Health and Disaster Risk Management in India

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Abstract

India has been rapidly urbanizing. Its state of health, well-being, and infrastructure capacity are in a period of transformation. Through the perspective of a rapidly urbanizing nation, this paper presents an overview of India's health capacity in managing disaster risks. It looks at demographic, epidemiological and developmental transitions in India and how that impacts decision making for the health sector. It studies relevant experiences and the current status of healthcare provisioning to identify issues aiding and ailing the achievement of health outcomes in times of disasters and otherwise.

Keywords: disaster resilience, public heath, disaster risk reduction, hospital safety, developmental risk.

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1. Introduction

Health is an essential indicator of a country's development. The level of development is an indicator for the impact of any disaster on health. Robust health infrastructure is crucial for effective response and long-term recovery benefits. This is especially important for a disaster-prone, resource-stretched and high- density country like India which sees recurrent small and medium disasters. These factors impact both health infrastructure and health outcomes. Firstly, India has suffered expensive economic consequences on health infrastructure due to disasters. Health infrastructure damage and reconstruction costs post the Indian Ocean Tsunami (2004) amounted to USD 30 million (Carballo et al., 2005). The 2001 Bhuj earthquake collapsed a 281-bed civil hospital leading to 172 deaths (Hengesh et al., 2002). Large scale failure of health systems is also known to result in a negative impact on a region's economy (ADB, 2005). The government bears much of these costs of damaged health infrastructure and poor health consequences. Hence, it is imperative that health infrastructure is planned to respond well to disaster cycles. Secondly, before the discussion on health infrastructure, it is important to take stock of developmental risk factors that impact general health outcomes and well-being.

This century has seen a remarkable transformation in the development landscape of India. Over the last 35 years, India has achieved an average Gross Domestic Product (GDP) growth of 6.3% per year; this is doubling every 11 years. While on one hand, the economic prosperity of the country improves income, education and the ability to purchase healthcare; development resulting from rapid growth has the potential to increase health risks from disasters. For instance, massive rural to urban migration is expected to add 300 million new urban residents in India by 2050. Accommodating this population influx to will accumulate risk in the form of unregulated growth, lack of mindful planning, environmental degradation, inefficient services such as sewage and waste disposal systems, high rate of infectious diseases and pollution. These risks ail the general well-being of the environment which indirectly hampers health outcomes. There is a need for mindful development that minimizes risk and improves the overall response capacity of the region.

2. India's burden of disease

2.1 Traditional burden

India is home to one-sixth of the world's population but shoulders a substantial 21% of the world's burden of disease (WHO, 2012). As a traditionally low income, developing country, India's health risks were a function of its poverty, illiteracy and poor public health services. Conditions included water-borne and vector-borne infections such as tuberculosis, cholera, leprosy, dengue, *chikungunya* in addition to acquired immunodeficiency syndrome and sexually transmitted diseases. These conditions along with child health, malnutrition, infant mortality, maternal mortality and gender equity issues continue to be persistent concerns. As a result, health priorities have focused on the provision of curative healthcare and institutional delivery. Since the early nineties,

substantial measures to address communicable diseases and nutrition have produced better outcomes. However, there is a long road ahead before India catches up with global baseline indicators for average performance in health-related outcomes.

2.2 Emerging burden

India's emergence of *first-order* health problems is an outcome of its burgeoning anthropogenic and climatological risks. As a fast growing economy, India is seeing a spike in chronic diseases. These include cardiovascular diseases, respiratory diseases, metabolic diseases, cancer, and mental illnesses. Non-communicable diseases (NCDs) accounted for 60% of total deaths in 2015 indicating a protracted epidemiological transition in India (WHO, 2015). These are substantially adding to India's burden of disease. The following issues highlight the impacts on health caused by this process of rapid development:

2.2.1 Air pollution

In 2015, air pollution became the most significant risk factor for health in India causing more death and disability than dietary risks or child and maternal malnutrition put together. Fourteen Indian cities featured in World Health Organization's (WHO) list of the 20 most polluted cities in the world by particulate matter concentration. This was also the year when India overtook China as the leader of deaths due to air pollution.[1]

2.2.2 Sanitation

In India, around 40 million people are affected by water-borne diseases annually leading to a loss of 73 million workdays (Bush et al., 2011). Open defecation and poor sanitation practices is a prevalent problem. The "Swachh Bharat Abhiyan" (Clean India Mission) is a national programme launched in 2014 in support of Sustainable Development Goal no. 06 to "Ensure availability and sustainable management of water and sanitation for all".[2] The campaign is taking actions to promote environmental cleanliness and end open defecation through the construction of toilets by 2020. In 2016, the Union Budget allocated USD 1.3 billion towards the mission (GoI, 2016). However, sanitation and cleanliness are more significant problems in behavioral change in government parlance. Media is playing an essential role in improving citizen ownership and sense of engagement.

2.2.3 Vector-borne diseases

As a predominantly tropical landscape with heavy rainfall and inefficient water management systems; the occurrences of rodent and vector-borne diseases see a

[1] Data summarized from WHO Global Ambient Air Quality Database (updated 2018): http://www.who.int/airpollution/data/cities/en/
[2] Clean India Mission: http://swachhbharatmission.gov.in

seasonal aggravation. Outbreaks of malaria, Japanese encephalitis (JE), dengue, leptospirosis, and diarrheal diseases significantly increase patient load in healthcare facilities (Ahern et al., 2005). These conditions are also common in the aftermath of hydrological disasters. WHO estimated the disability-adjusted life years lost because of vector-borne diseases in India to be 4.2 million, and malaria is believed to be responsible for nearly half of the cases (Kumar et al., 2007).

2.2.4 Urbanization

The *Smart Cities Mission* is a flagship urban renewal and retrofit programme of the Government of India. It proposes to develop 100 cities across India as models for guiding future urbanization.[3] The objective of this mission includes provisioning of core infrastructure; and improving quality of life through accessible services including health. A spatial analysis of 90 proposed smart cities illustrates that 76% of these cities lie in zones that are at medium to high risk of floods, earthquakes, and winds or all three (*see Annexure 3*). Any new development in these cities is an opportunity to mainstream disaster risk resilience to minimize the creation of new risks. However, as a scheme that is meant to be "*open to the interpretation of city authorities*"; disaster resilience does not figure as a prominent development priority.

2.2.5 Infrastructure development

In India, responsibility for provisioning infrastructure services for health, water, sanitation, sewage, and power is assigned to different levels of authorities at the national, state (provincial), district and local levels (municipal, *panchayat*). [4] At the lowest level, municipal authorities have the power to make service provisions within their "*legally notified boundaries*". Massive rural to urban population flow in India is creating regions known as "*census towns*".[5] These are places satisfy the legal criteria of a town but are not notified as statutory towns. This means that these are neither regulated by municipal bye laws nor can the local authority make development decisions. A paper on "*Regulating Infrastructure Development for India*" brings forth this lack of a comprehensive power devolution as reasons for poor planning and regulation of services (Sapatnekar et al., 2018). This has direct consequences on the quality of the environment, health and coping capacities for disasters. As of 2011, census towns constituted as much as 49% of emerging urban towns in India.[6]

3. India's health and hazard landscape

More than half of India's landmass is vulnerable to more than one hazard of high intensity. In the period between 1970-2015, India witnessed 614 recorded disasters such as floods, earthquakes, extreme temperature, drought, landslides, and storms leading to

[3] Smart cities India: http://smartcities.gov.in/content/
[4] Village council
[5] *Places with a minimum population of 5000 and a density of at least 400 per square km, and at least 75% of the male working population engaged in non-agricultural pursuits.*
[6] Census India 2011: http://censusindia.gov.in/2011-Common/CensusData2011.html

more than 198,000 deaths; affecting more than 2 billion people; and causing losses of USD 93 billion (Louvain (UCL)-CRED, 2015).

While India has consistently ranked high on the list of fatalities due to natural disasters, the economic losses to infrastructure are seeing a steep rise *(Table 1)*. The last decade has highlighted the frailty of health systems in India. Floods in the state of Kerala (2018) damaged a 125-year old hospital that served 350,000 people.[7] This was similar to the Chennai floods of 2015 where 18 patients died due to a power failure or the high risk of infections during annual urban flooding in Mumbai (Barnagarwala, 2017). A notably tragic example of disaster impact to a health facility was the collapse of the 281 bed civil hospital during the Gujarat earthquake (2001) that killed 172 people. This incident led to the adoption of the base isolation technology for earthquake resistance of buildings. This was later included in the revision of the Indian Seismic code IS 1893: 2002 for Criteria for Earthquake Resistant Design of Structures (Indian Standards, 2002). An overview of seismic vulnerability of 1.6 lakh public health facilities across India indicates that more than 54% fall in moderate to very high-risk zones *(see Annexure 1).*

3.1 Existing literature

Public health emergencies and disasters is a sparsely researched subject in India. The majority of publicly available reports look at individual health conditions, impacts from specific disaster events or on evaluating existing policies. Evolution of this research is in relation to India's evolving policy discourse on disasters which developed further with the occurrence of major disasters (*See Annexure 2*) The Odisha Super Cyclone (1999), the Gujarat earthquake (2004) and the Indian Ocean Tsunami (2004) are the most researched subjects for their impact on health. Before the Super Cyclone, there are studies on impacts of vector-borne diseases such as leptospirosis (WHO, 2000), cholera outbreaks (Sur et al., 2000) and a study on psychiatric disorders in survivors of the 1993 Latur earthquake that killed over 10,000 people (*graded VIII on the Mercalli intensity scale*) (Sharan et al., 1996).

After 2000, India's ongoing epidemiological transition from communicable to non-communicable diseases saw studies emerge on the threat of chronic diseases, cardiovascular diseases (Shah and Mathur, 2010, Rastogi et al., 2004, diabetes, cancers, hypertension (Reddy et al., 2005, Ghaffar et al. 2004, Patel et al., 2011, Misra et al., 2011) and an overview of mental health priorities, also reflecting on impacts from disasters (Khandelwal et al., 2004). A relevant study on health systems was on the epidemic preparedness in public health that looked at environmental forecasting and disease surveillance methods to promote epidemic prevention control (Myers et al., 2000). The Odisha super cyclone, which impacted more than 10,000 people, triggered several studies on mental health vulnerability (Kar et al., 2004) and post-traumatic stress disorder (Sharan et al., 1996, Kar et al., 2007).

Studies on outbreaks of vector and water-borne diseases saw sustained interest

[7] http://www.gkexperts.in/125-year-old-hospital-among-the-best-in-country-ruined-in-kerala-floods/

with a focus on single conditions that typically result from flooding such as leptospirosis (Rao et al., 2003, Vijayachari et al., 2008, Sehgal et al., 2002), diarrhea (Mondal et. al., 2001), chikungunya (Mavalankar et al., 2007) and general challenges of managing infectious diseases (John et al., 2011). (Jha, R. et al., 2016) studied evolution of disaster policies in India that brought about the massive reduction of mortality during a disaster through better early warning and evacuation systems.[8] The 2001 Gujarat earthquake that killed around 18,000 and injured over 150,000 led to focused research on health sector development for disaster preparedness (Bremer, 2003) and the importance of community medical response to reduce casualties (Roy et al., 2002).

Table 1: Major disaster events in India

Year	Type	Name	Deaths	Affected	Damages (USD '000)
1971	Storm	E: Odisha, Andhra Pradesh	9658	6900000	30000
1972	Drought	N,W: Rajasthan, Himachal and Uttar Pradesh	n.a.	200000000	100000
1977	Tropical cyclone	S: Andhra Pradesh cyclone	14204	14469800	498535
1978	Flood	E: West Bengal floods	3800	32000000	165000
1987	Drought	North, West and Eastern India	300	300000000	not available
1993	Earthquake	W: Latur earthquake	9748	30000	280000
1999	Tropical cyclone	E: Super Cyclone	9843	12628312	2500000
2001	Earthquake	W: Gujarat earthquake	20005	6321812	2623000
2002	Drought	All India	n.a.	300000000	910722
2004	Earthquake	S: Indian Ocean Tsunami	16389	654512	1022800
2013	Riverine Flood	North India floods	6054	504473	1100000
2013	Tropical cyclone	E: Cyclone Phailin	47	13230000	633471

Source: EM-DAT Disaster Database
Notes: North; S: South; E: West; E: East

3.2 The state of health system during a disaster: The case of the Gujarat earthquake 2001

The vulnerability of the population and deficiencies in the existing health system aggravates the pressure on healthcare facilities during a disaster. An on ground situation

[8] Sustained efforts of the government in Odisha brought down the rate of mortality to 0.5% in Cyclone Phailin 2013 as compared to Super Cyclone in 1999.

study was conducted after the Gujarat earthquake (2001). It found that the military medical unit had to step in to respond to health emergencies. Initially equipped to treat 750 casualties, the units handled thousands of patients out of four tents. 11 surgical teams came in from across the country to perform 2002 major and 7524 minor operations. There was a shortage of critical surgical equipment, linen with the total absence of essential services such as water, fuel and power and bio-waste disposal (Bremer, 2003).

3.3 Climate Change and health

Climate change and its impact on health took a central position on the international agenda (Griggs and Noguer, 2002). Research emerged on the impact of temperature (Akhtar et al., 2007), rainfall (Ahern et al., 2005), tsunamis (Carballo et al., 2005), changing pattern of vector-borne diseases (Bhattacharya et al., 2006, Kumar et al., 2007) and extreme events on human health (Bush et al., 2011, Dhara et al., 2013). Recent climate emergencies in India included a heat wave in Orissa 2004, a cold wave in Uttaranchal and Uttar Pradesh 2004, a tsunami affecting Tamil Nadu, Andhra, Kerala, and the Andaman Nicobar Islands 2004, floods in Madhya Pradesh and Gujarat 2005, rains and floods in Maharashtra (2005), and a cyclone in Andhra Pradesh (WHO, 2005). The Indian Ocean Tsunami (2004) that killed 10,000 people in India and rendered several homeless brought forth further research on the economic impact on public health infrastructure due to disasters (ADB, 2005). The magnitude of human loss in both the tsunami and the earthquake brought further studies on mental health and psychosocial care for adults (Becker, 2007, Sharan et al., 1996) and women (Becker, 2009) survivors of the disaster.

Studies on strengthening emergency medical care and trauma care see limited research as they also do not have a central organization system (Razzak and Kellermann, 2002, Joshipura, 2008, Joshipura et al., 2003, Kobusingye et al., 2005, Pandian et al., 2006, Ramanujam and Aschkenasy, 2007). The importance of education on emergency medicine is elaborated in the INDO-US joint working paper on academic medicine (Das et al., 2008).

4. Role of Government

4.1 Public health system

As per the Constitution of India (GoI, 1956); public health, sanitation, hospitals, and dispensaries fall under the purview of the State. Larger welfare items such as medical education, family welfare, and quality control fall under the purview of both the Center and the State. As a federal system, India allocates decision making power to the Center and administrative units under it i.e. the States (provinces). The Ministry of Health and Family Welfare (MoHFW) is responsible for running programmes and establishing policies for health. The system of health service delivery is through a three-tier system based on the level of care and population it serves:

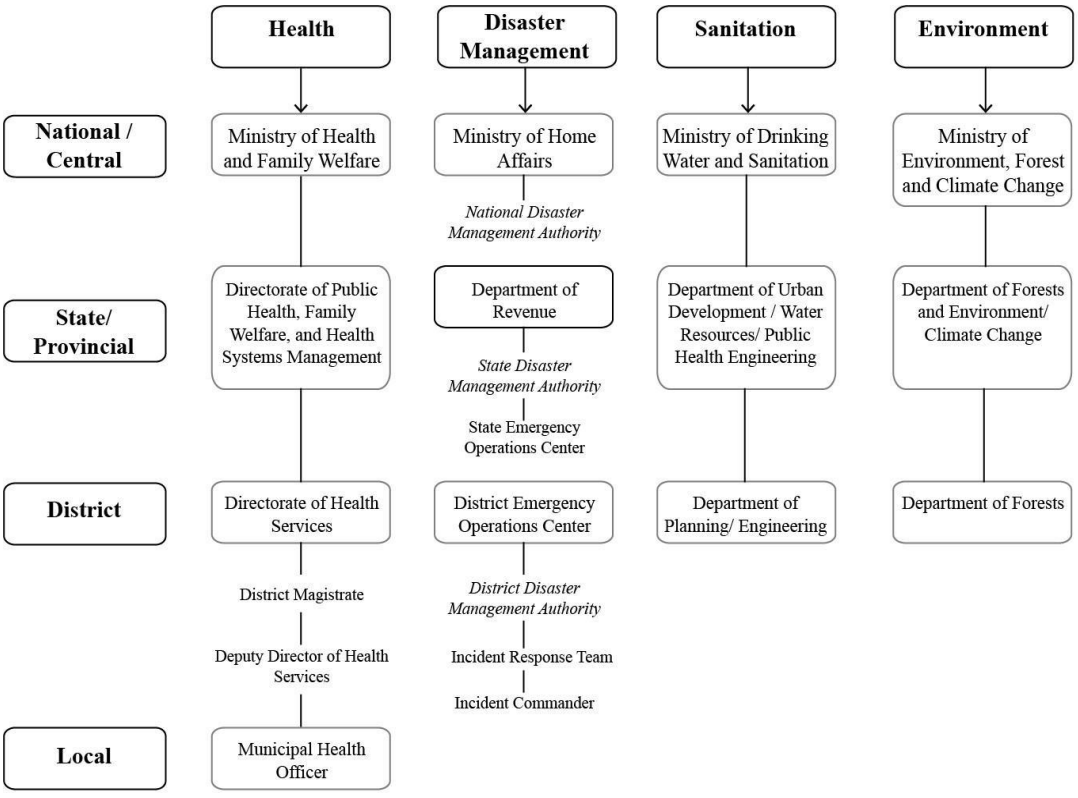
1. **Primary healthcare**: Sub-Centers (SC) and Primary Health Centers (PHC) for villages and tribal areas;

2. **Secondary healthcare**: District hospitals (DH) and Community Health Centers (CHC) at the block level; and
3. **Tertiary healthcare**: Advanced medical research institutions.

Management of health during disasters falls under the larger umbrella of public health. Since 1950 (post-independence), India has amalgamated delivery of public health and medical services *(fig 1).* A *Model Public Health Act* was developed (in 1955 and 1987) to promote preventive public healthcare ecosystem (monitoring, inspecting, regulating). However, it did not gain leverage for adoption by states. There were single focus health schemes for prevalent problems such as leprosy, tuberculosis, malaria and high maternal and child mortality (Lakshminarayanan, 2011). The focus on curative medical services reduced the emphasis on preventive public health measures.

Health has several social, economic and environmental determinants. However, there was separation of governance of key sectors such as public health, environment, water resources and sanitation. International donor agencies also focused on more measurable programmes such as vaccination, mortality and disease surveillance. This has increased the incentive to design narrow focus programmes whose outcomes can be more easily measured as opposed to broader programmes for mitigation and prevention that need longer time horizons (Das Gupta et al., 2009).

Figure 1: Public Health and Disaster Management in India



Source: Drawn by authors with data from Planning Commission and allied documents.

To take a comprehensive overview of health, the National Health Mission (NHM) was launched in 2013 to strengthen health systems and improve public health delivery across India.[9] NHM takes a macro view of areas affecting health such as water, sanitation, education, nutrition, social and gender equality and develops separate funding pools for each. NHM publishes the Indian Public Health Standards (IPHS) enumerating compliance requirements for public health facilities to build consistency in healthcare infrastructure planning and upgradation.[10] The guidelines require all facilities to be built to be resilient to flooding, earthquakes and emergencies aligned with the guidelines set out in the National Building Code *(Table 2).*

In order to improve service delivery, capacity building, assessment of expenditure framework and accountability, support is sought from multilateral development agencies. The Asian Development Bank supports the National Health Mission (Bank, 2018) whereas the World Bank has provided support to a range of health system strengthening projects in several states of India (Uttar Pradesh, Odisha, Uttarakhand, Karnataka, Nagaland).

Table 2: Hierarchy of public healthcare facilities in India and the population they serve

Health Institution	**Avg. population to be served**	**Beds**	**Avg. population being served**				
			Odisha	**Assam**	**UP**	**Bihar**	**Punjab**
District Hospital	35,000 to 30,000,000	101-500	1,446,461	1,246,771	1,513,730	2,731,701	1,458,118
Sub-divisional Hospital	500,000 600,000	31-100	1,613,360	2,833,570	19,981,234	3,460,155	791,550
Community Health Center	80,000 1,20,000	30	116,520	145,651	217,187	1,526,539	184,695
Primary Health Center	20,000 30,000	6	74,112	83,118	190,116	156,332	64,881
Sub-centers	3000 to 5000	2	28,096	36,370	76,999	56,786	9,388

Source: Indian Public Health Standards

4.1.1 Public Health in the state of Tamil Nadu

The state of Tamil Nadu (TN) has set an example of efficient management of public health systems. It has consistently produced better health outcomes with the same average per capita expenditure on health as India. Unlike other states, TN does not merge the delivery of public health and medical services; gaining from respective economies of

[9] National Health Mission: http://www.nhm.gov.in/
[10] Indian Public Health Standards: http://nhm.gov.in/nhm/nrhm/guidelines/ indian-public-health-standards.html

scope (M. D. Gupta et al., 2010). Since 1922, it has legislated for an independent Directorate of Public Health with an administrative authority board and budget (GoI, 1939). The Madras Public Health Act enables the state to adopt a macro view on public health and has mandated to address any situation that poses a "*credible health threat*". This includes maintenance of drains, solid waste management, poorly designed infrastructure, animals in unhealthy conditions, etc. The Directorate has a dedicated cadre of professionals who are trained in activities related to public health such as managerial executives, grass root health workers, entomologists, laboratory staff and laborers for sanitation activities. The Directorate works with larger budgets than medical services and medical education.

This method of governance allows the state to conduct annual "*anticipatory planning*" to prepare for recurring disasters such as floods, endemic diseases, and public health emergencies. Tamil Nadu's highly organized response to the Indian Ocean tsunami was a result of this well-oiled public health machinery.[11] Despite the magnitude of the disaster that killed around 18,000 people in India; no significant disease outbreaks were reported in India (Organization, 2013).

4.1.2 National Health Policy (NHP)

The National Health Policy (NHP) was an outcome of the *Alma-Ata Declaration* that guides approach for health in national plans. It aims at achieving universal health coverage and delivering affordable preventive, promotive and rehabilitative healthcare. NHP 2002 *(clause 5.2)* recognized the need for a robust disaster management plan to cope with calamities. However, NHP 2017 elaborated creation of a unified emergency response system and maintenance of excess capacities in health infrastructure to better respond to both man-made and natural disasters. It proposes that from the level of the Community Health Centers, all institutions must develop and maintain mass casualty management protocol. To better ensure effective emergency management, it upholds capacity building of local governments and the community as first responders. It envisages provision of a trauma management and life support ambulances for one per *3 million* people in urban areas and one per *1 million* people in rural areas (GoI, 2017).

4.2 Disaster Management

The governance response to manage natural disasters in India is the Disaster Management Act 2005 (DM Act). Until the early 2000s, the focus of India's disaster management policy was on relief and rescue operations (Jha, R. Basu, and A. Basu, 2016). The role of a healthcare institution in mitigating disaster impact did not receive a clear mandate (Das, 2005). The National Disaster Management Authority (NDMA) was formed in 2005 under the Ministry of Home Affairs (MHA) to manage economic, environmental and developmental issues relating to disasters. As a signatory to the Sendai Framework for Disaster Risk Reduction, India was one of the first countries to devise a National

[11] WHO South Asia tsunami situation reports: http://www.who.int/hac/crises/international/asia_tsunami/sitrep/en/

Disaster Management Plan (2005). It was drafted with an aim to achieve a substantial reduction of disaster risk and reduction of disruptions to critical services (GoI, 2005).

The years after 2005, the newly formed National Disaster Management Authority (NDMA) published several standards on specific hazards. This included guidelines for minimum standards of relief (NDMA, n.d.); management of earthquakes (NDMA, 2007b), tsunamis (NDMA, 2010b), floods (NDMA, 2008b), urban floods (NDMA, 2010c), cyclones (NDMA, 2008a), drought (NDMA, 2010a), landslides (NDMA, 2009a), nuclear emergency (NDMA, 2009b) and chemical disasters (NDMA, 2007a). These guidelines included a section on medical preparedness and mass casualty management in the case of each of these disasters. NDMA also published comprehensive guidelines on psycho-social health (NDMA, 2009c). In 2016, NDMA published guidelines for hospital safety (India, 2016).

4.2.1 Guidelines for Hospital Safety

The DM Act requires state governments to formulate State Disaster Management Plans (SDMPs) which detail how to prepare, mitigate, respond and recover from disasters. A component of these plans is medical preparedness and mass casualty management. It recommends that State may provide healthcare and services by following the standards laid down by the National Authority *(Part II, point 24(d)).* The Act prescribes every hospital to have an emergency plan that must be updated regularly with periodic checks and mock drills.

NDMA's hazard specific management guidelines provide details on appropriate medical preparedness and healthcare delivery system to deal with injuries, conditions, and diseases associated with that hazard. It further assigns responsibilities to departments in the state, district, state health departments, private hospitals, and urban local bodies to enable multi-agency collaboration.

The NDMA guideline for earthquakes recommends selective seismic strengthening and retrofitting of lifeline structures in earthquake-prone areas. These are applicable for hospitals and health facilities, tertiary care centers and all hospitals designated as major hospitals. It requires them to be updated on the India Disaster Resource Network (IDRN) database (NDMA, 2007b). The guidelines for urban flooding recommend involvement of the corporate sector to improve the delivery of relief measures (NDMA, 2010c). NDMA published its *"minimum standards of relief*" for persons affected by disasters including rehabilitation, shelter, food, health, water, sanitation, and vulnerable groups.

In 2016, NDMA laid down guidelines for *hospital safety* to mainstream disaster prevention, mitigation, preparedness and response activities into the health sector (NDMA, 2016). The document brings together from a spectrum of guidelines from national (National Building Code, Bureau of Indian Standards, Clinical Establishment Act, Indian Public Health Standards) and international (Pan American Health Organization, World Health Organization) sources. It empaneled domain experts to further improve upon these guidelines and provides frameworks for implementation. It elaborates in detail on the some of the following parameters for hospitals and disasters:

1. Awareness generation for hospital safety
2. Hospital disaster preparedness
3. Design and safety of hospital buildings
4. Fire safety
5. Licensing and accreditation

Table 3: Hierarchy of public healthcare (primary and secondary) in India

Priority Area	Action
Priority Area I	Strengthening institutional mechanisms
Priority Area II	Advocacy, awareness generation and education
Priority Area III	Capacity building
Priority Area IV	Preparedness, response and recovery
Priority Area V	Risk reduction and structural mitigation

Source: Indian Public Health Standards

Based on the learnings from the above components, the document lays down a *"National Action Framework for Hospital Safety"*. It highlights five priority areas for action along with highlighting gaps, recommending interventions, estimating a timeline and assigning work to requisite agencies *(Table 3).* However, in practice, it has been found that there is a gap in compliance to building codes, lack of planning and preparedness and variation in quality of medical facilities. There is no statutory provision to regulate and standardize disaster response plans for hospitals. Hence, hospitals do not maintain disaster management plans. In a survey, it was found that only 26% of trauma care health facilities had a well-documented disaster management plan (Joshipura, 2008, Mehta et al., 2006). In an onsite survey of primary health facilities in a flood-prone district, it was found that basic response utilities such a power backup, a line of standard operating procedures and equipment were missing. Monitoring these aspects of hospital management is the responsibility of States and administrative units under them (Phalkey et al., 2012).

4.2.2 Health in State Disaster Management Plans (SDMP)

Under the DM Act, each State is required to prepare a State Disaster Management Plan (SDMP) to carry forward national goals for disaster management. The SDMP is expected to cover the state's vulnerabilities, measures for the prevention and mitigation of disasters, capacity building and assignment of responsibilities to relevant departments in the event of a calamity. Hospitals are identified as critical/lifeline facilities. The SDMP document addresses all phases of a disaster (preparedness, mitigation, response). The level of detail of a State Disaster Management Plan did not seem proportional to the

disaster proneness of the state or the number of health facilities at risk (*see Annexure 1*). Plans were also out of date. Even though the law requires states to update their plans annually, only 8 states had updated their plans till 2016. Plans dedicate the majority of their sections to respond to a disaster, rather than prepare for one in their Standard Operating Procedures (SOPs) *(Table 4)*.

Table 4: Principal departments responsible for aspects related to health and disaster risk at the State level

Department	Responsibility
Health and Family Welfare	Healthcare infrastructure, response, contingency plans, preparedness and mitigation, vulnerability assessments, mass casualty plan, ambulance network, hospital networking, first aid, training and capacity building
Public Health Engineering Department	Drinking water supply & sanitation, extreme events, ground water resources
Revenue and Disaster Management	Buildings & lifeline infrastructure operations and construction compliance with Indian construction codes, training and capacity building
Urban Development and Urban Local Bodies	Development of built stock and provision of services such as drainage, sewage, drinking water, etc

Source: State disaster management plans

While plans alone will not determine the quality of response to a disaster, lack of a well-drafted plan will result in poorly implemented practices when both time and resources are limited. SDMPs lean heavily to the "response" phase of a disaster. Standard Operating Procedures (SOPs) for concerned departments also elaborates more steps for response and rehabilitation. In comparison with global frameworks indicators for the non-structural and functional resilience of health are poorly covered. A review of State Disaster Management Plans of 22 states in India presents the following findings:

Structural indicators are clearly communicated and find mention in 75% of the documents. E.g. the state of Himachal Pradesh mentions that 48% of its medical institutions are located in highly vulnerable districts and must comply with codes of the Bureau of Indian Standards (BIS). Punjab recommends assigning a quality auditor agency to monitor construction in seismic zones 3, 4 and 5 (medium to very high earthquake risk). The collapse of the civil hospital during the Bhuj earthquake triggered the last revision of the Indian Seismic Code for Earthquake Resistant Design of Structures (IS 1893: 2002). This has also improved the inclusion of structural indicators in most SDMPs as there is both legal mandates and evolved guidelines for facilities to follow.

Non-structural indicators are the least addressed in all documents. Less than 50% refer to even one of the indicators from the WHO Safe Hospitals indicators. Points on the safety of medical equipment, furniture, backup supplies are mentioned as part of larger checklists for response but do not provide action points. Independent agencies in India lay down plans focusing of strengthening non-structural utilities (GeoHazard, 2009). The NDMA guidelines on Hospital Safety elaborate on this. As a relatively recent document, it

has not seen adoption in state plans yet. However, the SDMPs do not refer to any other universal guidelines that hospitals may follow for safety of non-structural aspects.

Functional indicators find a mention in 75% of the documents. All states recommend the preparation of a medical preparedness plan, mass casualty management plan and checklists to train health workers for emergencies. A fundamental requirement to enable functional continuity of hospitals during emergencies is a list of all available health facilities and supporting services (such as power station, police station, ambulances). A mere 50% of documents provide any information on health facilities in the state. Assam and Odisha provide details on the population being served. Odisha also highlights provisioning of a dedicated high tension power line to the district headquarter hospitals for uninterrupted communication with the health control room.

Functional indicators for post-disaster psycho-social support and mental health are missing across documents, except Meghalaya. At least one- third of the survivors of the super-cyclone in the state of Odisha suffered disabling psychiatric symptoms (Kar et al., 2007). NDMA has recognized this issue as "*a continuum of the interventions in disaster situations*" and laid down guidelines on Psycho-social Support and Mental Health Services (PSSMHS) in Disasters (2009).

Other indicators such as mobile hospitals, media management, district level data, and Standard Operating Procedures are well addressed. 16 of the 22 states mention utilizing the India Disaster Resource Network (IDRN). It is an online portal that includes data of health professionals and medical equipment to accelerate decision making during a disaster. Assam and Gujarat have established a functional State Disaster Resource Network (SDRN).

5. Elements of health and disaster risk management in India

5.1 Resource management

Health response during and after a disaster may be hampered by the shortage of or unavailability of human resources and equipment. To maintain a centralized resource inventory for disaster response, Government of India in collaboration with the United Nations Development Program (Disaster Risk Management) launched the India Disaster Resource Network (IDRN) *(Table 5)*.[12]

IDRN is a web-based inventory that captures and collates data systematically regarding resources available at the level of the line departments in a district (local administrative unit). The website hosts a country-wide query system where one can look for availability of medical equipment, skilled health workers and critical health-related supplies at the level of the district. The portal is monitored by the National Institute of Disaster Management (NIDM) and offers authorized access to officers of the government including emergency officers, relief managers, district collectors/magistrates, and other

[12] India Disaster Resource Network: www.idrn.gov.in

officers to upload and access data.

Currently, the IDRN offers information for more than 75% of districts in India. To enable contribution of equipment from the private sector, the portal hosts a module where the Confederation of Indian Industry (CII)[13] and Builders Association of India (BAI)[14] can upload resource details to the database. Selected states are pioneering the use of this online inventory format with improved databases of resource inventories that are compatible with the national interface. The state of Gujarat that has taken the lead with a State Disaster Resource Network which has information for resources in 97% of its villages (GSDMA, 2003). However, the quality and comprehensiveness of data are in a process of continual improvement.[15]

Table 5: India Disaster Resource Network (IDRN)

Resource type	Items
Skilled human resources	Anesthetist, general physician, gynecologist, lab technicians, medical first responders, OT assistants, firefighting team, paramedics, radiologists, surgeons and trauma specialists
Equipment type	Air compressor, Aluminum ladder, Aspects blanket, Breathing apparatus, CT scan, Defibrillator, Detection kit: for poison in water, First Aid Kits, Rubber gloves, Light ambulance van, Medium ambulance van, Mechanical ventilators, Mobile blood bank, Mobile lab service, Mobile medical van, Mobile OT Unit, MRI, Face mask, Portable alpha monitor, Portable ECG, Portable decontamination apparatus, Portable oxygen cylinders, Portable suction unit, Portable ultra-sound, Portable ventilators, Portable x-rays
Critical supplies	Anti-snake venom, Bronchodilators, Chlorine tablets, Decontamination solution, Vaccines, Iodate tablets

Source: IDRN website

5.2 Disease and epidemic surveillance

Lack of robust surveillance systems, low immunization coverage, and poor sanitation systems has led to an inefficient disease control system in India. Seasonally high incidences of vector-borne diseases, water-borne diseases, and endemic diseases are frequent. After the Bhuj earthquake (2001), WHO set up an onsite surveillance system with 620 reporting sites (Bremer, 2003). To detect and monitor disease outbreaks systematically, the Ministry of Health and Family Welfare with the support of the World Bank set up the Integrated Disease Surveillance Program (IDSP)[16] in 2004. The IDSP was

[13] Confederation of Indian Industry : https://www.cii.in/
[14] Builders Association of India : https://www.baionline.in/
[15] Gujarat SDRN: http://117.239.205.164/sdrnguj/
[16] Integrated Disease Surveillance Programme: http://www.idsp.nic.in

preceded by the National Surveillance Programme for Communicable Diseases (NSPCD) which was set up in 1997 (*See Annexure 2 and Table 6)*.

Table 6: Integrated Disease Surveillance Program (IDSP): List of diseases under regular surveillance

Disease type	Disease name
Vector-borne	Malaria, Dengue, Japanese Encephalitis (JE), Chikungunya, etc
Water-borne	Acute Diarrheal Disease (Cholera),Typhoid, Gastroenteritis, Hepatitis
Respiratory	Tuberculosis
Vaccine preventable	Measles
Under eradication	Polio
International commitments	Plague, Yellow fever
Unusual clinical syndromes	Meningo-encephalitis, respiratory distress, hemorrhagic fevers, other undiagnosed conditions
Sexually transmitted diseases (under sentinel surveillance)	Blood-borne, HIV/HBV, HCV
Non-communicable diseases	Cardiovascular, Diabetes, strokes, fluorosis, etc
Others	Water Quality, Outdoor Air Quality, Road Traffic Accidents

Source: IDSP website

IDSP monitors trends in occurrences of communicable and non-communicable diseases across the country. Its plan includes integrating existing surveillance systems, strengthening of public health laboratories, training and deploying of Rapid Response Teams (RRT) for timely action during possible epidemic situations. For e.g. after the Indian Ocean Tsunami (2004), a one-page surveillance instrument was developed to monitor 10 priority health conditions among the displaced population (Nsubuga et al., 2006). A decentralized model is adopted where data collection, capture and analysis are conducted at the local administrative units which then flows upwards to the national level. This is done in weekly intervals in three formats *(suspected, presumptive, laboratory-confirmed*). In order to facilitate faster reporting and put out early warning signals for outbreaks, a satellite-based communication and learning network: Education Satellite (EduSat) was established by the National Centre for Disease Control (NCDC) and Indian Space Research Organisation (ISRO). It connects communication terminals at National, State Headquarters, District Surveillance Units and Government Medical Colleges (Raut and Bhola, 2014).

IDSP is vital to evaluate the performance of public health interventions and resource allocations. Since the programme depends on local level data collection, it is only as effective as the quality of local capacity to report and maintain records. The government needs to further invest in rigorous technical capacity building to improve the quality of surveillance. Selected states are pioneering the use of technology to track specific health conditions for better response (Dasgupta et al., 2016). Karnataka has

developed a digital database of spatial and temporal distribution of mortality and morbidity of vector-borne diseases.[17] Punjab has created a portal for online reporting of climate-related cases of illness.[18]

5.3 Mobile medical units and sanitation

A critical health component of disaster management is containment of epidemics. This requires a system that provides clean water, sanitation (in-situ, ex-situ) and promotes good hygiene. NDMA presents *"Guidelines on Minimum Standards of Relief"* covering fundamental service requirements at relief and rehabilitation camps such as temporary shelter, food, water, sanitation, medical cover and needs of vulnerable groups (NDMA, n.d.). The Ministry of Health and Family Welfare recently released Operational Guidelines for Mobile Medical Units that outlines the nature of service, quality, monitoring, and financing mechanism essential for such a fleet (GoI, 2018). In 2011, the Ministry of Rural Development released the standard operating procedure (SOP) for drinking water supply and sanitation services during natural hazards (GoI, 2011). The Bureau of Indian Standards offers guidelines for construction of some commonly use sanitation apparatus during disasters such as Leaching Pits for Rural Communities (IS: 12314) and Installation of Septic Tanks (IS: 2470) (BIS, 1993, BIS, 2007).

5.4 Trauma care

Post-disaster, a system must be able to provide emergency care for physical trauma (falls, injuries, burns) and maintain referral networks of facilities to cater to various emergencies. In India, a trauma-related death occurs every 1.9 minutes, mainly due to traffic accidents (Madan, 2006) which are estimated to cause economic losses of up to 3% of GDP (Joshipura et al., 2003). Hence, work on trauma care leans heavily towards road traffic accidents. Trauma care is provided as part of casualty and emergency departments of hospitals. However, existing trauma care facilities or their professionals have no standard process of accreditation and training leading to disparity in levels of treatment. The National Health Policy (2002) envisaged the establishment of a "hub-spoke" trauma care network in large urban areas to reduce mortality (GoI, 2002). This was followed by a national program on *Capacity building for developing Trauma Care Facilities in Government Hospitals on National Highways*.

To offer skilled human resources for disaster medicine, the Medical Council of India offers 37 seats in various colleges for a postgraduate degree in Accident and Emergency Medicine (as of July 2014).[19] A "National Trauma Management Course" accredited by the International Association of Trauma Surgery and Intensive Care (IATSIC) is available in larger cities (Joshipura, 2008).

[17] State of Karnataka: http://nvbdcp.gov.in/index4.php?lang=1&level=0&linkid=506&lid=3783
[18] State of Punjab: https://www.punjabnvbdcp.in/denguelogin.php
[19] Emergency Medicine India: http://www.emergencymedicine.in/current/articles.php?article_id=56

5.4.1 Training on trauma life support

In 2012 NDMA, in collaboration with the Apex Trauma Center at the All India Institute of Medical Sciences (AIIMS) conducted the Pilot Project on Capacity Building for Advanced Trauma Life Support in India (NDMA, 2013). This was a capacity building project for selected doctors, nurses, and paramedics on various protocols and guidelines of trauma care followed internationally. Assam, Bihar and Andhra Pradesh were the chosen states. The training included:

1. Advanced Trauma Life Support (ATLS)
2. Advanced Trauma Care for Nurses (ATCN)
3. Pre-Hospital Trauma Life Support (PHTLS)
4. Rural Trauma Team Development Course (RTTDC)

The trained professionals are required to disseminate this knowledge in their respective states. Around 129 doctors and 50 nurses completed the various courses. Training included procedures for various kinds of trauma (head, musculoskeletal, spinal cord, burns and cold) and various age groups (pediatrics, elderly, women).

5.4.2 Emergency Medical Service (EMS)

Improving health service delivery during disasters requires a responsive and time-sensitive Emergency Medical Service (EMS). This includes transporting patients, offering Basic Life Support (BLS) and Advanced Life Support (ALS) before actual care may begin. India does not have a centralized body to manage operations of Emergency Medical Services.

Currently, EMS systems are a consolidation of initiatives by different states with different models of delivery with wide variability in dispatch and transport capabilities. It was reported in 2006 that only 12% of stroke patients used ambulances to reach a hospital in an urban city (Pandian et al., 2006). The existing national scheme (*toll-free number: 108*) is monitored by the Emergency Management and Research Institute (EMRI).[20] EMRI works on a public-private partnership model and operates more than 2600 ambulances. Individual states have modified versions of this system to offer transport, pre-hospital stabilization services, referral facilities for healthcare professionals or all of the above. (Sharma, Brandler, 2014).

Emergency Medicine was recognized as a specialized training by the Medical Council of India in 2009. Formal training in emergency medicine is provided in collaboration with international organizations such as RCGP UK (Royal College of General Practitioners, UK), CEM UK (College of Emergency Medicine, UK) and GWU USA (George Washington University, USA) (Subhan and Jain, 2010).

[20] Emergency Management and Research Institute: http://www.emri.in/ideology/

5.4.3 Mental health and psychosocial support

Good mental health is an essential aspect of the rebuilding process for a population that has experienced events beyond its coping capacity (Becker, 2007). Health facilities are responsible for managing both short term and long term emotional consequences of disasters. At least one-third of the survivors of the super-cyclone in the state of Odisha suffered disabling psychiatric symptoms (Murthy et al., 2003).

India's mental health response during disasters has evolved from identifying and treating individual psychiatric cases to strengthening the coping abilities of survivors in a community (Kishore Kumar et al., 2000). The National Mental Health Programme (NMHP) includes strategies for Psychosocial Care and Mental Health Services in disasters (PSMHS). NDMA has laid down guidelines to improve coping capacities of disaster struck communities by offering appropriate support to rebuild their lives. The service networks consists of psychiatric units of tertiary healthcare facilities, and educational institutions, clinical psychologists, social workers, NGOs, paramedical professionals, community level workers, and volunteers. It encompasses an *"all hazard"* health plan for response, relief and rehabilitation aspects of different kinds of disasters (NDMA, 2009c).

5.4.4 Heat stress

Temperature trends have been rising steadily in the last 15 years, 2016 was India's hottest year on record (Bush et al., 2011). To better enforce healthcare systems during heat waves, the Ahmedabad Heat Action Plan was formulated in 2017. As a first of its kind in the South Asian region; one of its chief pillars is dedicated to capacity building among health professionals and training of medical staff to manage heat-related illness (GoI, 2017). There are plans to scale this up to other Indian cities (Knowlton et al., 2014).

5.4.5 Social resilience

Grass root and community level initiatives actively support health provisions during disasters. In the flood-prone state of West Bengal, flood micro plans have been made at the district level with information on alternate health service points in case of flooding. Urban governing bodies have designed response mechanisms to reduce the risk of outbreaks after flooding. Post the Mumbai floods of 2005, the municipal corporation provided comprehensive healthcare services through 130 specially constituted medical teams. Over 300000 patients were treated virtually at their doorstep through outreach camps (Dasgupta, et al., 2016, K. Gupta, 2007).

6. Way forward

Despite its large population, India has demonstrated its potential for efficient delivery and campaigning for public health services through various schemes. However, maintaining service quality over extended periods of time has been a continuing issue. The diversified institutional landscape has proven to be both an opportunity for

innovation at the local level and a challenge for implementing frameworks at the central levels. Evaluation of the effectiveness of central health schemes and their impact on health infrastructure, health outcomes and emergency services needs sustained investigation. This would set the space for broader environmental and societal goals that improve systemic coping capacity in the event of a disaster. The above overview of the health and disaster risk management of India throws up some critical challenges that need to be addressed immediately:

- **Information infrastructure**: Good decision making may be correlated with better data and analysis. Better and organized registries for infectious diseases, trauma care and geospatial database on hospitals need to be comprehensively updated and maintained.

- **Capacity building**: The shortage in capacities of healthcare facilities and expertise in specialized areas such as trauma care, mental health, immunization, and emergency medicine needs to be better integrated.

- **Risk assessment**: Better resource management during an emergency, such as the golden hour, requires systematic documentation and assessment of the situation. Combining data assessment, surveillance and monitoring across all states is essential for evidence-based decisions and reducing biases in the allocation of resources.

- **Climate variability**: Moving from a post-disaster reactive to an integrated approach will involve adopting an "all-hazard "approach that applies to health facilities in a specific region. Changes in weather variables are known to affect incidents of seasonal, climate-sensitive vector-borne and water-borne diseases, such as malaria and diarrheal illness (Dasgupta, et al., 2016). Hence, ensuring resilience will require systematic mapping of variability in climate to analyze its impact on health.

Building resilience of health for disasters is a subset of the general well-being of the health system. This is an especially enormous challenge when a country is still working its way to navigate deficiencies in the system and achieve baseline indicators for health. Concentrated and sustained efforts and investments in the medical community, health infrastructure innovation and the society at large will be critical to building robust health systems responsive to disasters.

Annexure 1: Seismic vulnerability of public health facilities

A study was conducted to analyze seismic vulnerability of public health facilities in India. Data on geo-locations of 160,000 public health facilities including primary, secondary and tertiary care facilities was analyzed for which seismic zone they fall in. 54.25% of facilities fall in medium to very high risk earthquake zones. A state wise scheme of number of health facilities in each zone if presented in the table below:

Table 7: Seismic vulnerability of public health facilities in India

State	Predominant seismic zone	Zone 3	Zone 4	Zone 5	Total
A&N Islands	5	0	0	31	31
Andhra Pradesh	3	775	0	0	775
Andhra Pradesh Old	3	579	0	0	579
Arunachal Pradesh	5	0	0	160	160
Assam	5	0	0	884	884
Chandigarh	4	0	46	0	46
Chhattisgarh	3	159	46	0	159
Dadra & Nagar Haveli	3	13	0	0	13
Daman & Diu	3	7	0	0	7
Delhi	4	0	601	0	601
Goa	3	39	0	0	39
Gujarat	3/4	1697	141	78	1916
Haryana	3/4	223	360	0	583
Himachal Pradesh	4/5	0	317	314	631
Jammu & Kashmir	4/5	2	506	291	799
Jharkhand	3	315	34	0	349
Karnataka	3	366	0	0	366
Kerala	3	1265	0	0	1265
Lakshadweep	3	9	0	0	9
Madhya Pradesh	3	608	0	0	608
Maharashtra	3	1893	169	0	2062
Manipur	5	0	0	114	114
Meghalaya	5	0	0	176	176
Mizoram	5	0	0	83	83
Nagaland	5	0	0	153	153
Odisha	3	456	0	0	456
Puducherry	3	4	0	0	4
Punjab	3/4	279	429	5	713
Rajasthan	3	439	167	1	607
Sikkim	5	0	0	32	32
Tamil Nadu	3	887	0	0	887
Telangana	3	175	0	0	175
Tripura	5	0	0	70	70
Uttarakhand	4	1	273	51	325
West Bengal	3	914	295	27	1236
Total	-	11105	3338	2470	16913
Percentage of total number of hospitals	-	**35.62 %**	**10.71 %**	**7.92%**	-

Source: Health data from www.data.gov.in and seismic zones from National Disaster Management Authority.

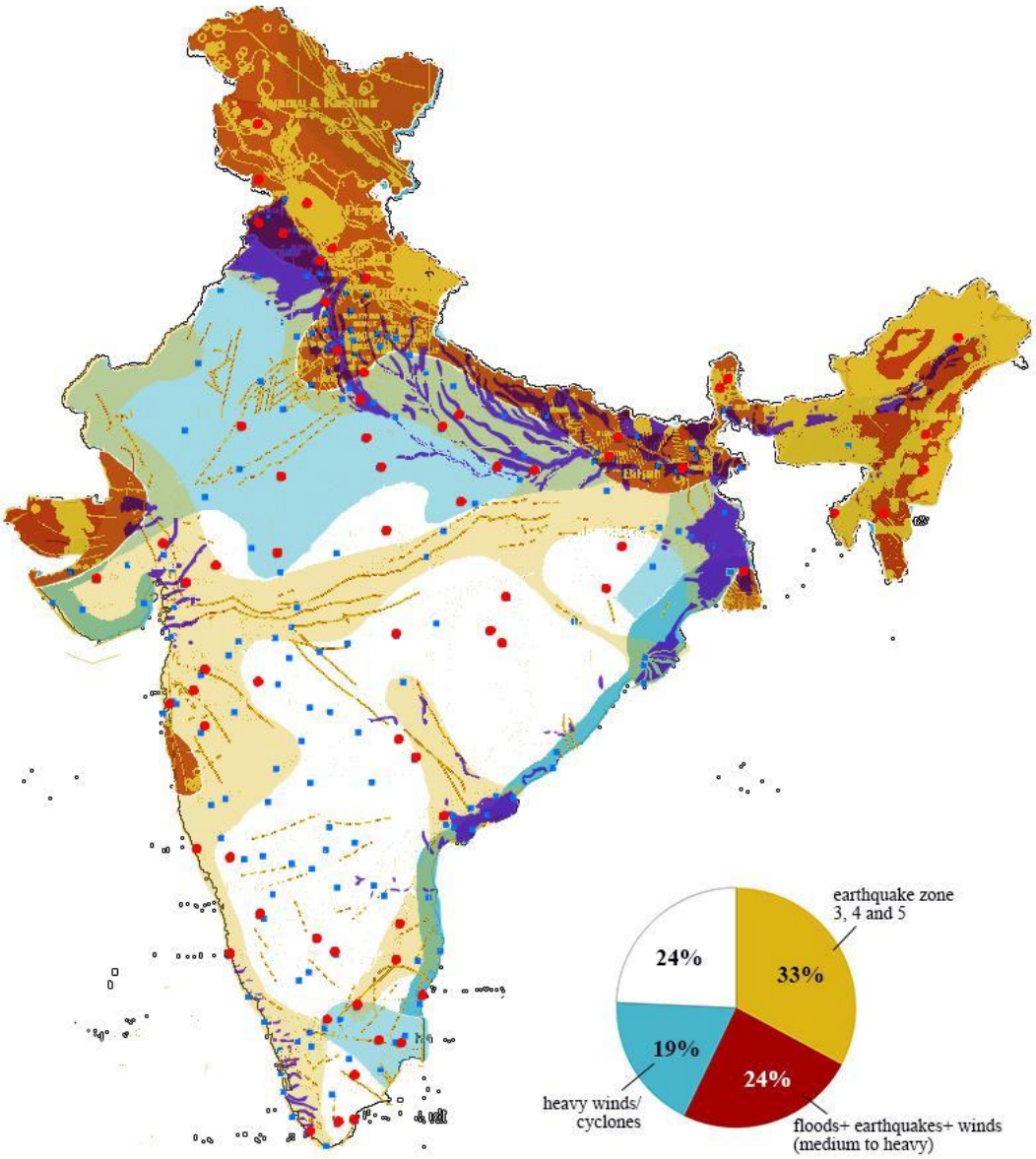
Annexure 2: Relevant programmes and policies in health and disaster risk management in India

Table 8: Chronology of relevant programmes and policies in health and disaster risk management in India.

Year	Institution/ Policy/ Programme
1911	Indian Council of Medical Research [1949 (renamed to ICMR)]
1933	Medical Council of India
1966	Indian Standard Code for criteria for earthquake resistant design of structures; 1st revision
1976	Ministry of Health and Family Welfare
1983	National Health Policy
1987	Modern public health act
1995	National Institute of Disaster Management (training and capacity development programs)
1997	Integrated Disease Surveillance Programme (pilot)
1998	National Surveillance Programme for Communicable Diseases
2002	Indian Standard Code for criteria for earthquake resistant design of structures; 5th revision
2003	National Vector-Borne Diseases Control Programme
2004	Integrated Disease Surveillance Programme
2005	Disaster Management Act
2005	National Disaster Management Authority (NDMA) established
2005	National Rural Health Mission
2007	Indian Public Health Standards (IPHS) for public healthcare infrastructure planning and upgradation.
2007	Department of Health Research under the Ministry of Health & Family Welfare
2007	NDMA guidelines on Medical Preparedness and Mass Casualty Management; Preparation of state disaster management plans; Earthquakes
2008	NDMA guidelines for Cyclones and Floods
2009	National Health Bill
2009	National Disaster Management Policy
2009	NDMA guidelines for Floods; Landslides and snow avalanches; Nuclear and Radio- logical Emergencies; Psycho-social support and mental health services
2010	NDMA guidelines on Management of urban flooding; Tsunamis; Drought; Management of dead in the aftermath of disaster; incident response system
2012	NIDM / UNDP report on mainstreaming disaster risk reduction into health
2013	Mental Healthcare Bill
2013	Pilot project on capacity building for advanced trauma life support in India
2015	National Health Mission
2016	NDMA guidelines for Hospital Safety
2017	National Health Policy
2017	Draft Public Health Bill (Prevention, Control and Management of epidemics, bio- terrorism and disasters)

Annexure 3: Proposed Smart Cities at risk of earthquakes, floods and cyclonic winds

Fig. 8.2: Multi-hazard vulnerability map of India indicating locations of proposed Smart Cities



Source: (Drawn by authors with data from NDMA, www.data.gov.in and www.mapsofindia.com)

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