Terrorism & health

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Abstract

Terrorist attacks are human perpetrated community disasters that injure the innocent and spread fear, anxiety, and dread throughout the population. After a terrorist attack, many people exhibit striking resilience and may even report beneficial outcomes. However, a large body of work has also linked exposure to terrorist attacks with deleterious physical and mental health outcomes. Directly exposed individuals may be physically impacted through injury or exposure to environmental contaminants and are at risk for psychosocial difficulties including Posttraumatic Stress Disorder (PTSD), anxiety, depression, and functional impairment; indirectly exposed individuals, such first responded, are also negatively impacted. Moreover, after an attack, many citizens are exposed through the media, including television, newspaper, radio, and social media coverage; consequences of this media-based exposure often mimic those generally associated with direct exposure to traumatic events. While proximity to terrorist acts has been correlated with negative outcomes in some instances, a large body of research indicates that proximity to an event and symptoms do not necessarily co-occur in a "dose-response" relationship; people far removed from the event may experience deleterious physical and mental health consequences. Longitudinal studies further suggest that effects may be persistent. Physiological reactions and coping strategies may help explain variability in outcomes. Clarifying the predictors of adaptive and maladaptive responses is essential to advance theory and inform the design and administration of more effective post-attack services.

Key points

- Define terrorism and outline its characteristics
- Present the historical context for empirical studies of the health effects of terrorist attacks
- Present an overview of the common mental and physical health outcomes associated with exposure to terrorism
- Discuss types of exposure to terrorism, including direct, indirect, and media-based exposure

Glossary

Indirect Exposure Witnessing a collective trauma through exposure to personal narratives in the context of one's professional role
Media-based exposure Witnessing a collective trauma through the media
Posttraumatic Growth Positive psychological change that occurs after struggling with a challenging life circumstance

Relative Risk Appraisal Process that links exposure to an adverse event with subjective appraisal of future risk
Religiosity Active participation in religious activities or social structures
Resiliency Capacity of individuals to adapt successfully to disturbances/adversities that threaten the stability of their lives; the ability to "rebound" when one's ability to function has been impaired to some degree by an adverse experience
Resistance The ability to withstand or adapt to adversity—"psychological immunity" to stress
Secondary Stressors Practical strains that occur as a result of a larger negative event

Introduction

Terrorist attacks are unique community disasters. They are random, uncontrollable, and unpredictable events, perpetrated by humans for the specific objective of generating fear and anxiety in the populace (**Silver and Matthew, 2008**). Exposure to terrorism occurs in a variety of contexts, including through the media, with a wide range of deleterious consequences for physical and mental health. In this article, we provide an overview of the definition of terrorism and define its historical context. We then present an overview of the deleterious physical and mental health outcomes associated with exposure to terrorist attacks. The myriad types of exposure that occur throughout the populace are then outlined. Finally, policy implications and directions for preventing and addressing terrorism are discussion.

Definitions and characteristics

Terrorism remains difficult to define at least in part due to the shifting terrorism landscape (e.g., cyberterrorism, lone offenders) (**Combs, 2018**; see **Gross et al., 2017**; **Perry et al., 2018**). Additionally, while countries typically have state-approved definitions of terrorism, varying national perspectives and priorities have led to years of continued debate on an appropriate universal definition of terrorism at the international level (**United Nations, 2021**). Yet there are many overlapping elements across varying definitions of terrorism, many of which are addressed in a 2012 Academic Consensus that defines terrorism as a fear-generating tactic with primarily political or ideological undertones, often executed for propagandistic and psychological purposes (**Schmid, 2012**), even though not uniformly (**Silver and Matthew, 2008**).

In contrast to conventional warfare, terrorist attacks are aimed at civilians rather than military combatants; the "rules" of warfare are often completely disregarded. Consequently, the injured tend to be innocent and defenseless victims, indiscriminately harmed by brutal and often shocking means. Importantly, terrorism targets the broader population, not only those physically attacked in order to intimidate, frighten, destabilize, and impair societal functioning (**Schmid, 2012**). This manipulation of the cognitive and emotional mechanisms of the fear response seeks to elicit broad perceptions of a threatening surrounding environment. Such appraisal processes are integral components of the stress process generally (**Lazarus and Folkman, 1984**) and terrorist acts specifically (**Cairns and Wilson, 1989**), with potentially long-lasting psychological and physical consequences (**Silver, 2011**).

Terrorism can be perpetrated by individuals, organizations, and governments. Much of what is discussed in the literature is terrorism perpetrated by individuals or organizations. Although state-sponsored terrorism has received much less attention, it is a tool sometimes used by governments to protect their interests and spread their ideology on the international stage. This article will focus on the impacts of individual or organizational terrorism, as it comprises the bulk of the literature on psychosocial responses.

Terrorist acts can be further broken down into domestic terrorism (i.e., acts used to advance ideological goals propagated by domestic actors, such as the Oklahoma City bombing; see **Federal Bureau of Investigation, 2020**) and international terrorism [i.e., acts from foreign terrorist organizations or nations, such as 9/11 (18 U.S.C. § 2331)]. This distinction can elicit different psychological and behavioral responses from the affected population. In the case of the 9/11 international terrorist attack there was a widespread increase in shared national identity among Americans (**Li and Brewer, 2004**) and a noticeable shift toward greater conservatism in many (**Bonanno and Jost, 2006**). Domestic terrorist events have proven more difficult to classify as the perpetrators' motivations may be less readily understood and the event definitionally blurred with hate crimes or acts of mass murder as is the case in many mass shootings (e.g., 2017 Las Vegas shooting; see **Dolliver and Kearns, 2022**). Without a clear "us" versus "them," as is typically the case with international terrorism, domestic terrorist events are more susceptible to media bias (**Zulli et al., 2021**) and lend themselves well to divisive sociopolitical responses.

Terrorism impacts the population by: (1) harming the directly attacked, (2) causing illness and injury from debris and other harmful toxins released into the surrounding area (e.g., bombs exploding), (3) creating "secondary stressors" through disruption of daily life (e.g., access to services such as healthcare and transportation) (e.g., **De Cauwer et al., 2017**; **Shalev et al., 2006**), (4) causing psychological distress to both the directly exposed and the broader population through indirect or media-based exposure, and (5) damaging individuals' physical health as a result of a heightened acute stress response (e.g., **Garfin et al., 2018b**; **Holman et al., 2008**). As a result of these multifaceted and far-reaching effects, terrorism has challenged clinicians, researchers, and policy makers seeking to better understand population-level reactions to these events. How are individuals and communities affected? What predicts resilience or vulnerability to the negative impacts of these events? What are the long-term repercussions of terrorism? Who is in need of interventions? Which services are most effective in promoting health following exposure to terrorism? How widely and when should services be distributed

throughout the population? In investigating these questions, stakeholders are more able to prepare and mobilize resources in the event of future terrorist attacks.

Historical perspective

Formal studies of the human psychological impact of terrorism began with studies of the conflict in Northern Ireland. Early inquiries acknowledged the potential for terrorism's long-term negative health repercussions, but lacked methodologically stringent designs (**Curran, 1988**). Since these early inquiries, there has been a vast expansion of studies examining responses to terrorism and exploring practical and theoretical issues with some using improved designs such as longitudinal assessments and/or representative samples. The majority of this work has focused on Israel (e.g., **Berger et al., 2007**; **Gelkopf et al., 2012**; **Hobfoll et al., 2006, 2009**; **Pfefferbaum et al., 2019**), the Alfred P. Murrah Federal Building bombing in Oklahoma City (e.g., **North et al., 2004**; **Pfefferbaum et al., 2001**; **Tucker et al., 2016**), and, most prolifically, the September 11, 2001 (9/11) attacks on the World Trade Center (WTC) in New York City and the Pentagon building in Washington, DC (e.g., **Garfin et al., 2018a**; **Schlenger et al., 2002**; **Silver, 2011**; **Silver et al., 2002**). Other work has focused on the Madrid bombing of 2004 (e.g., **Conejero and Etxebarria, 2007**), the 2005 bombings of the London transportation network (e.g., **Brewin et al., 2010**), the Boston Marathon bombings (e.g., **Garfin et al., 2020**; **Holman et al., 2014**), and the Utøya Island mass shooting (e.g., **Dyb et al., 2014**; **Stene et al., 2016**; **Thoresen et al., 2012**). Many of these studies have used epidemiological methods to describe responses throughout the population. This flourishing area of research has tangible implications for those seeking to mitigate the physical and mental health burdens often associated with acts of terrorism.

Commonly studied outcomes

Posttraumatic stress disorder (PTSD) and posttraumatic stress symptoms (PTS) are by far the most commonly studied outcomes after terrorist acts (e.g., **Dyb et al., 2014**; **Shalev et al., 2012**). As stated in the DSM-5 (American Psychiatric Association, 2013), a diagnosis of PTSD requires direct exposure to a traumatic event involving actual death or injury to oneself, the direct witnessing of such an event to another, or repeatedly hearing adverse details of an event (e.g., first responders, medics Criterion A). A PTSD diagnosis also requires at least one intrusion symptom (Criterion B; e.g., nightmares, persistent or recurring memories of the event), one or two avoidance symptoms (Criterion C; e.g., avoidance of trauma-related stimuli), two or more negative alterations in cognitions or mood (Criterion D; e.g., feeling isolated, overly negative thoughts about oneself or the world), and two or more alterations in arousal and reactivity (e.g., hypervigilance, difficulty sleeping). Notably, criteria for PTSD changed markedly from DSM-IV (American Psychiatric Association, 2000), with pre-2013 studies of terrorism likely followed earlier criteria. Importantly, given that PTS symptom structures in those directly, indirectly (heard a personal narrative) and via the media exposed to terrorist attacks is strikingly similar (**Suvak et al., 2008**), the utility of relying on Criterion A as a prerequisite for a PTSD diagnosis has been questioned (**Brewin et al., 2009**; **May and Wisco, 2016**). Consequently, to capture symptomatology in the broader population, researchers often examine PTS after terrorist attacks, measuring traumatic stress responses without the use of Criterion A. Such issues are particularly important in the context of terrorism, where the intention is to frighten and intimidate large populations and the vast majority of those impacted are indirectly exposed.

Other commonly studied outcomes include acute stress reactions (e.g., **Holman et al., 2008, 2019**), anxiety disorders (e.g., **DiMaggio et al., 2007**), general distress (e.g., **Shalev et al., 2012**), functional impairment (e.g., **Neria et al., 2013**; **Shalev et al., 2012**; **Silver et al., 2002**; **Stene et al., 2019**), depression (e.g., **Bowler et al., 2016**; **Henrich and Shahar, 2008**; **Kar, 2019**), ongoing fear and worry about future attacks (e.g., **Holman and Silver, 2005**; **Thompson et al., 2019**), sleep disturbances (e.g., **Goodwin et al., 2018**; **Grønli et al., 2017**; **Porcheret et al., 2022**), and changes in political views (e.g., **Morgan et al., 2011**; **Torabi and Seo, 2004**). Behavioral and attitudinal shifts, which can have important lifestyle and public health implications, have also been examined. For example, after the 2005 London transportation network bombings, 23% of people reported that they felt unsafe on public transit, and 76% intended to travel less because of the bombings (**Rubin et al., 2005**). Similarly, after 9/11, anxiety about future terrorist attacks was positively correlated with choices congruent with a more sedentary lifestyle (e.g., more time spent indoors and tendency to watch more television) (**Torabi and Seo, 2004**). Moreover, attitudinal changes may present differently depending on the sociodemographic characteristics (e.g., age, gender) of the affected persons. For example, adolescent survivors of the Utøya Island shooting displayed lower academic performance and increased school absences with greater impairments reported by female students (**Stene et al., 2019**; **Strøm et al., 2016**), potentially indicating decreased academic achievement motivation following the terrorist attack and differential impacts based on gender.

Although most of the research on terrorism has focused on psychopathology and other deleterious psychosocial outcomes, positive and adaptive responses have also been studied. In the wake of a terrorist attack, some report a better appreciation of life, more meaningful personal relationships, changed priorities, and a richer existential or spiritual life (**Shaw et al., 2021**; **Tedeschi and Calhoun, 2004**). For example, in a nationally representative sample, 57% of Americans reported perceived societal benefits (e.g., increased political or religious engagement and prosocial behavior) that occurred following 9/11 (**Poulin et al., 2009**). Similarly, a review by **Morgan et al. (2011)** noted that prosocial behaviors such as donating blood and money and patriotism increased after 9/11.

Research on resiliency (ability to rebound after distress-inducing adversity) and resistance (psychological "immunity" to the negative impact of adversity) is important given that positive adjustment is frequent (**Bonanno et al., 2006**; **Curran, 1988**; **Pietrzak et al.,**

2014; **Schlenger et al., 2002**; **Silver et al., 2002**). For example, in a population-based study of 2752 New York residents conducted approximately 6 months after 9/11, resilience was common; high resilience was indicated in 65.1% of the sample, and 33% failed to endorse more than one symptom of PTSD (**Bonanno et al., 2006**). A study of WTC responders (police and non-professional volunteers such as construction workers) found overall high levels of PTSD resistance trajectories, but police responders were significantly more likely to exhibit resistance (78%) compared to non-traditional responders (58%), perhaps indicating a protective effect of professional training on resistance to PTSD (**Pietrzak et al., 2014**). Yet not all studies have found such widespread positive adaptation. In a longitudinal, representative sample of Israeli Jews and Arabs during the Second Intifada (2004–05), a time of heavy terrorist and rocket attacks, only 22.1% of participants exhibited resistance, a minority exhibited resilience, and the majority (54%) exhibited a chronic distress trajectory (**Hobfoll et al., 2009**). Variability in these profiles could be explained by several factors; better outcomes were associated with being male, Jewish (i.e., not the minority in Israel), higher income, higher education, less psychosocial resource loss, and less economic loss (**Hobfoll et al., 2009**). These findings may provide useful information to help capitalize on people's natural strengths in the aftermath of terrorism and may help identify people less likely to exhibit resilient or resistant responses. This may help guide the design, implementation, and distribution of interventions to increase adaptive responses in the population.

In a related vein, posttraumatic growth (PTG), or positive psychological change experienced as a result of struggle with highly challenging life circumstances, has been documented after terrorist attacks (**Blix et al., 2015**; **Pollari et al., 2020**; **Pooley et al., 2013**; **Tedeschi and Calhoun, 1996**; **Tucker et al., 2016**). Several studies have demonstrated an observed positive relationship between event centrality (i.e., fundamental integration of the event into one's identity or personal narrative) and PTG as was seen in a longitudinal study of 2011 Oslo bombing survivors, although the direction of the relationship is undetermined (**Blix et al., 2015**). PTG may develop or persist over an extended post-attack period. Among individuals directly exposed to the Oklahoma City bombing, more than 18 years after the attack, over half of respondents reported that they experienced at least a moderate degree of growth across seven (out of 10) positive growth items (e.g., "I have a greater appreciation for the value of my own life) on the Posttraumatic Growth Inventory (PTGI-S) (**Tucker et al., 2016**). Of note, while PTG and resilience might both be viewed as "positive outcomes" associated with exposure to negative events, they are best viewed as distinct concepts. As indicated in a study of adolescents, citizens, and army personnel exposed to terror in Israel and after the second Lebanon War, PTG and resilience were inversely correlated (**Levine et al., 2009**). This suggests while resilience may reflect a lack of distress or an ability to bounce back following exposure, PTG involves using the experience to grow as an individual. It is also possible that for some individuals, the process of managing distress symptoms and overcoming them leads to enhanced psychological development.

Type of exposure

Every terrorist act, by definition, has directly and indirectly exposed targets. As a result, it is important to consider the impact of these acts on those exposed, directly, indirectly, and via the media. Without considering the full range of intended targets, we cannot accurately understand the toll terrorism takes on human mental and physical health.

Direct exposure

Those directly exposed to terrorist attacks are at risk for mental and physical health problems – effects that are frequently linked (**Holman et al., 2008**; **Li et al., 2018**; **Nair et al., 2012**; **Yu et al., 2021**) and may influence each other in a bidirectional manner (**Robinson, 2003**; **Sharp and Harvey, 2001**). After the 9/11 terrorist attacks, many rescue workers were involved in clean up and recovery efforts and subsequently developed associated mental health problems. In a study of 28,962 WTC disaster workers, prevalence of PTSD was 12.4%; greater risk was correlated with less preparation and training, earlier start date, and longer duration of service (Perrin et al., 2007). After 9/11, of those enrolled in the WTC Health Registry (described above), 24.5% reported both lower quality of life and more unmet mental health needs (**Nair et al., 2012**). After controlling for demographic and 9/11-related exposures, participants with lower respiratory symptoms were more than 4 times as likely to have met criteria for PTSD; those with poorer quality of life 2–3 years after 9/11 were more likely to have died 5–6 years post-9/11. Additionally, deleterious health outcomes may develop over time and differ depending on the life stage of the survivor. For example, a longitudinal study found that adolescents directly exposed to 9/11 who developed behavioral problems were more likely to be consistent smokers in adulthood and were 3.5 and 6 times more likely to have probable PTSD and depression respectively, demonstrating the importance of capturing the unique needs of adolescent terrorist attack survivors (**Gargano et al., 2018**). Such findings illustrate the link between physical health problems, stress physiology, emotional states, and psychopathology.

Mental health

A growing body of research has demonstrated the lack of a clear dose–response relationship between exposure to terrorist attacks and mental health outcomes (e.g., **Thoresen et al., 2012**). In a study of residents from two suburbs of Jerusalem (one directly exposed to terrorist attacks and one indirectly exposed), both communities reported financial burdens, interruption of daily life, trauma exposure (although the directly exposed community reported more), and PTS symptoms (**Shalev et al., 2006**). Importantly, this study did not find a proximity effect; that is, rates of PTSD were not statistically different in directly and indirectly exposed populations. However, the authors acknowledge the potential for a "ceiling effect," as both cities were located relatively close to Jerusalem, where terrorist attacks frequently occur. Similarly, degree of exposure to terrorism was unrelated to traumatic stress-related symptoms in a nationally representative sample

of Israeli adults (**Bleich et al., 2003**); cultural factors or habituation may offer a partial explanation for these findings. Most recently, researchers demonstrated that extended exposure to media coverage of the Boston Marathon bombings (3 or more hours per day in the week following the attack) was associated with higher levels of acute stress symptoms than was direct exposure (being at or having a loved one present at the bombings (**Holman et al., 2014**). Following the 2011 terrorist attacks in Oslo and Utøya Island, psychological proximity characterized by worry for a close other or having a close relationship to a relative of a victim was a unique predictor of PTS while geographic (physical) proximity was not a predictor (**Thoresen et al., 2012**). These findings raise questions about the meaning and impact of "direct" exposure and suggest the need for a more nuanced definition of exposure to terrorist attacks and other collective traumas.

After exposure to any traumatic event, including terrorist attacks, many people's psychological distress will abate over time. However, for others, symptoms will persist or subsequently emerge. For example, in a longitudinal study of survivors of the 1974 terrorist attack on Ma'a lot, Israel, where a group of high-school children were taken hostage, a vast majority of survivors reported persistent event-related PTS over 17 years later (**Desivilya et al., 1996**). Similarly, while WTC disaster recovery workers exhibited substantial reductions in distress between assessments taken at 1–2 years, 3–4 years, and 5–6 years postattack, many workers continued to present with symptoms and others experienced delayed-onset PTSD (**Cukor et al., 2011**). A study of firefighters and emergency medical service workers 7–9 years post-9/11 found that 7% still met criteria for probable-PTSD and 19.4% had probable depression (**Webber et al., 2011**). A longitudinal study of 16,488 rescue and recovery workers taken from the WTC Health Registry, 10–11 years post-9/11, identified that over 10% were in higher risk PTSD trajectories (i.e., moderate-increasing and high-stable) demonstrating that their PTSD symptoms were either continuing to increase over time or resisted abatement even a decade after the attack (**Maslow et al., 2015**). Ongoing exposure may be especially distressing over time: in a sample of 709 Israeli Jews and Arabs, exposure to ongoing terrorism following the second intifada was associated with chronic distress in a majority (54.1%) of participants (**Hobfoll et al., 2009**). Importantly, while physical health conditions (discussed in the following section) may be more readily diagnosable and treatable, mental health care needs may go undetected or treated, Indeed, data from a WTC Health Registry study (N = 36,897) showed those participants with post-9/11 PTSD and/or depression had the highest rates of unmet mental health care needs (**Jordan et al., 2019**).

Physical health

Terrorist attacks cause physical injury to the individuals who are the direct recipients of the violent act. Before 9/11, the Murrah Federal Building bombing killed more people than any previous act of terrorism on American soil: 167 people died and 592 sustained injuries (**Mallonee et al., 1996**). However, the 9/11 attacks were unprecedented in terms of the number of casualties, physical injuries, and damage to the physical landscape. The plane crash, subsequent collapse of the twin towers, smoldering fires, and removal of debris spewed chemical contaminants, glass, steel, cement, fires, and jet fuel over the densely populated Manhattan area, impacting the respiratory health of those exposed (**Landrigan et al., 2004**). The people most at risk included firefighters and other first responders, although residents from the surrounding areas were also impacted. A survey conducted on 2812 residents approximately 12 months after the attacks found that 55.8% of residents in the highly exposed area closest to Ground Zero developed respiratory problems, compared to 20.1% in a control area (**Reibman et al., 2005**). Of relevance to mental health outcomes, environmental contaminants may have interacted with the psychological stress of experiencing the terrorist attacks, as indicated by studies linking 9/11-related PTSD and respiratory problems (e.g., asthma) (**Fagan et al., 2003**; **Jordan et al., 2019**). Such effects did not necessarily wane over time. Exposure to 9/11 was associated with both asthma and PTS symptoms 5–6 years after the WTC collapse; in analyses of a longitudinal cohort study that drew on data from the World Trade Center Health Registry (the largest post-disaster registry in the United States history, total N = 71,437), asthma and PTS symptoms often cooccurred in individuals directly exposed to the attacks (e.g., office workers, those involved in the rescue efforts, and passersby) (**Brackbill et al., 2009**; **Nair et al., 2012**). Moreover, 10–11 years after the attack, 57% of respondents with delayed PTSD trajectories and 69% with chronic PTSD reported comorbidity with physical (e.g., asthma, pulmonary fibrosis) and mental health outcomes (e.g., depression, anxiety) (**Li et al., 2018**). Relatedly, another WTC Health Registry study (N = 29,012) found that 9/11-related PTSD was a risk factor for having recurrent strokes underscoring the importance of investigating the interactions between mental and physical health outcomes after terrorist attacks (**Yu et al., 2021**).

Data from the WTC Health Registry study further suggest that standardized mortality ratios for rescue workers and non-rescue workers were actually lower than those for the New York City region overall (**Jordan et al., 2018**). However, exposure to dust near the WTC attacks was associated with increased risk for severe headaches, skin rash, heartburn, heart disease, and stroke when respondents were compared to those who had not been exposed to the dust (**Brackbill et al., 2006**; **Jordan et al., 2011a,b**; **Yu et al., 2021**). Indeed, respondents who (1) were not involved in the rescue/recovery and (2) reported intermediate/high levels of WTC dust/debris exposure had higher mortality when compared to respondents with low exposure—a finding driven largely by greater cardiovascular mortality in the highly exposed group. However, these results need to be considered cautiously as the convenience sample included only 14% of eligible respondents, all of whom volunteered for the study, and importantly, the "pre-9/11" health data were retrospectively recalled 2 years after the 9/11 attacks (**Brackbill et al., 2006**). Nonetheless, there are important implications for healthcare service utilization, which may increase throughout the population following acts of terrorism (**Holman and Silver, 2011**; **Stene et al., 2016**). For example, a study of 444 Manhattan residents examined hospital administrative records and found that health service utilization, outpatient visits, and functional impairment increased the year following 9/11; greater loss was associated with worse outcomes (e.g., more missed work and greater psychological distress (**Neria et al., 2013**)).

Additionally, access to and utilization of healthcare services may vary significantly depending on the sociodemographic characteristics of the affected population. Such was the case for immigrant survivors of the Utøya Island mass shooting who were more likely to have unmet healthcare needs and be less satisfied with follow-up efforts indicating more attention is needed to ensure all groups can access ser-

vices equitably after terrorist attacks (**Stene et al., 2016**). More directly, terrorist attacks often target healthcare facilities, creating an immediate impediment for those seeking treatment, and halting treatment for people who may have been under medical care prior to the attacks (**De Cauwer et al., 2017**). In Ireland in the 1980s, terrorists frequently used this tactic, targeting healthcare workers and hospitals, which resulted in broad and detrimental health consequences throughout the community (**Zwi and Ugalde, 1989**). Besides directly harming the physical health of those in need of healthcare, such actions further generate anxiety in the population about access to necessary services.

Indirect exposure

Indirect trauma exposure can occur through occupational exposures such as hospital staff or relief workers who care for victims and thus hear survivor narratives or experience other distressing and repeated exposures to attack-related details as a function of their job. A study of relief workers demonstrated acute PTSD (less than 3 months) in 4.6% of those who heard survivor narratives and 6.4% of those directly exposed; 6–8 months later, none met criteria for full PTSD (**Zimering et al., 2006**). Such striking resilience could be explained by a combination of intervention, pre-9/11 trainings, and the personal disposition of those who choose to be recovery workers. One month after the November 2015 Paris terrorist attacks healthcare personnel who had participated in rescue and relief efforts exhibited probable PTSD rates 2.76 times that of healthcare personnel who did not directly participate in rescue operations demonstrating that a dose-response may be more prevalent among those indirectly exposed through occupational exposure (**De Stefano et al., 2018**). About a year after the 2016 terror attack in Nice where a truck rammed into a crowd of people during a Bastille day celebration, 9.6% of hospital workers with "professional exposure" (i.e., those staff not on site during the attack but cared for victims of the attack) exhibited probable PTSD compared to 12.2% of those hospital workers that were directly exposed to the attack (**Bentz et al., 2021**). Future research on the relationship between indirect exposure and PTSD symptoms is essential given this body of evidence.

Media-based exposure

Terrorist attacks, when considered in the context of the increasingly media-saturated nature of our society, stand in stark contrast to traditional warfare. People geographically distant from terrorist events are quickly exposed through radio, television, print, and social media. This allows for events to be transmitted rapidly and as they occur (**Silver and Matthew, 2008**) and for repeated exposure to disturbing images (**Ahern et al., 2002**; **Holman et al., 2019**). Indeed, over 60% of Americans watched the 9/11 terrorist attacks occur live on television (**Silver et al., 2002**). Many repeatedly saw the planes crashing into the WTC or people falling or jumping from the towers in postattack news coverage (**Ahern et al., 2002**). This media exposure can have striking physical and mental health consequences. Research conducted after the Oklahoma City Murrah federal building bombings first provided convincing evidence that individuals only exposed to terrorism via the media could exhibit symptoms typically associated with direct exposure to traumatic events (**Pfefferbaum et al., 2018**). Seven weeks after the bombing, television exposure was correlated with PTS in middle school students without physical or emotional exposure to the event (**Pfefferbaum et al., 2001**); these effects extended to print media as well (**Pfefferbaum et al., 2003**). Additionally, the media may pose a distinct challenge to wellbeing through cyclical impacts wherein those who experience PTS and increases in worry after media-based exposure to one violent event (e.g., the Boston Marathon bombings) may engage in greater amounts of media coverage of the next violent event (e.g., Pulse nightclub massacre) furthering their distress (**Thompson et al., 2019**). Importantly, media exposure to terrorist attacks does not occur in a vacuum. In fact, those who are exposed to greater media coverage of terrorist attacks may likely be engaging in greater coverage of other collective traumas (e.g., COVID-19, climate disasters) compounding the impact of media-based exposure to these collective traumas (**Silver et al., 2021**).

Mental health

Research conducted after the September 11th terrorist attacks significantly expanded this research and stood in stark contrast to traditional views of post-disaster mental health, which predict a linear relationship between proximity to a traumatic event and psychological distress (**Marshall et al., 2007**). The psychological effects of 9/11 were evident across America and even extended to other continents, as school children in London reported PTS associated with 9/11-related television exposure (**Holmes et al., 2007**). Throughout America, increased 9/11 television coverage, as well as specific gruesome images, were positively associated with 9/11-related PTS (**Ahern et al., 2002**; **Bernstein et al., 2007**; **Schlenger et al., 2002**). Effects persisted for years after the attacks; the amount of television exposure in the week following 9/11 was positively associated with PTS symptoms and physical health problems 2–3 years later (**Silver et al., 2013**). As smartphones and social media have become the primary mode of news transmission for adolescents and young adults (**Anderson and Jiang, 2018**) there is increasing evidence to support the link between internet-based media exposure and mental health outcomes. For example, in the wake of the Boston Marathon bombings, Boston-area youth spent approximately 2 h per day watching news coverage related to the event and event-related exposure was significantly related to child PTSD symptoms even after accounting for direct exposure (**Comer et al., 2016**). Furthermore, post-event media exposure can serve to exacerbate negative psychological outcomes of individuals indirectly and via the media; prolonged grief was associated with four or more hours of daily media coverage in bereaved parents and siblings of the Utøya Island shooting (**Kristensen et al., 2016**).

Terrorism-related media exposure may promote distress long after the event's initial occurrence (**Robert et al., 2021**). Those who watched more anniversary coverage of 9/11 exhibited higher PTSD and were more at risk for developing delayed-onset PTSD 1-year post-attack (**Bernstein et al., 2007**). Research conducted after other terrorist attacks echoed these findings, although not conclusively.

For example, after the 2005 London transportation network bombings, 31% of people in a representative sample of Londoners reported substantial stress (**Rubin et al., 2005**) and 11% continued to report substantial stress 7 months later (**Rubin et al., 2007**). In contrast, two days after the Dimona bombings in Israel, researchers conducted a telephone survey of randomly sampled adults, stratified by proximity, and found that distress symptoms (anxiety, stress, and fear) were higher in those geographically closer to the event (**Amital et al., 2012**). These findings suggest that geographic proximity may have a stronger effect in the immediate aftermath of a terrorist attack, perhaps due to secondary stressors that interrupt daily life and essential services or a variety of other factors. Proximity may matter less after the debris has been cleared and basic services restored, but the psychological residue remains (**Amital et al., 2012**). Taken together, these findings have important implications for post-disaster intervention: in the immediate aftermath, it may be important to focus efforts on restoring basic services, whereas other forms of psychosocial intervention should be distributed more widely as time progresses.

Physical health

As the connection between mental and physical health is increasingly understood, it is important to consider the link between terrorism-related distress in those exposed indirectly and via the media and subsequent physical health consequences. For example, after 9/11, healthcare utilization increased dramatically, and not just for the direct victims of the attacks (**Holman and Silver, 2011**). Psychological reactions in the immediate aftermath of terrorism may have long-term implications for physical health: among those both indirectly and directly exposed to 9/11, more severe acute stress reactions predicted significantly increased incidence of cardiovascular problems 3 years after the attacks in a nationally representative sample (**Holman et al., 2008**). Early exposure to television reports about the 9/11 attacks was associated with increased incidence of physical ailments over the 3 years following 9/11 among respondents living across the United States (**Silver et al., 2013**). These findings are unique in that health status collected before 9/11 was included in the analyses, thus demonstrating increases in physical health ailments over 3 years following the attacks. The consequences of terrorism may even extend to fetal health: gestation during 9/11 was associated with increased male fetal death (**Bruckner et al., 2010**), and babies born to mothers who were exposed to 3 days of aerial bombardment in their second trimester during the Arab–Israel war of 1967 had higher incidence of schizophrenia (**Malaspina et al., 2008**). In sum, there is a growing body of research demonstrating the negative physical health impacts of indirect exposure to terrorism. These findings suggest that widespread psychological terror does more than intimidate and instill fear. It can also translate into physiologic stress responses strong enough to trigger pathophysiology consistent with stress-related diseases.

Mechanisms of adverse responses

An important theoretical and practical issue relates to the process by which exposure to terrorism is translated into physical and mental health outcomes. The theory of relative risk appraisal draws from the cognitive science, risk appraisal, traumatic stress, and psychopathology literature to define the psychological processes linking exposure to terrorist events and subjective responses (**Marshall et al., 2007**). As viewed in the cognitive sciences, human perception is a multidimensional process, as we are actively engaged in interpreting information from the environment. A "dose–response" perspective linking proximity and response implements a classical behaviorist "stimulus–response" model that fails to account for the role of other factors that influence health outcomes (e.g., individual differences, social surroundings, prior experiences, and demographic factors) in the wake of a terrorist event. For example, some research findings support a sensitization effect such that those who were exposed (both indirectly and directly) to previous collective traumas exhibited heightened acute stress responses after the Boston Marathon bombings (**Garfin et al., 2015**). Through "catastrophic secondary appraisal," information from the environment (which includes both direct and indirect exposure to an event) alters our views of a potential threat, and may predict subsequent PTSD (**Engelhard et al., 2002**). A tendency toward maladaptive emotion regulation strategies (e.g., catastrophizing and rumination) prior to an event can also predict negative outcomes (e.g., PTSD) post-event as was demonstrated by media-exposed Boston-area youth after the Boston Marathon attack (**Jenness et al., 2016**). Another characteristic of terrorism that may influence cognitive processes and postattack distress is that an individual or group of individuals are blameworthy in perpetrating terrorist acts; prospective research from the stress and coping literature has indicated that attributing responsibility for a negative event to another person is associated with greater likelihood of subsequent PTSD and greater distress.

A large body of research suggests that biological mechanisms may partially explain variability in health outcomes. Such ideas stem from landmark work done in the 1920s indicating that neurobiological systems are rapidly activated by an individual's perception of threat and by strong emotions (**Cannon and Britton, 1925**). Terrorism may simultaneously act as both an acute and chronic stressor, generating physiological symptoms associated with the acute stress responses (immediate feeling of danger during and right after the attacks) and chronic stressors that may occur as society deals with practical problems resulting from the destructive acts as well as ongoing feelings of worry or dread about future attacks (see **Holman et al., 2008**; **Holman and Silver, 2005**). As people appraise the environment as threatening, multiple components of the stress response may be activated (**McEwen, 1998**, **2007**); such appraisals may similarly occur for both directly and indirectly exposed individuals. Variability in these responses is likely to have a genetic component that may help explain why some people react strongly and experience physical health problems linked to their acute stress response while others adapt more easily (**Holman, 2012**). Indeed, one need not experience terrorism directly to demonstrate genetic susceptibility to stress-related mental and physical health problems (**Holman, 2012**; **Holman et al., 2011**).

Coping

Individuals exhibit wide variability in coping strategies after a traumatic event (**Wortman and Boerner, 2011**; **Wortman and Silver, 1989**). Coping after a terrorist attack may be a product of culture, individual differences, and available resources. A common response is seeking emotional support from other people (see **Rimé, 2009**). After the Nairobi bombings in Kenya, the vast majority (93%) reported using relatives and friends for emotional support; other common responses included seeking professional healthcare services (64%), turning to religion (48%), medication (35%), and alcohol use (11%); most used more than one source (**Zhang et al., 2013**). After the London subway bombings, 75% of people reported a desire to contact others (**Rubin et al., 2005**). Such support seeking may be quite adaptive. Social support appeared to buffer Israeli middle school students from depression following terror attacks by Qassam rockets (**Henrich and Shahar, 2008**). In a related vein, **Mehl and Pennebaker (2003)** found, perhaps surprisingly, that after 9/11, the number of daily social interactions did not increase. However, dyadic and in-person interactions increased, suggesting specificity in the use of social support following acts of terrorism (**Mehl and Pennebaker, 2003**).

Use of various coping strategies has been differentially associated with positive and negative outcomes. Spirituality (an individual's self-perceived commitment to spiritual practices) and religiosity (active participation in religious social structures) predicted more positive physical and mental health outcomes in a national sample of Americans after 9/11 (**McIntosh et al., 2011**). Other strategies have been associated with negative outcomes. **Silver et al. (2002)** found that after 9/11, avoidant coping (e.g., giving up, denial, and self-distraction) and disengaging from coping strategies predicted subsequent PTS. Moreover, the efficacy of coping strategies may be culturally specific. In a study of 913 Israeli adolescents exposed to terrorist attacks, problem solving strategies were correlated with positive outcomes, whereas emotion focused coping was associated with PTS and mental health problems (**Braun-Lewensohn et al., 2009**). The authors note that problem-focused coping might be particularly adaptive in places like Israel where there are constant threats of terrorism.

Associations with subsequent stressors

Reactions to terrorism may also be impacted by negative life events that occur after the event and may also influence reactions to future collective stressors. After 9/11, delayed-onset PTSD and non-remittance of symptoms was predicted by negative life events that happened since the initial attacks (**Adams and Boscarino, 2006**). After the Boston Marathon bombings, those reporting more stressful events in the six months following the attack also reported greater bombing-related posttraumatic stress and functional impairment six months post-attack (Garfin et al., 20).

Conclusion/summary/outlook

The past several decades have seen a proliferation of research examining predictors of physical and mental health outcomes following acts of terrorism. Advances have been made in describing prevalence of, and variability in, maladaptive and adaptive responses. Such research has the potential to advance theories regarding exposure to traumatic events more generally and may help inform the design of evidence-based interventions and more appropriately distributed post-event relief services. Identifying predictors of resilience, resistance, and long-term distress is important as policy makers and healthcare providers seek to mitigate the far-reaching effects of terrorism. Recommendations to prevent and manage terrorism include developing greater awareness and training, continuing efforts to assess and address radicalization and extremism, developing and deploying online counter-messaging efforts when appropriate, and continuing federal efforts to develop and disseminate best practices (**Jackson and Costello, 2019**). Additionally, several advances have been made in the development of evidence-based practices and interventions following terrorist acts (**Watson et al., 2011**). Examples include psychological first aid which seeks to reduce distress and provide practical information after a disaster (see **Watson et al., 2011**), and community-based cognitive therapies, effective in Northern Ireland after the Omagh bombing (**Gillespie et al., 2002**). More general practices may include ongoing assessments, case management, and the design of treatment portfolios for affected individuals (**Neria et al., 2013**).

Future research on terrorism should include more assessments in low-income countries, where terrorist attacks are more frequent but less often empirically studied (**Zwi and Ugalde, 1989**). Work on long-term effects should continue and grow to include more long-term assessments of potential physical health consequences of both direct and indirect exposure. Exploring biological or genetic differences is a particularly exciting area of future research that may help further explain variability in responses. Future research needs to push the boundaries defining "exposure" to include the myriad ways mass media is prolonging our terror-related experiences and potentially enhancing the risk for mental and physical health impacts (**Holman et al., 2014**). Building population resistance and resilience to terrorism's negative health effects requires clarification of the many interacting biological, personal, interpersonal, and societal processes affecting individual and community-level responses. Armed with this broader contextual understanding of the many ways terrorism affects us, we can develop targeted public health interventions that prevent its far-reaching and long-lasting effects.

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