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IN PURSUIT OF NUCLEAR SECURITY

REDUCING INDIA'S RISKS TO NUCLEAR TERRORISM

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Executive Summary

NUCLEAR SECURITY concerns have intensified since the end of the Cold War, but these became particularly acute after the 9/11 terrorist attacks on the United States, as Washington grew concerned about the ability of terrorist groups to obtain nuclear and other radioactive materials. Indeed, the nuclear threat is no longer mere fodder for fiction. According to the International Atomic Energy Agency (IAEA), between 1993 and 2023, there were 4,243 incidents of illegal or unauthorised activities involving nuclear and radioactive materials.

Yet, while the world more seriously regarded the nuclear threat in the context of terrorism only after 9/11, India has had such awareness for far longer. For India, the spectre of nuclear terrorism is magnified by Pakistan's nuclear arsenal and its deep linkages to terrorist organisations. This report identifies and evaluates these nuclear terrorism threats based on India's counterterrorism experience in the past three decades.

The India-Pakistan relationship is complex and carries enormous historical baggage, fuelling a volatile regional security environment. For India, its nuclear threat perception encompasses a number of plausible scenarios: Pakistan's direct

involvement in nuclear terrorism; internal security breaches; and the theft of nuclear materials. While the likelihood of domestic violent non-state actors acquiring nuclear weapons is low, the risks of "dirty bombs" or cyberattacks on nuclear facilities are significant.

Given India's unstable neighbourhood, including beyond Pakistan to the larger South Asian region, India has had to remain vigilant to multiple threats to its nuclear infrastructure. Based on the IAEA's broad principles on nuclear security, India has adopted a risk-reduction strategy involving legal, intelligence, diplomatic, and operational measures. Given the evolving nature of threats, however, this report recommends additional safeguards, such as advanced threat detection, robust security audits, comprehensive trainings, and advanced cybersecurity measures.

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Introduction

NUCLEAR SECURITY became a worrying issue in the early 1990s after the end of the Cold War. That the erstwhile Soviet Union was in possession of thousands of nuclear weapons and a large stockpile of weapons-usable fissile material and was home to a sizeable number of nuclear experts provoked concern.[1] The United States (US) feared that, upon the Soviet Union's fall, its tight internal policing system around its nuclear assets would collapse. This event would then put those weapons, radioactive material, and expertise into the world, including in a nuclear black market where malign actors, whether states or terrorists, could be scouting to purchase them. Compounding the fear was the idea that scientists from the erstwhile Soviet Union themselves could steal nuclear materials and transfer their technical expertise elsewhere.[2] These concerns heightened after the 9/11 terrorist attacks in the US, with Washington worrying that terrorist groups could get their hands on such materials.

As per the International Atomic Energy Agency's (IAEA) Incident and Trafficking Database (ITDB), there have been 4,243 incidents of illegal or unauthorised activities involving nuclear and other radioactive material between 1993 and 2023.[3] In 2023 alone,

there were 168 incidents based on information provided by IAEA member states. Given large quantities of nuclear materials available worldwide—nearly 2,000 metric tonnes of weapons-usable nuclear material available in 24 countries and in more than 100 facilities—the issue of securing nuclear materials and ensuring that they do not fall into the wrong hands is real. There are also concerns about the more easily accessible but potentially dangerous radiological sources such as Cesium-137, Cobalt-60, and Iridium-192 because of their common applications in areas such as medicine, agriculture, and industry.

The 9/11 terrorist attacks were a watershed event, ushering in a new sense of urgency as the threat of nuclear terrorism emerged. That the al-Qaeda leader Osama Bin Laden proclaimed that the procurement and use of weapons of mass destruction (WMDs) was his "Islamic duty" exacerbated the situation.[4] Many nations perceived the acquisition of nuclear devices by terrorist organisations and other violent non-state actors to be the single greatest threat to humanity's existence.[5]

Today the threat persists, even as the return of great-power politics is beginning to mask the danger from terrorism, overall, and nuclear terrorism, in particular. Indeed, in the aftermath of US withdrawal from Afghanistan in 2021 and the growth of extremism in West Asia, the threat of nuclear terrorism is growing. The implications of this growing threat are yet to be fully recognised.[6]

For India, the threat of nuclear terrorism raised concerns, especially with its rising prominence in South Asia, and given nuclear-armed Pakistan's deep linkages with pan-Islamic terrorist organisations and the anti-India terrorist groups in particular. While India has experienced the threat of cross-border terrorist attacks from Pakistan-based terrorist organisations for decades, the nuclear tests of 1998 added a new dimension to the threat. Faced with far superior Indian conventional military capabilities and the fears of nuclear escalation, Pakistan amplified the low-intensity conflict against India by utilising terrorist organisations like the Lashkar-e-Tayyaba (LeT) and Jaish-e-Mohammed (JeM).[7] American scholar Christine Fair describes this Pakistani policy as "jihad under the nuclear umbrella."[8] The spate of terrorist attacks by these organisations against Indian

government, military, and civilian targets in the late 1990s and early 2000s demonstrated Pakistan's use of this tactic. In 2008, the violence would culminate in the Mumbai terrorist attacks which targeted multiple locations and killed 174 people.[9]

The close linkages of these terrorist organisations with the Pakistani military establishment led to speculations and concerns over nuclear terrorism wherein India could face the following nuclear terrorism threat scenarios:

- Pakistan providing nuclear weapons to terrorist groups as a matter of state policy (authorised transfer)
- Sections of the Pakistani establishment or rogue elements within engaging in the transfer of technology and/or radiological materials in contravention of formal state policy or without necessary approvals from the highest political authorities (unauthorised transfer)
- Terrorists stealing nuclear materials without any support from state actors (theft)
- Pakistani state/rogue actors' support for terrorist actions against Indian facilities that could include nuclear power plants and other nuclear establishments, including through cyberattacks against power plants and other parts of nuclear establishment, causing disruption, chaos, or even deaths
- Attempts to acquire nuclear materials in India, including intelligence support and other types of support from Pakistan to keep its own role hidden

Furthermore, two closed-door discussions conducted by the authors of this report with Indian stakeholders[a] suggested two additional threat scenarios:

[a] These discussions were held in a hybrid format on 26 February 2024 and 6 June 2024.

- Use of nuclear and radiological materials by other state actors who have inimical interests towards India
- Domestic terrorism by Indian insurgents, including Naxalites or left-wing extremists

This report aims to identify and evaluate the nuclear terrorism threats that confront India. While there is literature on terrorism in India, and South Asia in general, it fails to effectively evaluate the elements of the nuclear terrorism threat.

This report thus identifies nuclear terrorism threats that can arise from India's neighbourhood as well as from within the country and ranks them in terms of the degree of likelihood.[b] The report will first examine Indian nuclear security in general, then gauge specific kinds of nuclear terrorism-related threats faced by India, while evaluating them according to the relative danger they pose. Subsequently, the report will outline steps India has taken to counter these threats and conclude with specific, targeted measures that India can take to mitigate them.

This report benefitted from two closed-door focus group discussions convened by the Observer Research Foundation (ORF) with representatives of India's national security establishment, the Department of Atomic Energy (DAE), and members of academia, civil society, and the Indian strategic community. In an effort to evaluate the perceived nuclear terrorism threats, the authors of this report also conducted an online survey among the relevant stakeholders. The survey questionnaire aimed to yield more objective insights on the subject, but the ranking is done not merely on the basis of the survey results but also extensive discussions with the Indian atomic energy and security officials. The survey and its findings are appended to this report.

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[b] Nuclear terrorism threats were identified following extensive discussions with security and atomic energy officials, including through two closed-door focus group discussions as mentioned earlier.

India's Nuclear Security Posture: Overview

INDIA IS SITUATED between two nuclear neighbours—Pakistan and China—and therefore has had to pay close attention to nuclear security especially as it has not had an enduring relationship with the two. India perceives a distinct threat from Pakistan because of the existence of terrorist organisations like the LeT and JeM and the Pakistani Army's deep links with pan-Islamic terrorist organisations like al-Qaeda.[10] China, meanwhile, exacerbates Indian concerns regarding the competing influence in this strategic region. Moreover, China's pivotal role in bolstering Pakistani nuclear capabilities and propping up north-eastern insurgent groups[c] in the past have had profound implications for regional stability.[11] Despite its international commitments to nuclear non-proliferation, China has provided extensive nuclear assistance to Pakistan, including technology transfers and material support, enabling the rapid expansion of its nuclear arsenal.[12]

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[c] China has previously supported groups such as the Naga National Council and Mizo National Front. See: Obja Borah Hazarika and Chandan Kumar Sarma, "The "China Factor" in the Northeast Component of India's Act East Policy: Implications for Security, Connectivity, Commerce," *International Journal of China Studies* 13, no. 1 (2022), https://ics.um.edu.my/img/files/IJCSV13N1/IJCS%20V13N1-03-Obja-Chandan.pdf.

This assistance, coupled with Pakistan's strategic focus on tactical nuclear weapons, poses challenges for India and upends regional stability. New Delhi views with concern the growing economic and military partnership between China and Pakistan, particularly amid initiatives like the China-Pakistan Economic Corridor. This close cooperation between Islamabad and Beijing has also shaped India's threat perception.[13]

Through the 1998 Pokhran nuclear tests, known as Operation Shakti, India demonstrated its nuclear capabilities and sought to deter potential nuclear threats, particularly from Pakistan and China. Following the tests, India developed and formalised its nuclear doctrine, which adhered to a 'No First Use' policy. The doctrine emphasised a "credible minimum deterrence posture" while underscoring the country's commitment to "massive" retaliation if any WMD, including tactical nuclear weapons, are used against it.[14]

Pakistan responded with its own round of nuclear tests in the same year, beginning the nuclearisation of South Asia. This escalation elevated the importance of nuclear weapons and their potential threats for India, including in terms of crisis management. The 1998 nuclear tests by both India and Pakistan marked a turning point in the overall security dynamics in the region. For India, it meant there was a need to develop a more nuanced and sophisticated approach to nuclear threat assessment and balancing.[15]

India continues to view nuclear weapons as a deterrent tool; yet, the possibility of use still exists.[16] Nevertheless, recognising the unparalleled negative consequences of nuclear use, India has behaved in a responsible manner. It has improved its nuclear material safety and security at both national and global levels, tightened national legal architecture, and participated in global efforts such as the Nuclear Security Summits. It is also signatory to a number of international instruments that address global nuclear proliferation and nuclear security governance. One such agreement is the International Convention for the Suppression of Acts of Nuclear Terrorism (Convention on Nuclear Terrorism or CNT), adopted by the United Nations General Assembly on 13 April 2005.[17] The convention

declares nuclear terrorism as a crime under international law. Further, India is party to the United Nations Security Council Resolution 1540 that disallows state support to non-state actors in building, stockpiling, or trading weaponisable material, including radioactive materials; it exhorts member states to establish stringent national regulations aimed at preventing the proliferation of these weapons and their delivery systems, especially in the context of nuclear terrorism.[18]

Pakistan, meanwhile, has continued to use non-state actors and terrorist groups to further its political objectives vis-à-vis India. Just a few months after both countries went nuclear, Pakistan initiated the Kargil war in May 1999. This limited war was accompanied by veiled threats on the use of nuclear weapons against India and underscored the need for India to respond to Pakistan's provocations while ensuring that its actions did not contribute to nuclear escalation.[19] Further, the 2008 Mumbai terrorist attacks, carried out by ten LeT members, along with other terrorist attacks,[d] forced India to review its threat assessment. The concern was that terrorist groups, especially those based in Pakistan, with support from its military establishment, could attempt to strike nuclear facilities and/or acquire nuclear and radioactive materials.

The worry was not unfounded. The Mumbai terrorist attacks in November 2008, for example, left the Indian nuclear establishment untouched but has been found to have been executed with the involvement of Pakistan's intelligence services, the ISI. Police interrogation reports, cited by the media, revealed the key role played by ISI in engaging figures like David Coleman Headley[e] in plotting the Mumbai attacks.[20] Similarly, the India head of the terrorist group Indian Mujahideen, Ahmad Zarar Siddibappa

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[d] In the 2000s, LeT carried out a series of serial blasts in various Indian cities including the October 2005 pre-Diwali blasts in Delhi and the July 2006 Mumbai suburban train bombings. See: Arun Vishwanathan and Sameer Patil, "Lashkar-e-Taiba (LeT)," in *Handbook of Terrorist and Insurgent Groups: A Global Survey of Threats, Tactics, and Characteristics,* ed. Scott N. Romaniuk, Animesh Roul, Amparo Pamela Fabe, János Besenyő (Boca Raton: CRC Press, Forthcoming).

[e] American terrorist who worked for the LeT.

alias Yasin Bhatkal, in 2013 claimed that he was "planning to set off a nuclear bomb in Surat." During interrogation by the National Investigation Agency (NIA), Yasin Bhatkal reportedly said that he had asked his superior, Riyaz Bhatkal, who was Pakistan-based, whether he "could arrange a small 'nuclear bomb'." Riyaz reportedly responded, "Anything can be arranged in Pakistan."[21]

Bhatkal was arrested in Nepal in August 2013, which indicates the pervasiveness and linkages of terrorism across South Asia. Even though his plans did not fructify, Bhatkal's confession is revealing of the interest and inclination of these terrorist groups and the linkages within Pakistan. Each of these terrorist attacks have shaped India's threat perception in the context of nuclear security, which in turn have framed New Delhi's overall approach to broader nuclear strategy and nuclear security in particular.[22]

According to the IAEA, the quantity of nuclear material required to build a nuclear bomb is 8 kg for plutonium and 25 kg for Highly Enriched Uranium (HEU).[23] Only 22 countries possess such weapons-grade nuclear materials, and India is one of them.[24] As of 2023, India is estimated to possess about 164 nuclear weapons.[25] Additionally, it has 22 nuclear reactors currently in operation, which produce large amounts of radioactive nuclear waste (spent fuel), with some even producing weapons-grade nuclear material.[26] India is among only five countries employing a plutonium fuel cycle in its nuclear reactors. There are more than 7,000 "radiation facilities" in the country, including institutions that use radiation sources or radiation-generating equipment for industrial, research, medical, consumer products, and scanning facilities.[27] These radioactive materials require security.

Nuclear Terrorism and India: A Threat Analysis

MIKE MULLEN, former chairman of the joint chiefs of staff of the US, once described the LeT as Pakistan's "proxy".[28] LeT, JeM, and other organisations have received extensive support from the Pakistani security establishment in executing terrorist attacks against India.[29] These attacks have also brought both countries to the verge of direct military conflict. American scholar Daniel Markey has stated that if there was any single terrorist organisation in Pakistan most likely to provoke an all-out war with India, it is the LeT.[30]

It has not helped that Pakistan has historically resisted international counterterrorism efforts, especially with respect to the UN's attempts to address the issue of terrorism emanating from Pakistan's borders. Pakistan has also found an ally in China to support its agenda as far as non-cooperation on terrorist groups is concerned. China has repeatedly prevented the United Nations from acting against terrorists sheltered in Pakistan.[31] In addition to Pakistan's close links to terrorist groups, the current domestic troubles fermenting political, economic, and social instability are particular cause for concern.[32]

Threat Actors

It is in this context that the threat of nuclear terrorism has come to the forefront for India, wherein the security establishment is concerned that there are various scenarios of how the threat of nuclear terrorism may turn out. This may manifest in the form of rogue elements in states like Pakistan, which have historically harboured terrorist groups, providing technical know-how, radiological materials, and other forms of support.

As far as India is concerned, there are two additional scenarios. The first is the possibility of terrorists acquiring or crafting a nuclear bomb and detonating it in a major city. This is potentially the most catastrophic scenario. In the past, terrorists have considered carrying out terrorist attacks in India by detonating nuclear bombs. For instance, in 2013, as mentioned briefly earlier, Yasin Bhatkal attempted to procure a nuclear bomb from Pakistan through an associate of his based in Pakistan, which he then disclosed to Indian interrogators.[33] The Pakistani associate had confirmed that "anything can be arranged in Pakistan". While this threat did not materialise, these are examples of attempts made by and intentions of terrorist groups to acquire nuclear material to carry out a terrorist attack with a nuclear device.[34]

The second is the employment of a 'dirty bomb' or Radiological Dispersal Device (RDD) which, though not as destructive as a nuclear bomb, is still capable of causing massive damage; it is also easier to acquire, assemble, and possibly even deploy.[35] The Indian security establishment considers both scenarios plausible.

The threat of nuclear terrorism, therefore, arises from two types of actors: external and internal.

External Threats

External threats include those emanating from outside India, mainly from terrorist organisations that could infiltrate the country's nuclear systems (or those of its neighbours) and execute a nuclear/radiological attack on Indian soil. As discussed earlier in this report, India's geographical proximity to

Pakistan, with whom it has a strained political relationship, has long put it at constant risk of terrorist activity.[36] Among the terrorist groups, al-Qaeda, Islamic State, Tehreek-e-Taliban-e-Pakistan (TTP), LeT and JeM stand out with the greatest potential to harness nuclear capabilities. Understanding the nature of these threats is imperative for crafting effective counter-strategies to safeguard India's nuclear facilities and broader security.[37]

The TTP, a militant organisation operating in the volatile regions of Pakistan and Afghanistan, is not necessarily an anti-India terror outfit, but the TTP's potential access to nuclear materials in Pakistan could pose a threat to South Asia and possibly escalate tensions in the region and beyond.[38] However, a much more serious threat emanates from the LeT and JeM, which have consistently carried out attacks against Indian targets—military, government, and civilian.[39] Both organisations have a well-documented anti-India agenda and possess sophisticated operational capabilities, making them alarming adversaries.[40]

LeT, founded by Hafiz Saeed, is one of the most dangerous terrorist organisations operating in the region. LeT is responsible for a number of high-profile attacks in India, including the 2008 Mumbai attacks.[41] LeT's operations are characterised by meticulous planning, coordinated execution, and the use of well-trained militants. The group's objectives include the "liberation" of Kashmir from Indian control and the establishment of an Islamic state in the region governed by Sharia law. LeT has also demonstrated the capability to strike at strategic locations, underscoring the gravity of its threat to national security.[42]

JeM was founded by Masood Azhar with the explicit aim of fighting against Indian interests.[43] It, too, has been involved in numerous attacks against Indian military and civilian targets. Notably, the group claimed responsibility for the 2001 attack on the Indian Parliament, which brought India and Pakistan to the brink of war. More recently, in 2019, JeM orchestrated the Pulwama attack, in which a suicide bomber targeted a convoy carrying Indian paramilitary personnel and killed 40 of them near Lethpora on the Jammu–Srinagar National Highway, leading to an escalation in India-Pakistan tensions.[44] JeM's sophisticated operational tactics, including the use of suicide bombings and armed assaults, pose

a severe threat to India's security. The group focuses on high-impact targets to demonstrate its offensive capabilities that have the potential to destabilise regional security.

Both groups have had extensive support from the Pakistani establishment for its anti-India activities.[45] Both LeT and JeM benefit from a support network that includes financial resources, training camps, and logistical assistance. This support is often traced back to elements within Pakistan, adding a layer of complexity to India's counterterrorism efforts.[46]

Internal Threats

While external threats pose a significant risk for India, there is also an internal dimension for India that includes Left-Wing Extremists (LWE), north-eastern insurgent groups, and radicalised individuals indoctrinated by extremist propaganda—what Indian law enforcement agencies call "lone wolves".

The LWE represents a different category of internal threat rooted in Maoist insurgency and rural discontent.[47] They focus on socio-economic grievances and armed struggle against the Indian state. However, the Naxalites'[f] propensity for violence, along with their anti-nuclear stance, cannot be overlooked in the context of nuclear security risks.[48] Interviews with senior police officials in Jodhpur, Rajasthan, in April 2014,[g] indicated that there are some indications of Naxalites showing interest in attacking Indian nuclear installations, but these claims could not be corroborated.

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f Referring to the Maoist motivated militant insurgency groups.

g Interviews with senior police officials by one of the authors on nuclear security in India as part of an earlier study on the same subject, Jodhpur, Rajasthan, 14 April 2014. The information was further corroborated most recently in July 2024 and there is still no confirmation of Naxalites' interest in nuclear weapons. Indeed, given that the left-wing violence has gone down significantly in recent years, it is unlikely that the Naxals will resort to nuclear weapons.

The same interviews indicated that it was possible that Naxals could join hands with jihadists under an anti-India platform, but this too, has not fructified.[49] However, given the severity of any nuclear or radiological incident, the threat from left-wing extremism is treated with a certain seriousness.

The north-eastern insurgent groups are also part of the internal threat matrix. While the insurgency has largely been on the decline, except for the recent unrest in Manipur, it does figure in the Indian threat calculus, given China's past linkages with these groups. Though Beijing has not employed these insurgent groups against India for a while, it has kept its options open and has several instruments at its disposal.[50]

Similarly, India appears to be "immune" to the 'lone wolves' phenomenon. In recent years, however, Indian law enforcement agencies have made several arrests of lone wolves who branch from radicalised civilian groups. These are individuals who have been radicalised through online social media platforms, encrypted chat rooms on the darknet, and propaganda on instant messaging apps.[51] While it is hard to get hold of definite information on such activities, these radicalised individuals still pose a threat to the security of India's nuclear infrastructure. This can be particularly true in the case of insider threats, where such radicalised individuals can engage in acts of sabotage.

There also exists the possibility of an insider (a lone wolf)-outsider joining hands in a sabotage or other nuclear incident. While not directly related to the lone-wolf phenomenon, the Kaiga incident in 2009 demonstrates the potential of such acts. In this instance, a disgruntled employee at the Kaiga Atomic Power Station in Karnataka was reportedly responsible for contaminating the drinking water supply with heavy water from the plant, which led to 45 employees being poisoned.[52] Given such instances, security managers have to examine all potential scenarios when it comes to safeguarding the nuclear plants. These dynamics pose a challenge to nuclear security.

In one of the closed-door discussions organised by ORF, there was broad consensus that terrorist organisations in India do not appear to possess the technical competence to engage in nuclear terrorism. Historically, they have not been technically proficient or employed anything beyond "simple" explosives. Other participants, however, argued that terrorist organisations do indeed have the capacity to engage in nuclear terrorism. They pointed out that the use of drones by terrorist organisations like Hezbollah and Houthi rebels proves that recent technological advances have a lower entry barrier, and therefore non-state actors could gain such technical proficiency more easily.[53] This has the potential to pose severe challenges to national security establishments worldwide in the future. Aerial and cyber threats to nuclear facilities are within the realm of possibility in terms of incidents because both these technologies are easily accessible and there are no foolproof countermeasures against them.

Current Regional Dynamics and Threat Scenarios

India appears to be in a "sweet spot", with no mass-casualty attacks on Indian soil since Pulwama in 2019. This is in contrast to a decade ago, when terrorist incidents within the country were commonplace across a variety of targets. However, as indicated by the recent spike in terrorist violence in the Jammu region, this should not result in complacency. Additionally, the October 2023 Hamas raid on Israel is proof that scenarios that were earlier considered improbable could materialise. The likelihood of the resurgence of a terrorist organisation is increasing daily. In addition, the possible activation of sleeper cells within India cannot be ignored. The same argument applies to nuclear terrorism.

In one of the focus group discussions organised by ORF, participants delved into the possible state-sponsored supply of nuclear material to terrorist groups. With Pakistan embroiled in internal conflict, personnel working at nuclear establishments may sell nuclear and/or radiological material to terrorist organisations. In contrast, in India, where nuclear

installations are heavily guarded, the likelihood of a breach is relatively low.[h] Additionally, Indian installations have robust and multifaceted accounting mechanisms. The surveillance and technologies that are employed in case of an intrusion enable even less than one microgram of nuclear material to be tracked. However, the radicalisation of insider elements remains the obvious challenge.

Indian nuclear weapons are stored in a de-mated form, with different components, like the delivery system and nuclear warhead, stored separately at various locations. This makes their assembly especially difficult. Therefore, even if a terrorist organisation acquires one or more of these components, they would not be usable in isolation. Additionally, the detonation technique for nuclear weapons is highly sophisticated, and there is no evidence that even organisations like al-Qaeda possess the necessary technical prowess.

Sabotage is much more feasible during the transportation of nuclear material. Radiological material, which is transported for uses in the agriculture and pharmaceutical industry, presents an added threat. The possibility of these materials being intercepted by traffickers during transportation is high. This has given rise to fears of nuclear smuggling. There were 168 incidents of illegal and unauthorised activities involving nuclear and radioactive materials in 2023 alone,[54] six of which were related to trafficking or malicious use of radioactive material. About 52 percent of all these incidents over the period of 1993-2023 occurred

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[h] This is a sharp context because of many vulnerabilities and failures that analysts attribute to Pakistan's security establishment. For instance, Shaun Gregory in a report said, "the vulnerabilities within Pakistan's nuclear safety and security arrangements mean that the risks of terrorist groups gaining access to nuclear materials are real. Moreover, militants have recently attacked a number of Pakistan's nuclear facilities, including an August 21, 2008 incident at the Wah cantonment, widely understood to be one of Pakistan's main nuclear weapons assembly sites." See: Shaun Gregory, "The Terrorist Threat to Pakistan's Nuclear Weapons," *CTC Sentinel,* Vol 2 Issue 7, July 2009, https://ctc.westpoint.edu/the-terrorist-threat-to-pakistans-nuclear-weapons/

during the authorised transport of these materials. In the past decade, this figure rose to 65 percent.[55] This makes nuclear material transport a key challenge in the context of nuclear security.

Nuclear smuggling has been a persistent issue for decades. Terrorist organisations and other non-state actors may seek to exploit existing smuggling networks or to establish their own networks to acquire fissile material or other nuclear-related items. Nuclear smuggling incidents, such as the case of the Nuclear Wal-Mart network led by Pakistani nuclear scientist A.Q. Khan, underscore the persistent threat posed by illicit trafficking networks.[56]

An additional scenario that needs attention is the threat posed by orphaned sources, which can be utilised for sabotage or can cause a radiation incident.[57] The Mayapuri incident in New Delhi in 2010[i] exemplifies how mishandling orphaned sources like Cobalt-60 could have severe consequences.[58] This challenge is not unique to India, though. Globally, there have been several incidents involving orphaned sources. Therefore, it would be beneficial to develop improved technology for the minor or trace detection of radioactive materials.

Another possible scenario that was debated in the focus group discussion was the bluff of a "nuclear bomb". A terrorist organisation could detonate a regular explosive device and claim that it was a nuclear device. Though this tactic has not been employed so far, it is the simplest to execute since it does not require an actual nuclear weapon or RDD but could create mass hysteria and panic. RDDs also do not create a nuclear explosion but spread radioactive material over a wide area upon detonation, causing fear, contamination, and potentially long-term health and environmental consequences. Extremist groups may view RDDs as more accessible alternatives to nuclear weapons, as they require less sophisticated technology and materials while causing significant psychological impact and disruption.[59]

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[i] In this incident, eight people were injured and one died after they were exposed to high radiation due to mistakes in handling radioactive material. The material in question—a research irradiator—belonged to the Delhi University and was sold to a scrap-metal dealer. He dismantled it, unaware of the hazard, causing radiation.

Another dimension of the nuclear threat is the vulnerability of nuclear facilities installed along the Indian coast, which could be potentially infiltrated using small boats or drones carrying explosives or RDDs. The incursion by sea that was executed by LeT terrorists during the 2008 Mumbai terrorist attacks underlined the importance of coastal security. Therefore, there is a need for a greater degree of vigilance around coastal areas.

Another concerning area in recent years is cybersecurity in nuclear installations.[60] The cyberattack on India's largest nuclear reactor in Kudankulam in September 2019 exemplifies the danger posed by the lack of a robust cybersecurity infrastructure.[61] Although the breach affected administrative systems and did not penetrate classified systems that controlled the operations of the nuclear plant,[62] it demonstrated the vulnerability of the nuclear infrastructure to cyberattacks.

The Russia-Ukraine War has also highlighted the threat posed by AI-enabled cyberattacks. State-sponsored non-state actors with advanced cyber capabilities could target India's nuclear infrastructure to disrupt operations, compromise sensitive data, or gain unauthorised access to critical systems. Non-state actors, including terrorist organisations and hacker groups, also pose cyber threats. These groups may lack the extensive resources of state actors, but they do not require large resources to execute sophisticated cyberattacks.

Attackers might employ advanced persistent threats to establish long-term presence within targeted systems to conduct surveillance and extract data.[63] Phishing, social engineering, and exploiting software vulnerabilities are common tactics used to gain initial access. Once inside, attackers can deploy malware that is designed to disrupt Industrial Control Systems or Supervisory Control and Data Acquisition (SCADA) systems that manage nuclear operations.[64] Cyberattacks can also provide another avenue for blackmailing or radicalising employees within nuclear installations.

Based on the above overview, this study identifies three kinds of threat scenarios as likely vis-à-vis nuclear terrorism: insider threat, cyberattacks, and use of orphaned sources. All of these scenarios could be utilised by terrorist organisations and other violent non-state actors to sabotage

and engage in nuclear terrorism targeting India. In addition, even if the terrorist organisations are unable to engage in violence by utilising the above scenarios, they could detonate an explosive device and claim it was a nuclear device to create mass hysteria and panic.

Due to the easy and affordable access to cyber warfare, the authors rank this as having the highest probability of threat to nuclear security. A close second is insider threats, which can arise from cybersecurity breaches or through radicalisation. Orphaned sources are ranked third.

Table 1: Threats and Plausible Outcomes

Threat	Potential Manifestation
External Threats	
Terrorist Organisations	- **Nuclear/Radiological Attack:** These organisations could infiltrate India's or its neighbours' nuclear systems and execute attacks. - **LeT & JeM:** Consistently targets India, carrying out high-profile attacks like the 2008 Mumbai attacks and the 2019 Pulwama attack. These groups possess sophisticated operational capabilities. - **State-Sponsored Terrorism:** Support from elements within Pakistan enhances their threat to Indian security.
Regional Geopolitical Tensions	- **Escalation Risk:** Proximity to Pakistan and strained political relations increase the risk of conflict, with potential involvement of nuclear materials.
Nuclear Smuggling	- **Trafficking during Transportation:** There is a high likelihood of nuclear/radiological materials being intercepted during transport, leading to smuggling or terrorist acquisition.
Cyber Threats	- **Cyberattacks on Nuclear Facilities:** Non-state actors could use cyberattacks to disrupt nuclear operations, steal sensitive data, or sabotage systems, as seen in the 2019 Kudankulam incident. - **AI-enabled Attacks:** State-sponsored actors could target India's nuclear infrastructure through advanced cyber means.

Coastal Security Threats	- **Infiltration via Sea:** Nuclear facilities along the coast are vulnerable to attacks from small boats or drones, as demonstrated by the 2008 Mumbai attacks.
Internal Threats	
Left-Wing Extremists (LWE)	- **Potential Alliances:** Despite the apparent lack of interest in nuclear weapons, LWE elements could collude with anti-India terrorist networks who may have a potential interest in nuclear weapons.
North-Eastern Insurgent Groups	- **Historical Links with China:** Though insurgency is declining, past linkages with China indicate a potential threat. - **Vulnerability during Unrest:** Any resurgence in unrest, like the recent events in Manipur, could exacerbate this threat.
Lone Wolves	- **Insider Sabotage:** Radicalised individuals could infiltrate nuclear facilities and engage in sabotage. - **Collaboration with Outsiders:** There is potential for insider-outsider collusion in attacks, similar to the 2009 Kaiga incident, in which a disgruntled employee poisoned drinking water at a nuclear facility.
Orphaned Radioactive Sources	- **Sabotage and Accidents:** Mishandling or deliberate use of orphaned sources, as seen in the 2010 Mayapuri incident, could lead to radiological incidents.
Fear Mongering with Misinformation	- **Mass Panic:** Terrorist organisations might detonate a conventional explosive and falsely claim it was a nuclear device, causing widespread panic and chaos.

Countermeasures Implemented by India

ADDRESSING THE NUCLEAR threat posed by terrorist organisations requires a multifaceted and robust nuclear security approach that includes legal measures, intelligence sharing, counterterrorism operations, diplomatic collaborations, and global commitments. Furthermore, strengthening nuclear security measures, including securing fissile materials, enhancing export controls, securing physical borders, and bolstering safeguards against illicit trafficking, are necessary steps to prevent terrorist organisations and other violent non-state actors from acquiring nuclear capabilities. This requires close collaboration among different stakeholders within the government establishment, international organisations, and other stakeholders such as industries and civil society.

Table 2: Key Countermeasures Deployed by India

Countermeasures	Description
Risk-Reduction Approach	India employs a multi-layered risk-reduction strategy that draws from the IAEA's suggestions and includes deterrence, robust security protocols, and continuous risk assessments to minimise the likelihood of nuclear or radiological incidents. The approach involves a combination of effective governance, national legal frameworks, and the establishment of appropriate institutions, all while adhering to international legal obligations to ensure comprehensive nuclear security.
Regulatory Tools	India has comprehensive laws governing nuclear safety and security, as summarised in Table 3. These laws provide the legal basis for controlling nuclear materials and ensuring safe practices in nuclear operations. This framework includes regulatory and oversight institutions like the Atomic Energy Regulatory Board (AERB), which enforces safety standards across different nuclear facilities and streamlines licensing processes through a digital platform called eLora (e-Licensing of Radiation Applications).
Security and Intelligence	India's nuclear facilities are protected by a combination of paramilitary units, such as the Central Industrial Security Force (CISF), and intelligence agencies like the Research and Analysis Wing (RAW), ensuring a high level of security.
Nuclear Facilities with Secure Designs	India's nuclear installations are designed with multiple safety and security layers, including physical barriers and access controls that protect against sabotage and unauthorised access.
Emergency Response Systems	India has developed comprehensive emergency response protocols that involve coordination between local, state, and national agencies, including specialised units for rapid response to nuclear or radiological emergencies.

Technological Innovations	India invests in advanced technologies such as radiation detection systems, surveillance technologies, and AI-enabled cybersecurity measures to enhance the protection and monitoring of nuclear facilities and materials.
Insider Threat Detection	India's nuclear sector employs stringent vetting processes, continuous monitoring, and psychological assessments to detect and mitigate insider threats, with particular attention to the potential radicalisation of personnel.
Monitoring of Other Radiological Sources	Beyond nuclear facilities, India monitors other radiological sources, such as those used in medical, industrial, and research settings, to prevent their misuse or accidental release, ensuring a comprehensive approach to radiological safety.
Public Awareness	Public education campaigns and community engagement are part of India's approach to increasing awareness of nuclear safety, emergency preparedness, and the risks associated with radiological materials.
International Perceptions	India actively engages with international bodies such as the IAEA. It also adheres to global non-proliferation norms to maintain and enhance its reputation as a responsible nuclear state, aiding diplomatic and security efforts.

Risk-Reduction Approach

India has adopted a 'risk-reduction' approach to nuclear security, whereby attempts are made to bring the risks down to an acceptable level. The IAEA's "risk informed approach to nuclear security measures" has influenced this three-tier strategy:[65]

1. The first tier involves physical protection measures for nuclear and radioactive materials, in addition to material accountability, which

is provided in all nuclear facilities, including during their transport, in all life-cycle phases. Technology, especially surveillance and databasing tools, plays an essential role in this. India has invested in and developed these technologies indigenously. For instance, India can account for sensitive and strategic materials like plutonium and uranium up to an accuracy of almost a milligram.[j] There are also other technologies and access control mechanisms, both physical, such as spike strips and cement/steel barriers, as well as technology-aided, such as biometric systems, that have been implemented to help delay access to the core of a facility in case of a security breach.[k] Such measures and technologies provide security personnel in a facility some lead time to take control of a situation while calling for external assistance.

2. The second tier involves the detection of any material that has left regulatory control. Extending from the first tier of physical protections, the access and control systems help Indian authorities detect any material that is unaccounted for. Additionally, to be able to detect such material, inter-agency cooperation is important, and such preparedness requires the involvement of security forces.

3. The third tier uses security forces to respond to a potential emergency. The Central Industrial Security Force (CISF) is one such organisation, which holds regular drills to prepare for emergencies on material loss and detection as well as potential disasters, including the appropriate steps to be taken in case any such material enters the public domain accidentally or through intentional attacks.[66]

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j Information confirmed by former Indian Department of Atomic Energy officials during the focus group discussions held in June 2024.

k Based on interviews with senior police officers posted in nuclear establishments in Maharashtra, 18 February 2014. These were corroborated with senior Indian police officials during interactions in Delhi in July 2024.

Legislative Framework

The three-tier approach is implemented through effective governance, national legal frameworks, and the establishment of appropriate institutions, alongside adhering to international legal obligations. The Atomic Energy Act of 1962 serves as the umbrella legislation and provides the legal framework for all aspects of developing nuclear and radiation technologies, including their security.[67] Rules and guidelines issued under this Act form the backbone of India's framework for governing nuclear activities. The legislation also authorises the central government to establish rules and regulations and release periodic notifications to execute the provisions of this Act.

Since its implementation, the Act has undergone amendments to strengthen the legal basis for India's nuclear security measures. Legislation concerning environmental issues—among others—has also been critical in determining the location and operation of nuclear power plants. These include the Environment (Protection) Act, 1986;[68] the Atomic Energy (Factories) Rules, 1996;[69] and the Electricity Act, 2003.[70] The DAE also formulated the Guidelines for Nuclear Transfers (Exports) in 2006.[71] Key legislation introduced under the Atomic Energy Act include the Atomic Energy (Radiation Protection) Rules 1971 (further revised in 2004);[72] the Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules 1984;[73] and the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987.[74]

The Atomic Energy (Radiation Protection) Rules sanction activities for nuclear fuel cycle facilities and radiation use in industry, medicine and research. After its revision in 2004, the Rules are more comprehensive and clearly set out the roles and responsibilities of different parties, including employers and Radiological Safety Officers, in protecting against radiation. The rules also clearly identify the powers and roles of the Atomic Energy Regulatory Board (AERB), detailing requirements in areas such as safety, health surveillance of workers, radiation surveillance and records, directives, inspections, and enforcement actions. The Radiological Safety Division of the AERB is mandated to ensure compliance with

the 2004 Radiation Protection Rules and the 1987 Atomic Energy (Safe Disposal of Radioactive Wastes) Rules and institute parameters for the decommissioning and disposal of radioactive waste. The provisions in the 1987 Rules lay out the responsibility on the AERB in ensuring that the licensees comply with their responsibilities regarding the safe disposal of radioactive waste. The Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984, are responsible for regulating the mining, processing, and handling of prescribed substances.

Other legal instruments have been formulated or augmented with amendments to strengthen nuclear security policy. For example, the Unlawful Activities (Prevention) Act 1967, amended in 2012, now includes terrorist activities already defined under several treaties, including the Convention on the Physical Protection of Nuclear Material (CPPNM) and the International Convention for Suppression of Acts of Nuclear Terrorism (2005).[75] The Act also incorporates UNSC Resolution 1373, which obligates countries to immediately freeze the assets of any person or persons accused of terrorist activities.[76] Currently, it has listed 42 terrorist organisations and 56 individual terrorists. All acts of terrorism involving WMDs are punishable offences under the Act.[77] India also established the NIA in 2008, which serves as the central counter-terrorism law enforcement agency in India.

In addition, recognising the need for enhanced domestic nuclear regulatory frameworks, India introduced the Nuclear Safety Regulatory Authority (NSRA) Bill in September 2011. This proposed legislation aimed to replace the AERB with a more independent NSRA, modelled after regulatory bodies in advanced nuclear states like France, the UK, and the US. However, the Bill faced criticism regarding the lack of clarity and autonomy of the proposed regulatory authority. Since 2014, attempts have been made to reintroduce an improved NSRA Bill that focuses on ensuring robust nuclear regulatory oversight aligned with international best practices, but the Indian Parliament is yet to conduct a debate on the Bill.

Table 3: Indian Approach to Nuclear Security and Safety

Governing Tool	Description
Atomic Energy Act, 1962	The foundational legislation for India's nuclear activities covers all aspects of developing and securing nuclear and radiation technologies. It authorises the central government to establish rules, regulations, and notifications.
Environmental and Operational Legislation	This includes critical laws like the Environment (Protection) Act of 1986, Atomic Energy (Factories) Rules of 1996, and the Electricity Act of 2003, which influence the location and operation of nuclear power plants and related activities.
Guidelines for Nuclear Transfers (Exports), 2006	Established by the Department of Atomic Energy (DAE) to govern the export of nuclear materials.
Atomic Energy (Radiation Protection) Rules, 1971	Rules that regulate radiation protection in nuclear fuel cycle facilities and other radiation-related industries.
Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987	Mandates the AERB to ensure licensees follow guidelines for the safe disposal of radioactive waste, including decommissioning procedures, to prevent environmental contamination.
Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substances) Rules, 1984	Governs the mining, processing, and handling of nuclear materials, ensuring safe and secure operations throughout these activities.
Unlawful Activities (Prevention) Act, 1967	The Act allows for freezing assets related to terrorist activities and lists organisations and individuals as terrorists.

National Investigation Agency (NIA), 2008	The NIA plays a crucial role in investigating and prosecuting crimes related to nuclear security and terrorism.
Nuclear Safety Regulatory Authority (NSRA) Bill, 2011	A proposed legislative measure to replace the AERB with an independent NSRA, modelled after regulatory bodies in advanced nuclear states.
Convention on the Physical Protection of Nuclear Material (CPPNM)	India is a signatory to the CPPNM, which mandates that nuclear materials are protected during international transport and sets out guidelines for the physical protection of nuclear facilities and materials domestically.
International Convention for Suppression of Acts of Nuclear Terrorism, 2005	India is committed to preventing nuclear terrorism by adhering to this international treaty, which criminalises the unlawful possession and use of nuclear materials and obligates countries to cooperate in addressing nuclear terrorism.
United Nations Security Council Resolution 1373	India has incorporated UNSC Resolution 1373 into its domestic legislation, thus mandating the freezing of assets linked to terrorist activities and requiring international cooperation in combating terrorism, including nuclear terrorism.

Regulatory Institutions

India also has several autonomous bodies that oversee and govern nuclear security and safety. One of the primary institutions is the Atomic Energy Commission (AEC), set up in 1948 initially under the Department of Scientific Research.[78] Subsequently, following a government resolution in 1958, the AEC was established in the Department of Atomic Energy (DAE) to function as an autonomous body with financial and executive powers. The AEC functions as an overarching body in nuclear security and safety. The members of the AEC are chosen by the Prime Minister based on the Secretary, DAE's recommendations. The AEC is primarily responsible for creating DAE policies and budgets, with execution assigned to the DAE.

In 1954, the DAE was assigned the task of developing nuclear power technology and applications of radiation technologies in various fields, including agriculture, industry and scientific research.[79] The DAE is also responsible for the design to operation of nuclear power and research reactors.

The AERB, established in 1983, is India's nuclear regulator and operates independently of nuclear power operators in the country.[80] This independence is essential to ensure its ability to regulate all activities related to the safety and security of nuclear and radioactive materials, particularly in terms of facilities and transport. The AERB has several committees under its umbrella to discharge its duties, including the Safety Review Committee for Operating Plants (SARCOP) and the Safety Review Committee for Applications of Radiation (SARCAR), which are responsible for safety review. SARCOP, established in 1988, assesses and enforces nuclear, radiological, and industrial safety in all operating plants under the DAE. SARCAR is responsible for streamlining the implementation of Radiation Protection Rules in all its processes and institutions that use radioisotopes and radiation materials in medical, industrial, and research institutes.

Each of these agencies plays a key role in enhancing nuclear security through better coordination as well as periodic review of existing measures, which augment the overall readiness of the nuclear establishment to deal with any contingency, including nuclear terrorism.

Licensing

Licensing is strictly subject to the operator submitting, to the AERB's satisfaction, that the emergency and security plans for installation and safe storage for sources are available within their premises. In the case of transport of radioactive material, ranging from Category 1 to Category 3 sources, the regulatory process involves online package tracking and an online real-time monitoring and reporting system called eLORA (e-Licensing of Radiation Applications), which is also used to report loss or theft to the police and the AERB within 24 hours.[81] The AERB is responsible for all licensing, including tech transfer at universities as well as the import

and export of materials. These are also enforced through India's export control mechanisms, including the Nuclear Suppliers Group, which are reviewed and updated in line with India's commitments under the global non-proliferation regime.[82]

Security Institutions in the Context of Nuclear Security

Besides the regulatory bodies in the nuclear sector, national security institutions also play an important role in maintaining nuclear security. These include intelligence agencies, the Central Industrial Security Force (CISF), state-level police forces, the military, and the National Disaster Management Agency (NDMA) and National Disaster Response Force (NDRF).

a. Intelligence Agencies

India's domestic intelligence agency, Intelligence Bureau (IB), along with state-level intelligence agencies, performs an important role in nuclear security by maintaining a close watch on the plans and activities of terrorist organisations and other violent non-state actors; monitoring physical security of the nuclear installations and movement of radioactive material; and performing periodic audits of nuclear installations. The external intelligence agency, Research and Analysis Wing, also plays a crucial role by monitoring the external environment, which may threaten India's nuclear security, including Pakistan-based terrorist organisations as well as the international nuclear black market.[83]

b. CISF

The agency is tasked with guarding India's critical installations and is the primary agency for physically protecting nuclear facilities. Towards this, it is responsible for access control and monitoring the movements of the staff and personnel posted at the facilities. In addition, it is one of the agencies responsible for radioactive materials' transportation security. The agency, which works under the Ministry of Home Affairs (MHA), imparts specialised training to its personnel in handling radiation leaks and other contingencies at nuclear facilities.[84]

c. State-Level Police Forces

As per MHA's guidelines, state-level police forces are tasked with the security of the outer periphery of nuclear installations.[85] They often act as first responders in cases of theft and crimes committed at nuclear facilities. Along with other agencies, they carry out security audits and perform regular mock drills, besides providing armed escorts during the transportation of nuclear materials. The intelligence wings of the state police forces work in tandem with the IB to monitor suspicious activities that may imperil the security of nuclear installations.

d. NDMA and NDRF

The NDMA is the designated agency for disaster mitigation and relief in India. It also includes NDRF, which acts as the primary force to respond to natural and man-made disasters, including any nuclear and radiological emergencies. The NDMA's guidelines on the Management of Nuclear and Radiological Emergencies list several contingency situations and steps that are to be taken to handle those situations.[86] These guidelines are an important step in shaping a holistic, all-stakeholder-inclusive approach to handling post-disaster scenarios. These guidelines include "a series of actions on the part of the various stakeholders at different levels of administration that would (i) mitigate the accident at source; (ii) prevent deterministic health effects in individuals and limit the probability of stochastic effects in the population; (iii) provide first aid and treatment of injuries; (iv) reduce the psychological impact on the population; and (v) protect the environment and property, all under the constraint of available resources."[87] The guidelines are also an important exercise in public awareness.

e. Military

The Indian military's role in securing nuclear installations is limited, reflecting the general practice of utilising and deploying the military only

when all other government agencies fail or if the task is beyond the capacity of civilian institutions. However, the Indian military imparts regular training on chemical, biological, radiological, and nuclear security to its personnel.

Inter-Agency Coordination

Inter-agency coordination is a crucial component of nuclear security, involving emergency preparations and training modules utilised by respective agencies, among other aspects. Even before the 9/11 terrorist attacks in the US, which reiterated the importance of nuclear security to the world at large, in 1987, India had established a Standing Group for Coordination and Review of Security Arrangement (SG-CRSA) for all nuclear facilities. A multi-agency group meets every four months with the aim of exchanging threat information, including any changes in the threat scenario, new and emerging threats, and the views of other national intelligence agencies regarding these threats. If required, this group also prepares standard operating procedures (SOPs) to address nuclear security issues. For example, after a cybersecurity incident at the Kudankulam nuclear facility in 2019, SG-CRSA issued an SOP addressing various new threats, including unmanned aerial intrusions into vital installation facilities, which has been shared with all of them.

The DAE has also constituted specialist groups like the Computer and Information Security Advisory Group (CISAG) and the Task Force for Information and Control Security (TAFICS) to monitor the cyber/information security of the Nuclear Power Corporation of India Limited (NPCIL), among other associated institutions of DAE, including regular cybersecurity audit, to address further potential cybersecurity intrusions.[88]

The Counter-Nuclear Smuggling Team (CNST) is another initiative that integrates multiple agencies with the functions of investigation, border management, and nuclear forensics while combating nuclear-smuggling cases.[89] The CNST compiles information quarterly and conducts tabletop exercises to ensure that each agency knows its responsibilities and duties. However, inter-agency coordination among the security agencies can be challenging. While this is not unique to India, given the density in

the country's cities and towns, any nuclear calamity would need to be handled with greater care and sensitivity. The ability of different agencies to work together under such circumstances becomes even more important. Generally, the different security organisations have engaged in simulation exercises to ensure preparedness, but the periodicity of exercises involving all the different security agencies needs to be improved. Some recent examples include specialised training and advanced courses, along with workshops on CBRN operations conducted for NDRF battalion personnel at the North Eastern Police Academy (NEPA) and Bhabha Atomic Research Centre (BARC) in 2015-2016. Similarly, in 2017, a workshop on the medical management of CBRN casualties for medical officers was held in New Delhi and BARC, Mumbai. In 2019, the NRDF began an annual training and refresher course on CBRN emergencies, including for first responders.[90] These courses were enhanced in 2024, when India deployed the NDRF to simulate potential attacks in the Ayodhya region as part of their continuous familiarisation exercise.[91]

Nuclear Facility Design and Security

India has a classified national Design Basis Threat (DBT) document, and each nuclear facility devises its own DBT document to design the physical protection aspects of the facilities.[92] The Indian DBT takes into account existing threats from saboteurs, thieves, terrorists and other malicious actors, their characteristic capabilities and tactics, as well as the possibility of collusion with insiders. Various surveillance, detection, and response mechanisms as well as access control measures are in place at nuclear facilities. This helps institute a graded security approach over four layers surrounding the most sensitive parts of the facility. Physical protection systems are also regularly audited by the AERB. India's national system of nuclear material accounting and control and personnel reliability measures play an important role in the practice of nuclear security, thereby ensuring compliance.

Security and inspections have the same underlying philosophy as nuclear safety regulations and inspections. The AERB conducts planned and random inspections for operational nuclear power plants and during various development stages of ongoing projects. The planned inspection usually

occurs once a year for operating plants. The inspection team (usually made up of four members) comprises members of the Committee for Reviewing Security Aspects of Nuclear Facility (CRSANF), who are trained and experienced in the nuclear security aspects. The AERB authorises the inspection team and the team leader or lead inspector. Inspections typically take three to four days, depending on the number of Operating Islands to be inspected.[93]

Emergency Response

In case of an emergency, India possesses 25 emergency response centres spread across the country to address any issues arising from input received from around 500 radiation monitoring stations, which are well connected and provide the real-time status of all activities in their respective areas. All nuclear power plants and related activities, including nuclear fuel cycle activities, are covered under this network so that no nuclear facility is out of the reach of nuclear radiation monitoring systems at any point of time. In the case of any eventuality, the NDMA is linked with local law enforcement agencies.[94] In addition, the DAE has constituted a Crisis Management Group (CMG), which deals with nuclear and radiological emergencies and incidents.[95] The CMG works out of a 24/7 control room, and its services are available to the NDMA if required. Periodic crisis management and off-site emergency exercises are conducted at all nuclear sites at intervals of two years, with active participation from all atomic energy and security agencies.

Diplomatic Collaborations and Global Commitments

India's nuclear security capabilities are bolstered by its active diplomatic collaborations. The country's collaboration with the IAEA facilitates knowledge sharing, capacity building, and technical assistance programmes. Further, bilateral agreements with like-minded partners enhance information exchange and coordinated responses to transnational threats, demonstrating the crucial role of global cooperation in enhancing India's nuclear security. For instance, the Global Centre for Nuclear Partnership (GCNEP) has 14 MoUs with several countries, such as the US, Russia, and France, and organisations such as the IAEA and has conducted more than 56

international programmes, including training courses and workshops on nuclear safety and security such as the physical protection of nuclear materials, vulnerability assessment, insider threat, computer security and controls, and security and transport of radioactive materials, drawing more than 500 participants from around 60 countries alongside over 1,000 Indian participants.[96]

India also invited the IAEA for an Integrated Regulatory Review Services (IRRS) mission in 2015.[97] This mission, a first for India, affirmed the AERB's operational independence while recommending statutory reinforcement to solidify its regulatory autonomy.

In terms of its global commitments, India is party to all 13 international instruments that are accepted as benchmarks for a state's commitment to combat international terrorism, including the International Convention for Suppression of Acts of Nuclear Terrorism (2005) and the Convention on the Physical Protection of Nuclear Material (CPPNM), along with the 2005 amendment which, among other provisions, brought the domestic transport of nuclear materials within its ambit.[98] Additionally, India supports the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (2003) and has voluntarily adopted its provisions.[99] India adheres to the Nuclear Suppliers Group (NSG) Guidelines on the supply of nuclear items, import and export of nuclear equipment, and physical protection of nuclear materials and facilities.[100] India has also supported the implementation of the UNSC Resolution 1540 (2004) regarding the non-proliferation of WMDs, especially to non-state actors, towards preventing WMD terrorism.[101] That India is a member/participating state in several international export control regimes such as the Wassenaar Arrangement and the Australia Group also signals its commitment to stringent export controls on sensitive technologies.[102]

Technological Innovations and Research

Investments in cutting-edge technologies and research initiatives are pivotal to advancing India's defences against nuclear terrorism. India has implemented technology that prevents the diversion of radioactive material and pursued a closed fuel cycle for plutonium reactors, implying

that plutonium is never stored in depositories; rather, it is purified and reused, effectively removing it from the public domain.[103] This ensures the avoidance of the buildup of stockpiles and the need to store large amounts of spent fuel in underground depositories, potentially giving malevolent actors easy access to plutonium. Additionally, Indian scientists are adopting proliferation-resistant technologies such as advanced heavy water reactors, which makes access to uranium particularly difficult in case of intrusion.[104]

Insider Threat Detection

Considering its vulnerability to tampering and technical failures, there is a need to pay attention to the human dimension in nuclear security, highlighting that excessive reliance on technology is not advisable. However, with human elements, there are potential threats like insider threats. These aspects need to be examined and strengthened with an augmented nuclear security culture. India has mitigated insider threats by implementing the "two-man rule", which states that no responsibility is left to any individual within the nuclear setup. This measure has proved to be highly effective. At the same time, dealing with insider threats requires a dynamic approach. India has also established a solid personnel reliability process through rigorous vetting and screening. While India has not faced any serious insider threats while operating nuclear facilities, given India's plans to expand its nuclear programme, India needs to remain vigilant for any disgruntlement among employees that could potentially turn into insider threats.

Other Radioactive Sources

The discussion on nuclear security extends beyond terrorism, as radioactive sources have several applications beyond nuclear facilities. Radioactive materials and equipment have thousands of licensees, including hospitals and industries, mainly due to an increasing number of medical centres and the importance of radiation-related diagnosis and procedures.

- Radiological equipment used by industry usually falls within Category 2 sources.[105] It is generally not a cause for concern due

to a well-organised corporate structure and stiff competition within the structure. The only vulnerability is short-distance transportation, particularly in instances such as last-minute orders, which may potentially lead to cutting corners. This is an area where enhanced security culture can help. In addition, care needs to be taken to prevent situations that can lead to paranoia and phobia among the general public.

- The only presence of large, Category 1 sources used for commercial purposes is in radiation processing plants, where gamma radiation sources are widely employed.[106] There are about 20 gamma-source-based plants in India, which have a substantial amount of stored cobalt, most of which has a half-life of 15-20 years. However, these sources are well-contained, usually within cells, and have sufficient physical protection. There is little scope for mishaps, except damage within the cell itself, which is not an appealing proposition for terrorists. There is a viable replacement for gamma sources in the form of electron beam accelerators, but this comes at a much higher cost and presents an economic challenge.[107]

Cases such as the Mayapuri incident of 2010 have proven that orphaned sources can have potentially lethal consequences, albeit on a smaller scale.[108] India has since taken measures to contain the threat posed by such sources. For instance, immediately after the incident, the AERB held awareness workshops for scrap dealers in Mayapuri and elsewhere. It also collaborated with the University Grants Commission to tighten the access of educational institutions' access to radiological material for scientific experiments.[109]

This also raises the question about whether it is possible to transition to non-radioactive source-based equipment in some sectors. For example, in the case of radiotherapy for cancer treatment, the availability of linear accelerators that do not contain radioactive sources invalidates the need for cobalt-60-based telecobalt equipment. India is already implementing this;

there are less than 300 telecobalt units in the country, and the number is diminishing.[I,110] X-ray-based systems are replacing blood irradiators that use cobalt and cesium. However, these alternatives are more expensive, and hospitals would require financial support to transition completely.

Therefore, fostering the adoption of proven alternative technologies to radioactive sources will benefit India. Consequently, there will be a need to mobilise resources and support to facilitate the transition. Moreover, when it comes to the human element, monitoring the human resources involved in facilities containing Category 1 and 2 sources is essential. Ensuring effective organisational management and culture is critical, as is the task of establishing sound operating procedures. Radioactive sources are involved across various applications, making practice-specific approach and guidance extremely important.

Public Awareness and Preparedness

Public awareness campaigns and community engagement initiatives play a crucial role in promoting vigilance and preparedness against nuclear terrorism. India has utilised various media platforms to disseminate positive and accurate information about nuclear power. For instance, at the Kudankulam Nuclear Power Plant, commercials on TV and radio were used to explain the safety of nuclear power.[111] These media campaigns included short videos and audio advertisements, quickly reaching a broad audience. Further, officials participated in public debates and provided simple analogies to explain complex nuclear processes, making the information more accessible to the general public.[112]

At a microscopic level, handouts and pamphlets have been distributed in regional languages, such as Tamil, Malayalam, and English, to ensure that information reaches a diverse audience. This method helped directly

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[I] There are certain types of treatment, however, where radioactive sources are introduced very close to the tumour, known as brachytherapy. There is no known viable replacement for them thus far.

address local communities' fears and concerns, particularly in regions where nuclear power plants are being constructed or operated.[113] Interactions with educational institutions, including presentations and Q&A sessions, have been crucial for raising awareness and building an understanding about nuclear power. Educational outreach has also been crucial to raising awareness and building understanding about nuclear power. These interactions targeted local opinion leaders in addition to students and academics, thereby influencing broader public opinion.[114]

Finally, in a crisis, communications systems are detailed as part of a Standard Operating Procedure (SOP). Indian nuclear power plants need to have detailed crisis communication plans in place. These plans include clear and immediate communication with the public and media to prevent misinformation and provide accurate updates on the situation. The emphasis is on transparency and timeliness to build and maintain trust during critical situations.[115]

International Perceptions

Despite these robust measures, certain international reports such as the Nuclear Threat Initiative's (NTI) *Nuclear Security Index* rank India low on metrics of nuclear security, even below Pakistan across most metrics.[116] This is potentially due to the NTI's tick-mark approach, which merely tracks whether or not a particular country has a specific regulation. The NTI's approach does not account for complexities such as how well the legislation is implemented and/or how regulatory bodies function in practical terms. Additionally, even when international regulations are followed in India, organisations such as the NTI perceive the situation differently due to differences in terminology, which India has rectified to a large extent in recent years. On the contrary, India's nuclear facilities have been examined by the IAEA, which has declared them to be on par with others in the developed world. A lack of transparency and external outreach by India's nuclear establishment also contribute to the misperception that requisite nuclear security measures are not in place in India. Another complicating factor is that there is no single database on

nuclear security in India, and consequently, multiple and scattered sources are utilised. The DAE has tried to correct this anomaly by introducing a nuclear security section in its annual reports, but this is relatively recent and somewhat limited in scope.[117]

Overall, India has strengthened its nuclear security architecture in line with the rapidly changing security scenario and threat perceptions. However, it cannot afford to be complacent in nuclear security because, unlike most other countries, the Indian neighbourhood is fraught with unstable conditions.

> *"India's nuclear security capabilities are bolstered by its active diplomatic collaborations."*

Recommendations

AS INDIA NAVIGATES the complex landscape of nuclear terrorism threats, drawing insights from international best practices can inform strategic recommendations to bolster defences and response capabilities. Examining successful approaches adopted by other nations would provide valuable lessons and actionable insights for enhancing India's preparedness and resilience.

Public Awareness and Community Engagement

The primary step should be increasing public awareness through campaigns and community engagement initiatives. These are integral to a resilient nuclear security framework. Some states have remained proactive, but it has not been done uniformly across the country. Additionally, strengthened engagements between nuclear plant operators and state disaster management authorities, along with the involvement of local bodies, can be useful in enhancing the support for nuclear energy in India. This is a critical component in the context of dealing with contingencies in particular. Atomic energy agencies also need to prioritise public engagement with a focus on enhancing the public understanding of nuclear security risks, promoting

transparent communication channels, and empowering local communities to safeguard critical infrastructure and respond effectively to potential threats. Disaster management agencies such as the NDRF and the state-level Response Force agencies could play a critical role in this regard.

Adaptive Response Strategies and Exercises

Dynamic threat environments necessitate agile and adaptive response strategies tailored to evolving scenarios. Models from countries like the US, France, the UK, and South Korea demonstrate the efficacy of regular simulations, crisis management exercises, and inter-agency coordination drills in testing readiness, refining response protocols, and enhancing interoperability across security agencies. India can strengthen its preparedness by institutionalising comprehensive scenario-based exercises, fostering more efficient inter-agency collaboration, and institutionalising lessons learned from international best practices to enhance readiness and resilience against nuclear terrorism incidents.

Cyber Warfare in Nuclear Establishment

The evolving nature of cyber threats necessitates robust cybersecurity measures to mitigate potential risks effectively. This involves a multi-layered defence strategy. The recommendations are tiered to advance from ground-level changes that can be approached immediately to overarching policy implementations to strengthen legal architecture in the long run. These include the following:

a. Employee Training and Awareness Programmes
   - Educating employees on cybersecurity best practices. Training staff to recognise phishing attempts, social engineering tactics, and other common attack vectors.

b. Regular Security Audits and Vulnerability Assessments
   - Conducting frequent security audits and vulnerability assessments to identify and address potential weaknesses in the nuclear infrastructure.

- Employing ethical hackers to perform penetration testing and simulate cyberattacks, ensuring preparedness against real-world threats.
- Adopting a zero-trust approach to cybersecurity, where no entity—internal or external—is inherently trusted.

c. Utilising Technological Tools
   - Utilising state-of-the-art intrusion detection systems and intrusion prevention systems to identify and mitigate cyber threats in real-time.
   - Implementing machine learning and artificial intelligence to enhance threat detection capabilities and swiftly respond to anomalies.
   - Developing comprehensive incident response plans to manage and mitigate the impact of cyber incidents and minimise recovery time.

d. Collaboration and Information Sharing
   - Engaging in threat intelligence and best practices sharing at a regional and international level with trusted countries, cybersecurity organisations, and industry partners.

Investments in Technological Innovations

Advancements in technology play a pivotal role in fortifying defences against evolving nuclear terrorism threats. Innovations in cybersecurity, radiation detection, and emergency response systems offer capabilities to pre-empt, detect, and mitigate potential risks. Countries like Israel and Japan exemplify proactive approaches through continuous research and development in cutting-edge technologies that enhance nuclear security resilience. India can benefit from intensifying investments in research partnerships, fostering collaboration between academia, industry, and government agencies to drive innovation and deploy state-of-the-art technologies across its nuclear infrastructure.

Enhanced International Cooperation

Successful international collaborations serve as force multipliers in combating nuclear terrorism threats. Models from collaborative platforms such as the Global Initiative to Combat Nuclear Terrorism showcase effective mechanisms for information sharing, capacity building, and joint exercises among participating states. India should prioritise expanding and deepening its partnerships with regional allies and like-minded partners as well as international organisations like the IAEA in order to leverage collective expertise and resources to strengthen mutual defences against shared threats.

> *"Dynamic threat environments necessitate agile and adaptive response strategies tailored to evolving scenarios."*

Conclusion

INDIA'S SECURITY posture is influenced by its volatile geographical location. The interplay of historical animosities, ongoing conflicts, political instability in neighbouring countries, and the ever-present threat of terrorism necessitates a vigilant and dynamic approach to national security. Safeguarding its nuclear assets, addressing conventional military threats, and navigating the complex geopolitical landscape are integral to India's comprehensive security strategy.

By drawing from international comparisons and adopting proactive measures, India can enhance its response to nuclear terrorism threats, safeguard national security, and contribute to global stability. Recommendations centred on strengthening legislative frameworks, fostering international cooperation, investing in technological innovations, promoting public awareness, and refining adaptive response strategies are critical to fortifying India's defences and resilience against the complex challenges of nuclear terrorism. As threats evolve, India's commitment to continuous improvement and collaboration remains pivotal in maintaining effective deterrence and preparedness capabilities on the global stage.

Therefore, the imperative for India is to leverage international lessons and strategic recommendations to fortify its defences against nuclear terrorism towards reinforcing its commitment to global security and resilience.

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Annexure

Annexure 1 - Survey Questionnaire

The following is a questionnaire that the ORF team circulated amongst the participants at the first focus group discussion, held on 26 February 2024. The objective of this exercise was to get more objective responses regarding threats and terrorism.

1. What is your general assessment of India's terrorism threat scenario?

- Low
- Moderate
- High
- Very high

2. How do you see linkages between nuclear issues and terrorism?

- Weak or non-existent
- Limited
- Moderate
- Strong

3. How do you assess border security in preventing nuclear material theft?

- Inadequate
- Somewhat effective
- Effective
- Highly effective

4. **How vigilant are the policy and technical wherewithal to detect the movement of nuclear materials in border areas?**
   - Not vigilant at all
   - Somewhat vigilant
   - Vigilant
   - Highly vigilant

5. **What are the different types of non-state actors that could pose a nuclear threat to India?**
   - Terrorist groups
   - Insurgent groups
   - Extremist groups
   - All of the above

6. **Which of the following are threats posed to India.**
   - Cross-border terrorist groups
   - India-based terrorist groups (on their own as well as with external support)
   - ISIS
   - Al-Qaeda / Al-Qaeda in South Asia
   - Left-wing extremists
   - Northeast insurgent groups

7. **What are the known vulnerabilities in India's nuclear programme that terrorists could exploit?**
   - Insider threats
   - Physical security weaknesses
   - Cybersecurity vulnerabilities
   - Interagency non-cooperation

8. **What would be the potential consequences of a nuclear terrorist attack in India, and how would the international community respond?**
   - Isolation of India
   - Humanitarian crisis
   - Global security concerns
   - All of the above

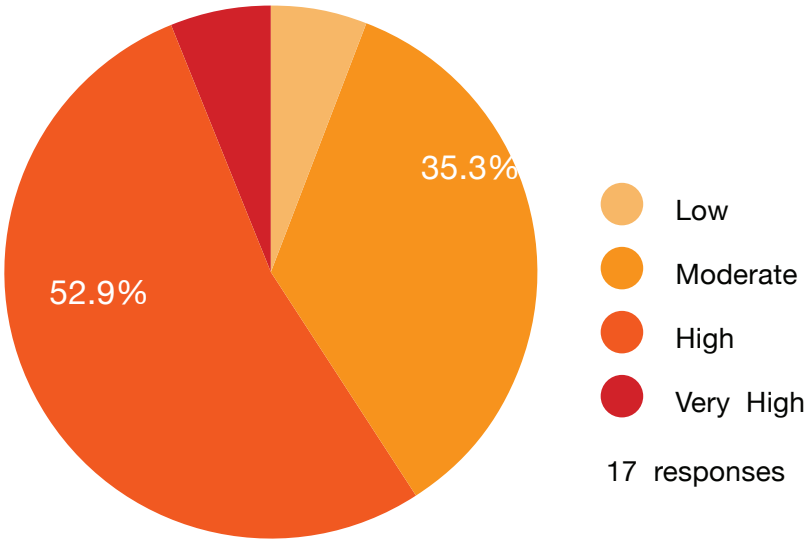
9. **What policies or initiatives do you think should be prioritised to strengthen India's nuclear security posture?**
   - Enhanced border surveillance
   - Improved intelligence-sharing mechanisms
   - Strengthened regulatory frameworks.
   - All of the above

10. **How resilient do you think India's nuclear infrastructure is to cyber-attacks?**
   - Highly vulnerable
   - Vulnerable
   - Moderately resilient
   - Highly resilient

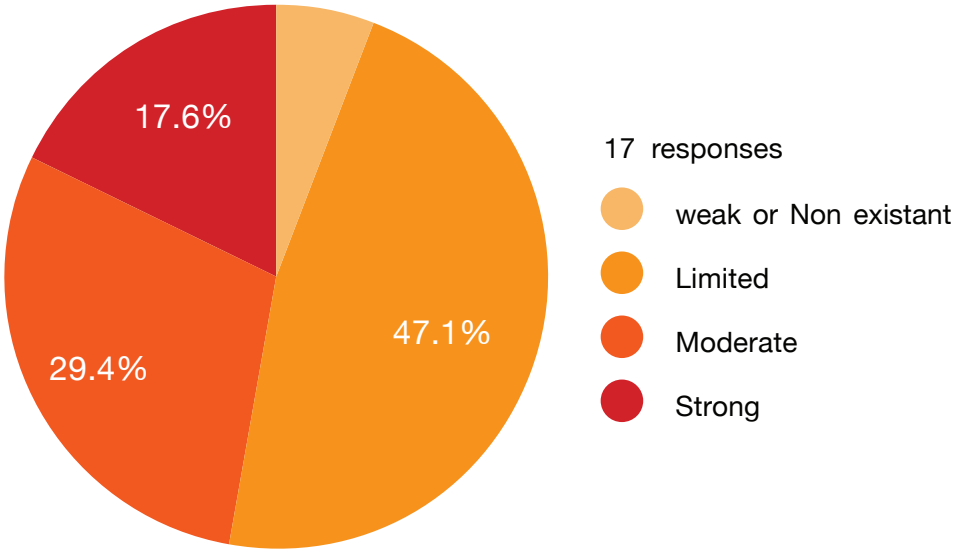
Annexure 2 - Findings of Survey Conducted on 26 February 2024

Following are the findings from the survey questionnaire circulated among the participants.

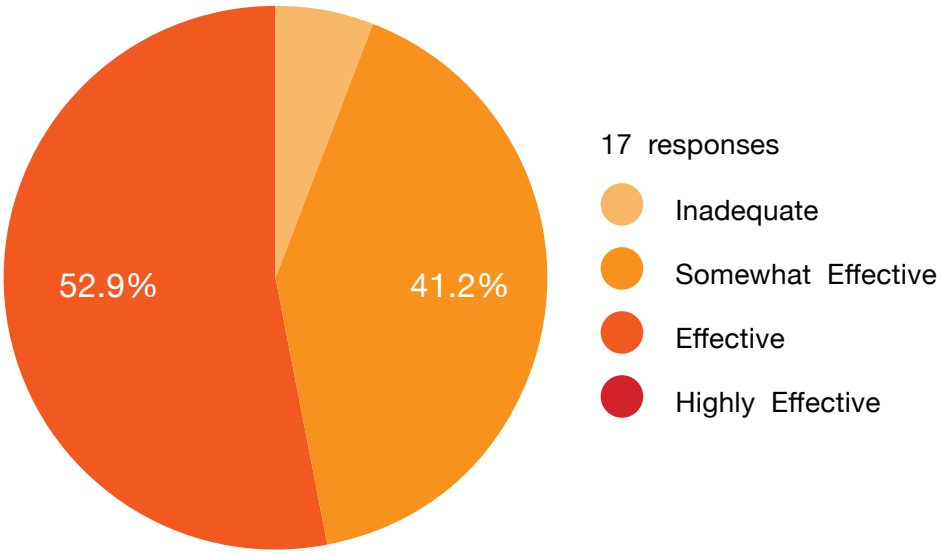
Q. 1: What is your general assessment of India's terrorism threat scenario?



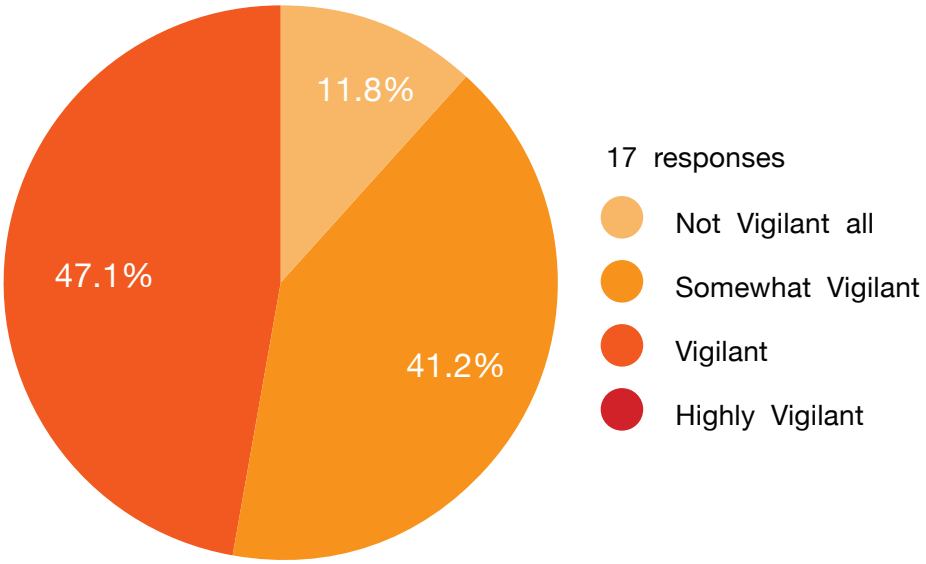
Q. 2: How do you see linkages between nuclear issues and terrorism?



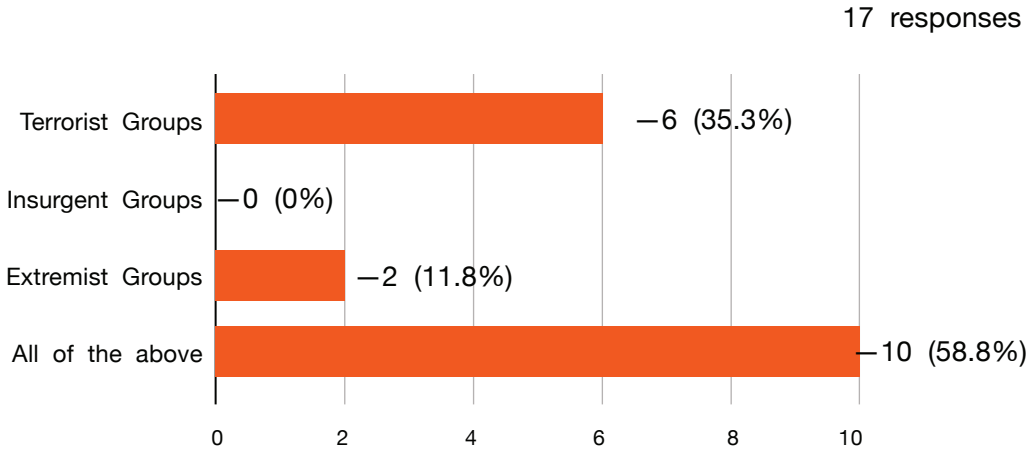
Q. 3: How do you assess border security in preventing nuclear material theft?



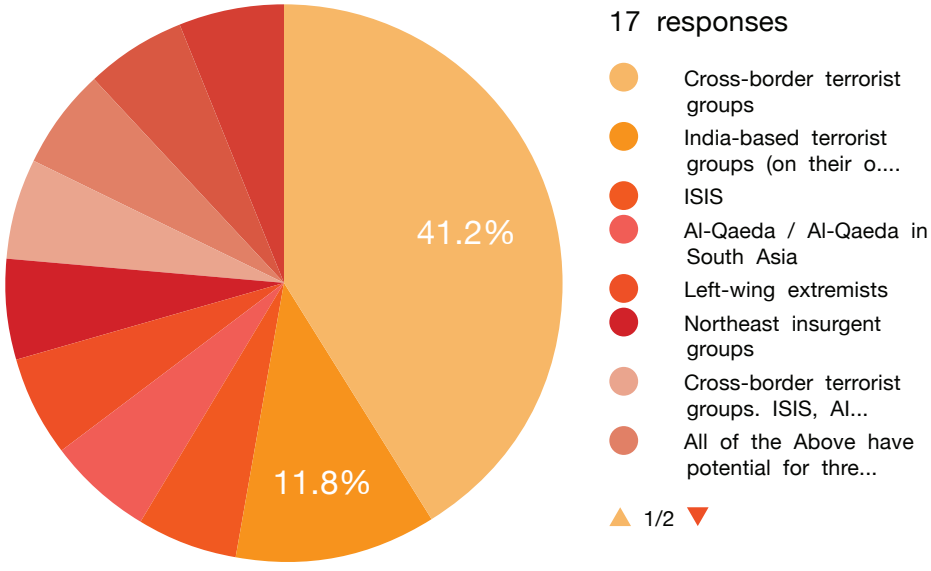
Q. 4: How vigilant are the policy and technical wherewithal to detect the movement of nuclear materials in border areas?



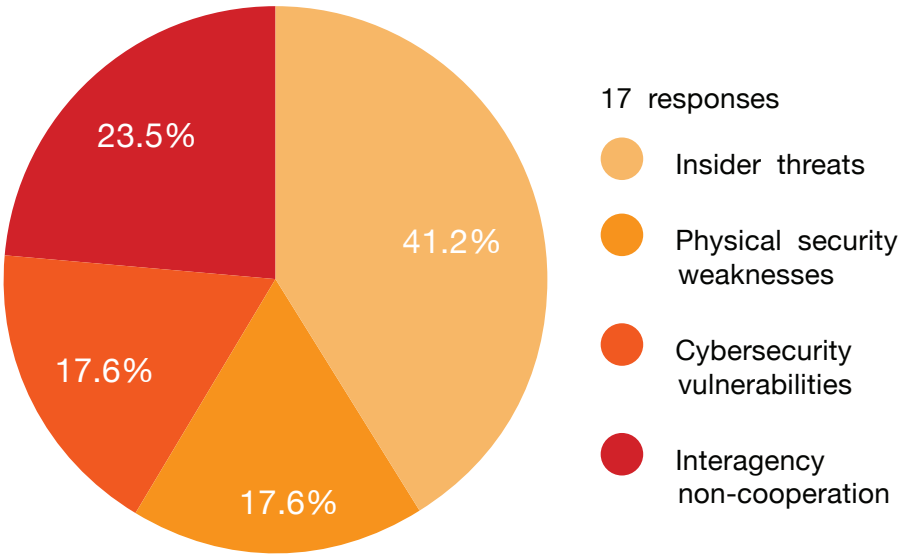
Q. 5: What are the different types of non-state actors that could pose a nuclear threat to India?



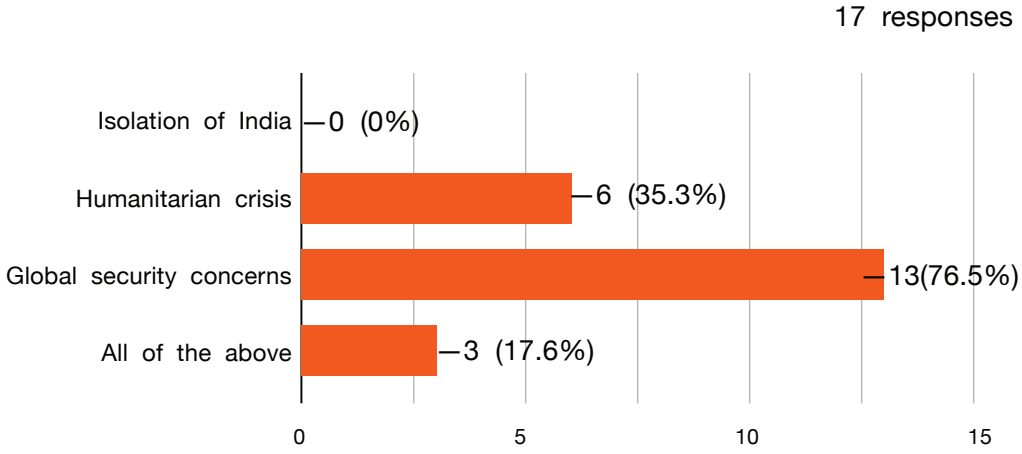
Q. 6: Which of the following are threats posed to India?



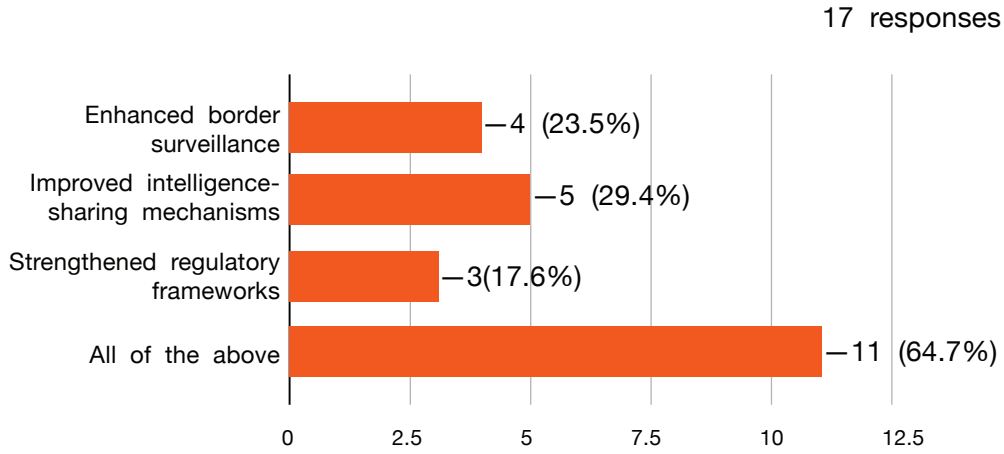
Q. 7: What are the known vulnerabilities in India's nuclear programme that terrorists could exploit?



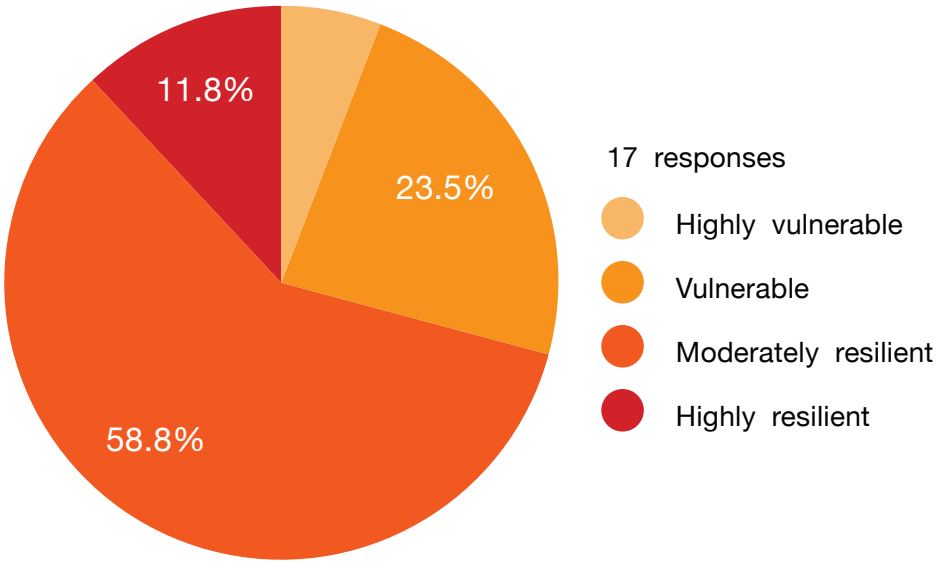
Q. 8: What would be the potential consequences of a nuclear terrorist attack in India, and how would the international community respond?



Q. 9: What policies or initiatives do you think should be prioritised to strengthen India's nuclear security posture?



Q. 10: How resilient do you think India's nuclear infrastructure is to cyber-attacks?



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