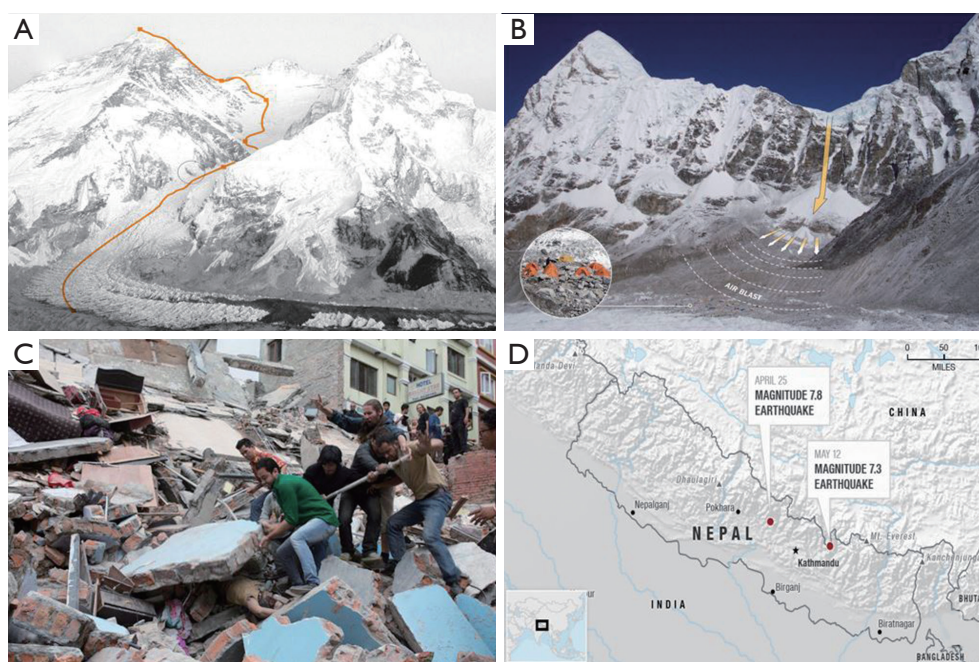


Figure 4 (A) Mount Everest, showing the southside route, camps, and location of the 2014 avalanche; (B) EBC Avalanche of 25 April 2015 from Pumori; (C) the greater tragedy in Kathmandu; (D) epicenter of the 12 May, 2015 Nepal Earthquake.

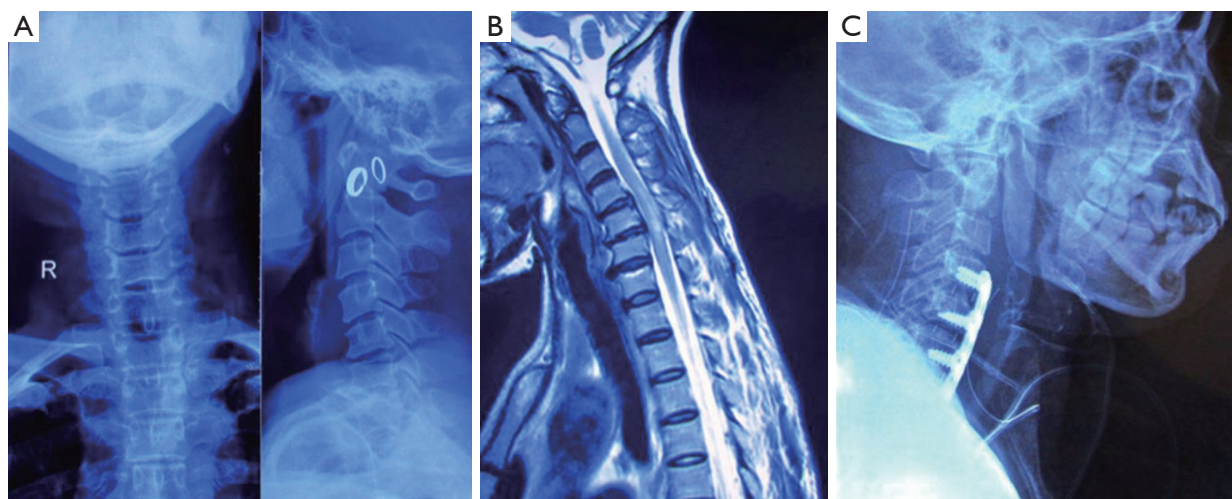


Figure 5 Patient #1 (A) Preoperative X-ray; (B) preoperative MRI; (C) postoperative X-ray. MRI, magnetic resonance imaging.

ventral spinal cord. She wore a supplemental cervical orthosis postop and neurologic function improved (*Figure 5*).

Case 2

Professor Giri at Bir Hospital had a healthy male in his

30's who sustained a flexion-translation mechanism to the thoracolumbar junction. The result was a T12-L1 fracture-dislocation with complete SCI by cord transection. Although ligamentous rupture was severe, the bony middle columnae of each vertebral corpus were relatively intact and capable of bearing axial load if reduced and stabilized.

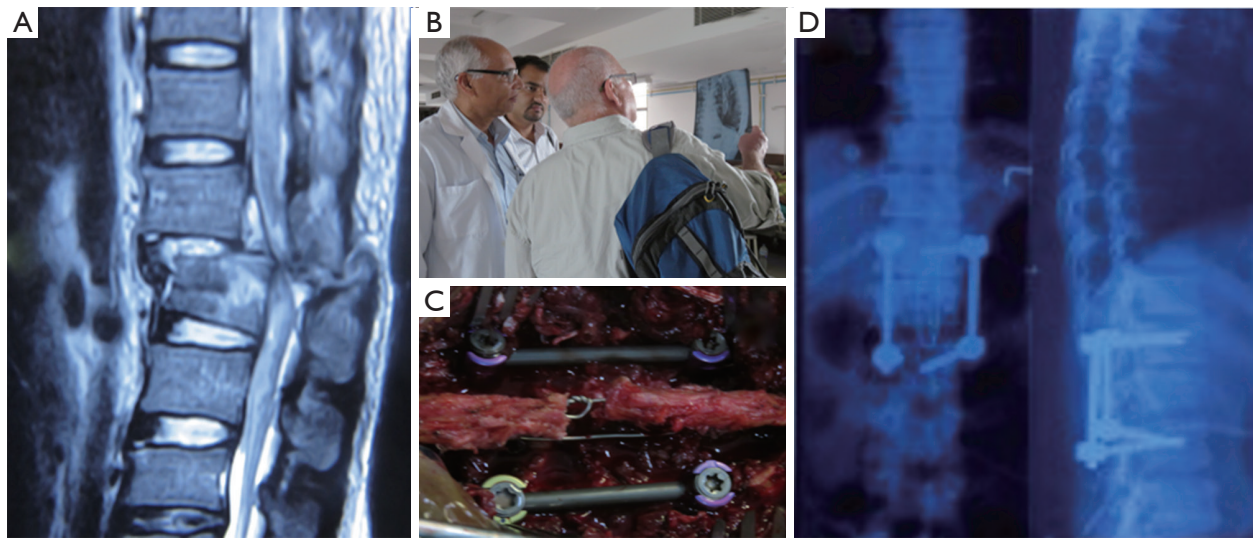


Figure 6 Patient #2 (A) Preoperative MRI; (B) Prof. Giri of Bir Hospital and Dr. Sutterlin of Spinal Health International (SHI); (C) intraoperative photo; (D) postoperative X-ray.

We therefore chose to utilize pedicle screws one level above and below the injury for fixation, supplemented by stainless steel wire tension band between spinous processes (as no crosslinks were available). The patient was mobilized for rehabilitation. Neurologic recovery was not expected to occur (*Figure 6*).

I returned to Nepal again 6 weeks later in July 2015 to supply additional implants and instruments and to assist in further surgeries. At that time, signs of recovery and rebuilding in Kathmandu were evident... traffic was back to normal!

The Nepal earthquakes of 2015 resulted in great human suffering and economic loss. Some estimates of the cost of this natural disaster exceed USD \$7 billion which is one third of the annual GDP. The tragic geologic event of 2015 resulted in 8,600 deaths and more than 20,000 injuries. A number of cultural heritage sites were damaged beyond repair. Disaster relief and support came from Nepal's nearest neighbors and from around the world. The Nepalis are a resilient and resourceful people. Even in tragedy, smiles were abundant, hope was pervasive, and miracles did occur (*Figure 7*). The men, women, and children of Nepal will rebuild their villages and communities in time, but the recovery will take years if not decades. I am grateful to have participated in a very small way.

The Himalaya will continue to display its awesome grandeur, but those who live amongst its natural beauty, and those who choose to visit, must at times accept its

prodigious power and occasional violence.

I am privileged to have gazed upon its wonder.

Further reading

- ❖ Available online: <https://www.usaid.gov/>
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- ❖ Available online: <https://www.cia.gov/index.html>
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- ❖ Available online: www.nbcnews.com
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- ❖ Available online: www.icefalladventures.com
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Figure 7 (A) Miracles; (B) smiles; (C) Chet and Binod with Spine Health International (SHI) Banner; (D) Ram guides cameraman Bill Angelucci of NBC News (USA).

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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