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Global Effects of Nuclear Conflict: Implications for Nuclear Policymaking, Then and Now

SUMMARY

Forty years ago, findings on the global climatic effects of nuclear war first introduced the prospect of "nuclear winter." In the decades since, the consequences of nuclear use have remained only incidental to considerations of nuclear policy. This paper explores that history and presents new research and key questions for policymakers to address given today's increasingly interconnected world. The authors highlight the need for renewed attention to the catastrophic effects of nuclear conflict as a crucial step toward reducing the risk of nuclear use.

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Introduction

Hiroshima, one year after the atomic bombing.

Since 1945, when the United States detonated nuclear weapons over Hiroshima and Nagasaki, the devastating power of the immediate heat, blast, and radiation of nuclear weapons has been well recognized by policymakers. But in today's interconnected and economically interdependent world, a major nuclear conflict, which could escalate from a single miscommunication or blunder, would extend far beyond the immediate areas and the people initially impacted. It would have significant repercussions around the globe, affecting the climate, food supply, public health, critical infrastructure, and global economy. Recent estimates indicate that more than two billion people could be affected in a regional nuclear conflict (and up to five billion as a result of a nuclear war between the United States and Russia), with most victims located in countries not subject to the immediate impacts.[1] Despite these estimates, the far-reaching, global implications of a nuclear conflict are not reflected in countries' nuclear policies and postures.

Efforts to understand the long-term societal effects of nuclear weapons use beyond the immediate blast and radiation effects date back to the early 1980s.[2] In 1983, a group of U.S. scientists introduced the American public to the phenomenon of "nuclear winter": the severe prolonged drop in temperature of the Earth's climate that would likely result from the soot, dust, firestorms, and smoke lifted into the atmosphere after a large-scale nuclear exchange. Although the risk of nuclear winter shaped the public and policy debate about nuclear weapons in the 1980s, comparatively little attention has been paid to this subject—or the cascading societal, economic, industrial, and political devastation that a large-scale nuclear war would visit upon the globe today—since the end of the Cold War.

This paper traces the policy debate and reception to nuclear winter studies in the United States in the 1980s, and outlines major developments since then in the geopolitical, economic, and technological environment that ought to impact considerations around nuclear policy and postures. It argues that the full suite of catastrophic effects of nuclear war, including their cascading impacts on societies and economies in combatant and non-combatant states, and the lack of preparedness to deal with them warrant renewed investigation and consideration of the implications of such effects for U.S. nuclear posture and policy.

[1] L. Xia, A. Robock, K. Scherrer et al., "Global Food Insecurity and Famine from Reduced Crop, Marine Fishery and Livestock Production Due to Climate Disruption from Nuclear War Soot Injection," *Nature Food* 3, (2022), 586–596, https://doi.org/10.1038/s43016-022-00573-0.

[2] Lawrence Badash, *A Nuclear Winter's Tale: Science and Politics in the 1980s* (Cambridge, MA: MIT Press: 2009).

Global Nuclear Effects and Nuclear Policymaking

A review of declassified documents and secondary literature and consultations with policy practitioners conducted by NTI reveal that following the advent of "nuclear winter" studies in the 1980s, some members of the U.S. defense community expressed concern that nuclear winter could undermine the strategic utility and credibility of nuclear deterrence postures—in part, due to potential "boomerang effects"[3] of nuclear use on the United States. Broader understanding of these effects could, in their view, undermine the credibility of nuclear use and therefore of "deterrence as doctrine."[4] Other policymakers, however, suggested that the implications of nuclear winter were "too difficult to contemplate" and that was reason enough to bolster nuclear deterrence, the concept that the threat of retaliation and its unacceptable consequences would inhibit states from using nuclear weapons first. With the dissolution of the Soviet Union as well as progress on arms control after the end of the Cold War, the topic of nuclear winter eventually faded from headlines.

Today's transformed global circumstances demand a renewed consideration of, and investigation into, the global effects of nuclear conflict.

Today's transformed global circumstances demand a renewed consideration of, and investigation into, the global effects of nuclear conflict. With a multipolar nuclear order, the erosion of arms control, and an active war in Europe initiated by a nuclear-armed state, the risk of nuclear war is arguably the highest now since the height of the Cold War more than three decades ago. Global systems have become complex and deeply intertwined in manners that create new vulnerabilities and opportunities for cascading failures with the potential to send ripple effects across diverse spheres such as the environment, economy, and society.[5] Whether it was a ship stuck in the Suez Canal, extreme weather, or a worldwide pandemic, single events in recent years have demonstrated the interdependency of economies and the fragility of global supply chains and critical infrastructure, causing wide-ranging disruptions.

Countries remain dangerously unprepared to deal with global crises and cascading failures. Many measures to increase preparedness and disaster resilience assume that resources for crisis response will be available "elsewhere." Similarly, disaster response mechanisms are often designed to facilitate rapid recovery from singular, sudden shocks but are poorly equipped to effectively deal with long-term and compound crises. The uncontrollable dynamics of cascading system failures and the lack of a playbook for recovery after nuclear use would magnify the harmful effects on populations worldwide.

[3] In this context, the term "boomerang effect" is used to describe the reverberating consequences that would be experienced by the state using nuclear weapons against another country. In simpler terms, it indicates that the consequences of a nuclear strike can come back to impact the nation launching the attack in the first place.

[4] Allen Lynch, *Political and Military Implications of the "Nuclear Winter" Theory* (Institute for East-West Security Studies, 1987), in Badash, *A Nuclear Winter's Tale*, 263.

[5] Federal Ministry of Austria and University of York, *Understanding the Humanitarian Consequences and Risks of Nuclear Weapons: New Findings from Recent Scholarship*, July 2023, https://www.bmeia.gv.at/fileadmin/user_upload/Zentrale/Aussenpolitik/Abruestung/Understanding_the_Humanitarian_Consequences_and_Risks_of_Nuclear_Weapons.pdf.

Notably, the 2022 U.S. Nuclear Posture Review states that the third and final purpose of U.S. nuclear weapons is to "achieve U.S. objectives if deterrence fails." However, U.S. and allied nuclear deterrence postures do not account for how the full suite of global nuclear effects might change risk and damage assessments with respect to achieving U.S. objectives in the event of nuclear conflict. To our knowledge, the consequences of nuclear use beyond those occurring in the immediate aftermath have remained only incidental to considerations of nuclear policy and posture and have had no evident effect on nuclear weapons employment policy. Without considering such effects, nuclear weapons policy will continue to be premised on an incomplete understanding of the consequences of nuclear use, risking catastrophic miscalculations and endangering national and global security.

Credit: Beds not bombs: Highlights from the Medact collection/Wellcome Collection

Nurses protesting against nuclear weapons, part of the Medical Campaign Against Nuclear Weapons (MCANW) and the Medical Association for the Prevention of War (MAPW).

Scientific Evidence and Cold War Nuclear Policymaking

In 1983, at the height of the Cold War, new research surfaced asserting the potential for nuclear winter following a war between the United States and the Soviet Union. These findings, conducted and popularized by Carl Sagan and his colleagues Brian Toon, Richard Turco, Tom Ackerman, and James Pollack (known by their initials, TTAPS), compelled policymakers in the United States and Europe to engage seriously with the global effects of nuclear war—whether by accepting, co-opting, or rejecting such scientific findings.

Although the earliest studies on the global effects of nuclear war (1980–1982) were less politically oriented, focusing on ozone depletion, dust, and later smoke from wildfires,[6] Sagan and his colleagues sought to popularize nuclear winter as a scientific theory with a clear political agenda. Recognizing an "imagination gap" between nuclear policy and nuclear war, Sagan and his peers hoped that the concept of nuclear winter would render concrete a threat only vaguely perceived by the public and policymakers alike. By rooting this image in scientific evidence, they hoped to positively impact disarmament negotiations.[7]

TTAPS' most significant contribution to the existing studies on potential global effects of nuclear war was to account for the soot generated from urban fires, and the sequence of "war scenario, fire ignition, smoke production, injection, global spreading, and…absorption of sunlight in the upper atmosphere and the resultant cooling of the earth."[8] They estimated that nuclear winter could be triggered by 100 megatons of nuclear explosions.[9]

As U.S. missiles were scheduled for deployment in Europe in 1983, TTAPS sought to balance the desire to publicize their results with the need to obtain peer review to gain credibility.[10] While waiting for *Science's* peer review process, TTAPS, backed by philanthropic foundations, organized a highly publicized conference, entitled "The World after Nuclear War," in October 1983 in Washington, DC, to announce the concept of nuclear winter.[11] The conference was attended by journalists, scientists, policy experts, and officials from the United States and more than 20 other countries. *Science* published the peer-reviewed article two months later, and Sagan pushed the debate explicitly into the policy sphere with an essay

[6] Paul Crutzen and John Birks, "The Atmosphere after a Nuclear War: Twilight at Noon," *Ambio* 11 (June 1982), 114–125.

[7] Simone Turchetti, "Trading Global Catastrophes: NATO's Science Diplomacy and Nuclear Winter," *Journal of Contemporary History* 56, no. 3 (2021), 544; Paul Rubinson, "Imagining the Apocalypse: Nuclear Winter in Science and the World," in *Understanding the Imaginary War; Culture, Thought and Nuclear Conflict, 1945–50* (Manchester: Manchester University Press), 254.

[8] DoD nuclear experts admitted with chagrin to never having considered this possibility before. Badash, *A Nuclear Winter's Tale*, 125; George Bing, "Global Effects of Nuclear War Study—First Quarterly Report January–March 1984," Lawrence Livermore National Laboratory, May 18, 1984, 7.

[9] Badash, *A Nuclear Winter's Tale*, 67–68. Modern thermonuclear weapons range in explosive yield, but assuming a 100-kiloton average yield per explosion, it would take approximately 1,000 nuclear weapons to result in 100 megatons of cumulative yield. Today, researchers estimate that a regional conflict involving up to 50 Hiroshima-sized nuclear weapons (15 kilotons each) on major population centers would produce a "nuclear winter" effect with cascading implications. See Jonas Jägermeyr et al., "A Regional Nuclear Conflict Would Compromise Global Food Security," *Proceedings of the National Academy of Sciences* 117, no. 13 (2020), 7071–81, https://doi.org/10.1073/pnas.1919049117.

[10] Rubinson, "Imagining the Apocalypse," 241.

[11] Badash, *A Nuclear Winter's Tale*, 66.

in the winter 1983–1984 issue of *Foreign Affairs*, critiquing nuclear deterrence strategies based on his findings about nuclear winter.[12]

The Pentagon, where the United States Department of Defense is headquartered.

Public documents and statements imply that most policymakers categorically dismissed Sagan's arguments. However, declassified documents reveal that some policymakers at the Department of Defense (DoD) and the North Atlantic Treaty Organization (NATO) recognized that scientific evidence about nuclear winter had the potential to significantly impact nuclear postures. As a result, they made efforts to publicly question or downplay the significance of such research shielding nuclear policies from criticism while outwardly defending the need to maintain the policy adopted early in the Reagan administration that a nuclear war was winnable, or at the very least survivable.[13]

Scientific evidence was thus marshaled to support both sides of the nuclear weapons policy debate as competing policy ambitions drove the promotion and demotion of international research on nuclear winter. In the United States, this occurred through nationally commissioned studies at the national laboratories; internationally, DoD representatives communicated their interpretation of nuclear winter studies to NATO at conferences such as the series of International Conferences on Nuclear War in Erice, Sicily.[14]

Following TTAPS' December 1983 study in *Science* and a related congressional mandate, the DoD commissioned Congressionally mandated studies from Lawrence Livermore National Laboratory (LLNL) and the National Academies' National Research Council. The Defense Nuclear Agency (predecessor to the Defense Threat Reduction Agency) also commissioned internal studies, while the Central Intelligence Agency undertook a study on Soviet knowledge of nuclear winter.[15]

The TTAPS findings "strongly influenced" work on global nuclear effects at LLNL, where researchers "qualitatively confirmed the conclusions" of the TTAPS group and "identified key assumptions and uncertainties and further work considered necessary."[16] They qualified that such remaining questions "should not detract from the credit [TTAPS] deserve" and merely "suggest the many uncertainties still to be addressed in further research."[17] However, rather than interpreting this uncertainty as requiring further funding and research, the DoD reports that followed interpreted these technical uncertainties as

[12] Carl Sagan, "Nuclear War and Climate Catastrophe: Some Policy Implications," *Foreign Affairs* (Winter 1983/1984), 276, 292.

[13] Of course, Reagan pivoted later in his administration declaring jointly with former President of the Soviet Union Mikhail Gorbachev that "a nuclear war cannot be won and must never be fought" in 1985.

[14] Turchetti, "Trading Global Catastrophes," 558.

[15] William Burr, "Nuclear Winter: U.S. Government Thinking During the 1980s," National Security Archive Briefing Book, 2022.

[16] Bing, "Global Effects of Nuclear War Study," 7.

[17] Ibid.

undermining the core findings and as reason to retain the nuclear status quo. (The parallels to climate change "debates" today are unmistakable.)

One internal document demonstrates especially well the internal conflict over the policy implications of nuclear winter. A 1985 report by RAND analyst J.J. Gertler provides significant insight into the internal briefings in the defense establishment on policy implications of nuclear weapons. Gertler held that nuclear winter had "serious short-term and long-term implications for United States foreign and strategic policy," and deemed it "disturbing" that some commentators insinuated otherwise.[18] According to Gertler, some key implications of TTAPS' nuclear winter research for U.S. nuclear policy included:

- Popular acceptance of nuclear winter could lead to an "unprecedented crisis of confidence within the NATO alliance" as the effects of a nuclear exchange in Europe would severely affect the United States, disincentivizing the United States to employ a nuclear strike.
- Because British or French arsenals alone could bring about a nuclear winter, then U.S. extended deterrence could be seen as redundant. Public realization of this fact could "reinforce calls on both sides of the Atlantic for a decoupling of the U.S. strategic arsenal from European defense" and drive a wedge between allies.
- Smaller tactical and theater nuclear weapons, sometimes referred to as "battlefield" nuclear weapons, would "cease to exist" as a distinct category as "any nuclear weapon could, by initiating nuclear winter, have adverse global consequences."
- A severe enough first strike would have significant or even greater repercussions for the attacking nation than the recipient, diminishing perceived strategic utility of deterrence.
- If a conventionally superior adversary (the USSR) were to bet that the United States would not use nuclear weapons out of fear of a nuclear winter, they could launch a conventional attack on Allied nations.

Moreover, Gertler argued that nuclear winter fundamentally undermines the theory of nuclear deterrence: as a threat of assured global apocalypse, nuclear winter lessens the credibility of the threat to use nuclear weapons by "swing[ing] the preponderance of doubt" core to nuclear deterrence's ideal functioning in the other direction. A state may be uncertain about its adversary's intentions but could believe that they are sufficiently afraid of nuclear winter that they will not respond to a given threat with such weapons.

As a result, Gertler proposed the following changes to U.S. policy:

- Avoid striking cities and highly combustible areas such as forests to diminish the effects of nuclear winter.
- Minimize the yield used by shifting U.S. policy toward small-yield and non-nuclear conventional weapons delivered with high accuracy.

[18] J.J. Gertler, "Some Policy Implications of Nuclear Winter," RAND Corporation, January 1985, 1; J. Scouras, L. Ice, M. Proper, "Nuclear Winter, Nuclear Strategy, Nuclear Risk," Johns Hopkins Applied Physics Laboratory, 2023, https://apps.dtic.mil/sti/trecms/pdf/AD1201181.pdf.

- Create a "clearly established policy which takes into account the effects of nuclear winter to guide National Command Authority (NCA) in the exigency of nuclear use, so that responses are not delayed by uncertainty."
- Understand the "boomerang effect" of each use of nuclear weapons so that the NCA can "know the likely effects on the U.S. of every given detonation" before issuing orders.
- Recognizing the danger of unilateral U.S. policy change, encourage the Soviets to "realize the seriousness of nuclear winter and incorporate it into their policy thinking."

Gertler also predicted that if the USSR were seen as more proactive and concerned about nuclear winter than the United States, then "third nations" who "are for the first time placed at direct risk in a superpower nuclear conflict" will favor the Soviet response. "Nuclear winter *will make a difference* to many nations, allied and nonaligned," wrote Gertler, "and we ought not be seen as heedless of its consequences."[19]

In contrast, in March 1985, the DoD report presented by Defense Secretary Casper Weinberger to the U.S. Congress concluded that the "issues raised by the possibility of effects of nuclear war on the atmosphere and climate only strengthen the basic imperative of U.S. national security policy—that nuclear war must be prevented."[20] Despite significant internal advice to the contrary, the DoD report underlined the uncertainties in nuclear winter findings and argued that nuclear winter theory did not require any change in the U.S. nuclear posture: deterrence policy and the Strategic Defense Initiative—also known as "Star Wars," the Reagan Administration's proposed ambitious (and never realized) national missile defense program—remained "fundamentally sound."[21]

This DoD report irritated some members of Congress who believed it evaded discussions on the impact of nuclear winter on military operations and on biological and environmental effects. White House science advisor, George Keyworth, described the report as "mostly mush."[22] Congress in turn asked the DoD for a more extensive review.

Later that month, DoD representatives briefed NATO on DoD's strategy with respect to nuclear winter, influencing the formation of NATO's official stance. Although it did not comment publicly until 1986, NATO reshaped its scientific diplomacy to downplay research that could show the catastrophic potential consequences of a nuclear attack.[23] This included organizing conferences such as those at Erice beginning in 1983, which offered support to competing research that downplayed environmental consequences of nuclear war, including that of U.S. physicist Edward Teller, who presented a strong stance in favor of increasing the U.S. defense budget.[24] NATO also began disqualifying research related to the effects of nuclear war from eligibility for NATO funding.[25]

[19] Ibid, 6.

[20] Secretary of Defense Caspar W. Weinberger, *The Potential Effects of Nuclear War on the Global Climate*, A Report to the U.S. Congress, March 1985, 172.

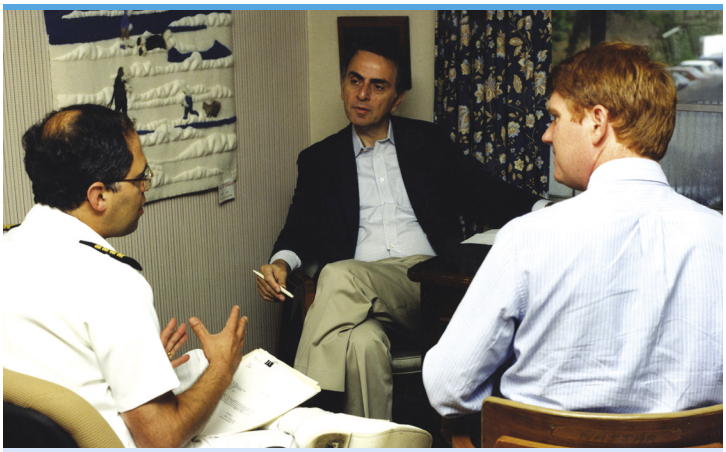
[21] Ibid.

[22] Wayne Biddle, "Pentagon Agrees Nuclear Warfare Could Block Sun, Freezing Earth," *New York Times*, May 2, 1985; Badash, *A Nuclear Winter's Tale*, 163–167.

[23] Turchetti, "Trading Global Catastrophes," 552.

[24] Ibid., 556.

[25] Ibid., 545–6, 561–2.



Carl Sagan (center) during a meeting in 1988.

In March 1986, DoD presented its revised report to Congress, which reiterated the first report's uncertainty, drawing from Teller's presentations at Erice as well as Teller's *Nature* article dismissing the TTAPS conclusions as "speculative." Even though Carl Sagan rebutted Teller's assertions as having "no quantitative foundation" and "insufficient technical base,"[26] the DoD report followed Teller's partisan line and simply reiterated the effectiveness of current security policies, arguing only for the need for rapid modernization of defense systems in the Western bloc. The report also emphasized the DoD's stance that President Reagan's Strategic Defense Initiative would suffice to address nuclear winter concerns, as a space shield would ideally destroy enough missiles on their path to target.

However, despite the Reagan administration's best efforts to discredit TTAPS' findings, Carl Sagan's celebrity, with the help of a marketing firm, artists, and filmmakers, helped to popularize knowledge of the "nuclear winter" phenomenon among the U.S. public, galvanizing the anti-nuclear "freeze" movement.[27] Although several other studies on nuclear winter were undertaken by the General Accounting Office, the Scientific Committee on the Problems of the Environment (SCOPE), and the Committee on Interagency Radiation Research and Policy throughout the second half of the 1980s, nuclear winter ultimately faded from political discourse with the end of the Cold War.

The discussion returned only years later with the advent of the "Humanitarian Initiative" and three international conferences spearheaded by Norway, Mexico, and Austria. The conferences, attended by a majority of states and numerous non-governmental organizations, underscored the urgent need for nuclear disarmament based on the factual understanding that no state or international body could adequately address the humanitarian emergency and provide sufficient assistance to those affected by a nuclear conflict. Building on the research TTAPS spearheaded in the 1980s, the conferences highlighted the transboundary and intergenerational health impacts and lasting infrastructure damage resulting from a nuclear detonation, offering a counternarrative considered vital to stigmatizing nuclear weapons and their purported deterrence value. This effort culminated in the entry into force of the Treaty on the Prohibition of Nuclear Weapons (TPNW) in 2021, bringing the consequences of nuclear weapons use to the forefront once again.

[26] Paul Rubinson, *Rethinking the American Antinuclear Movement* (Routledge, 2018), 244.

[27] Ibid., 129.

"If Deterrence Fails": 21st-Century Global Nuclear Effects and Implications for U.S. Nuclear Posture

Today, despite the world's significant socioeconomic, technological, and cultural transformations since the end of the Cold War, no comprehensive assessment of the full suite of potential catastrophic consequences of a nuclear weapons conflict has been adequately considered in the formulation of current U.S. or other nations' nuclear policies and posture. The role and strategic consequences of boomerang, climatic, and other downstream effects of nuclear war—including on non-combatant states—remain significantly neglected in nuclear war planning and strategy. Given the dependence on nuclear weapons in countries' security postures, serious consideration of the range of catastrophic consequences of a nuclear conflict such as these should be better reflected in nuclear policymaking.

Given the dependence on nuclear weapons in countries' security postures, serious consideration of the range of catastrophic consequences of a nuclear conflict such as these should be better reflected in nuclear policymaking.

Multipolar Nuclear Order and Increased Nuclear Risk

The rise of a multipolar nuclear order during the past 50 years expands the pathways to and exacerbates the risk of nuclear use and its catastrophic consequences. The Cold War was characterized by a bipolar nuclear order and thus the United States dedicated significant resources to understanding the Soviet Union's deterrence strategy and posture, including the USSR's understanding of the global catastrophic effects of nuclear winter. Today, to limit the risk of nuclear winter, policymakers must understand threat perceptions of global nuclear effects in the United States and Russia and in all states with nuclear weapons, each of whose arsenals, if used, could be capable of triggering global catastrophic effects at or near nuclear winter-level. Technological advances in warfare and hardware add further complexity to considerations about relying on nuclear weapons, with increasing risk stemming from growing cyberthreats, entanglement of nuclear and non-nuclear military infrastructure, and the increasing integration of artificial intelligence (AI) systems in nuclear control systems.

As an example, the 2022 U.S. Nuclear Posture Review states that effective deterrence requires "tailored strategies for potential adversaries that reflect our best understanding of their decision-making and priorities." Given the risks of boomerang effects, however, multipolarity complicates this task. If recent studies are correct that a nuclear exchange of a certain magnitude anywhere in the world (e.g., in South Asia) could cause significant adverse consequences for the United States, including but not limited to access to food, preventing nuclear conflict anywhere in the world should constitute a policy priority for the United States and other nuclear-armed states. However, nuclear-armed states, including the United States, often have softened language on the longer-term effects of nuclear use in official statements and chosen not to attend most international

humanitarian conferences with the exception of Vienna in 2014,[28] mirroring the U.S. government's public rejection of nuclear winter studies in the 1980s. If, however, "reduc[ing] the risk of nuclear war that could have catastrophic effects for us and the world" is part of the mission of U.S. nuclear policy, U.S. policymakers must acknowledge and understand how even a nuclear conflict not directly involving the United States could seriously affect U.S., allied, and other states' economic, food, and human security, and must join the international community in considering the global cascading effects of nuclear war.

Complexity, Interdependence, and Vulnerability to Cascading Failures

Another significant shift in the global security landscape is its growing complexity. The extent and speed at which technologies, economies, and societies are connected have increased. Since the 1950s, the global economy has grown almost 20 times larger as international trade has increased dramatically, resulting in the emergence of a "tightly coupled human social-ecological global system."[29] Today, no region of the world is self-sufficient: even a manufacturing-heavy region like the Asia-Pacific imports 25 percent of its energy, critical intermediate goods, and minerals, with North America as its main partner. The war in Ukraine has exposed vulnerabilities in the global critical infrastructure first brought to light by climate-related crises and the COVID-19 pandemic, significantly impacting the trade of critical goods and materials, such as food, fuel, and fertilizer, leading to a global food crisis.[30] The dire consequences of supply chain shocks in recent years would be dwarfed by the systemic repercussions that would follow a nuclear exchange.

Hence, the context in which the effects of a nuclear conflict would be felt today is very different from the environment that existed when nuclear deterrence theories were developed. For example, in the event of a major strategic nuclear conflict anywhere in the world, the consequences would have devastating effects on worldwide food security, severely impacting breadbasket regions in North America and Russia and importing nations like those in Africa and the Middle East. In the United States, the COVID-19 pandemic stands as evidence for the impact a two-year loss in productivity can have on the global economy. The consequences of a nuclear exchange would be significantly worse, accounting for often overlooked details such as the psychological impact of major disasters and human behavior, including reduced productivity of a workforce in the aftermath of a traumatic event as well as the inability of workers to get to and from jobs resulting from the unique destructive capability of a nuclear weapon. Given the near and longer-term debilitating economic, environmental, societal, and health effects of a nuclear conflict, not accounting for such outcomes in nuclear policymaking is enormously irresponsible.

[28] "Written Evidence Submitted by Alexander Kmentt (NPT0047)," UK Parliament, March 1, 2019, https://committees.parliament.uk/writtenevidence/99976/html/.

[29] T. Homer-Dixon, B. Walker, R. Biggs, et al., "Synchronous Failure: The Emerging Causal Architecture of Global Crisis," *Ecology and Society* 20, no. 3, 6.

[30] "War in Ukraine Drives Global Food Crisis," *World Food Programme Report*, June 24, 2022, https://www.wfp.org/publications/war-ukraine-drives-global-food-crisis; Julia Horowitz, "Russia's War in Ukraine Sparked a Historic Food Crisis. It's Not Over," CNN, January 17, 2023, https://www.cnn.com/2023/01/15/business/global-food-crisis-davos/index.html.

Interrelation of Global Security Threats

Due, in part, to a growing understanding of and concerns about climate change, scholarly investigations into "global catastrophic risk" and "existential risk" have shifted and expanded the framework in which nuclear policy is shaped. The 2022 U.S. National Security Strategy identifies climate change as "the existential challenge of our time." Growing attention to the climate-nuclear nexus has paved the way for a renewed discussion on the climatic effects of nuclear war, which could draw upon the lessons and accomplishments from this adjacent field when considering different impacts on policy. Discussions at NTI's Global Nuclear Effects Conference in 2022 further highlighted that analogies to both natural and anthropogenic hazard events can help improve understanding of the effects of nuclear use. For example, research on natural hazards such as volcanic eruptions and hurricanes, as well as global systemic risk more broadly, can provide otherwise scarce data and support the modeling of potential cascading failures in agricultural, economic, and social systems after a nuclear conflict.

Enduring Challenges

Although the world has seen significant transformations since the policy debates on nuclear winter in the 1980s, attitudes regarding nuclear deterrence have remained largely unchanged. U.S. postures reflect persisting beliefs in the military utility of nuclear weapons should deterrence fail whereas deep reductions of arsenals are viewed as destabilizing to security. Furthermore, the reliance of U.S. allies on extended deterrence continues to shape U.S. nuclear postures.

Credit: NATO

President Biden and NATO Secretary General Jens Stoltenberg during the 2023 NATO Vilnius Summit.

In addition, the risks of low-probability, high-impact events remain difficult to quantify and have therefore been excluded from policymaking processes. Certain technical aspects of nuclear winter studies continue to fuel claims about persisting scientific uncertainty. In 2018, researchers at Los Alamos National Laboratory contested findings that a nuclear war between India and Pakistan could trigger global "winter" effects, challenging widely adopted assumptions about the amount and composition of soot emissions that would result from the fires after a nuclear explosion ("fuel load"). Although a certain level of uncertainty will remain given the sheer number of variables that can impact the modeling of effects (e.g., use of different scenarios, lacking data, etc.), a growing amount of peer-reviewed, evidence-based literature concludes that a nuclear conflict would cause catastrophic climatic consequences that could trigger cascading failures in societies around the world.[31]

[31] "Understanding the Humanitarian Consequences and Risks of Nuclear Weapons: New Findings from Recent Scholarship," Federal Ministry Republic of Austria, July 2023, https://www.bmeia.gv.at/fileadmin/user_upload/Zentrale/Aussenpolitik/Abruestung/Understanding_the_Humanitarian_Consequences_and_Risks_of_Nuclear_Weapons.pdf.

Nuclear Policy Questions and Implications

Given the stakes in today's increasingly interconnected world, as well as new findings about the long-term global effects of nuclear use, renewed attention from policymakers and scientists on global nuclear effects and their policy implications is overdue.

Key questions to consider include:

- How does the recognition of global nuclear effects, including the risk of cascading effects, impact the role and perceived "utility" of nuclear weapons in national security strategies?
- How should the cascading effects of nuclear war for combatant and non-combatant states affect nuclear planning? How do they affect understanding of the legality of use and threat to use nuclear weapons?[32]
- How feasible is it to define a threshold (and with what amount of certainty) between "nuclear winter," "nuclear autumn," and "no-winter" scenarios? Is it possible to determine a "minimal deterrent" using this information?
- Given persisting uncertainty about the quantities of soot produced from a nuclear exchange, how should policymakers approach risk assessments in best- and worst-case scenarios?
- How can governments increase transparency regarding how nuclear-armed states incorporate understanding of nuclear effects into their nuclear use plans?
- Why has research into cascading nuclear effects remained neglected in nuclear policy discussions?
- How can the international community organize itself to promote dialogue, information-sharing, and new research on cascading effects of nuclear war between stakeholders, including governments, scientific communities, and civil society organizations?
- Outside the policy sphere, research indicates that public awareness and understanding of nuclear winter and the threats of nuclear conflict are very low.[33] Given today's fractured media environment, how might new research on the potential effects of nuclear war be conveyed to the public as well as to policymakers?

[32] If the consequences of a nuclear exchange extend to non-combatant states, it raises questions regarding the application of the law of armed conflict, specifically the principle of distinction. The principle of distinction requires parties to a conflict to differentiate between civilians and non-combatants, allowing attacks solely against military targets and avoiding harm to civilians. In the context of a nuclear scenario, the potential impact on non-combatant states may challenge the traditional application and effectiveness of this fundamental principle.

[33] Paul Ingram, "Public Awareness of Nuclear Winter and Implications for Escalation Control," Centre for Existential Risk, University of Cambridge, February 14, 2023.

- How might the effort to understand and combat climate change inform the study of and policy responses to global nuclear effects?
- How will the challenges presented by the cascading effects of nuclear war require the engagement of new stakeholders who have traditionally remained outside the nuclear policy space (e.g., the disaster response, health, infrastructure, food security, and agriculture policy sectors)?
- How might policymakers incorporate new findings, such as the recognition of societal interconnections, economic interdependence, and the risk of cascading failures, into new and existing guidance, responsibilities, and processes for civilian harm mitigation and response?

Such questions are difficult to answer unequivocally. Next steps could include considering these policy questions and implications as applied to different scenarios of potential nuclear conflict.

For example, how might findings of global nuclear weapons effects differ in scenarios of limited nuclear use and tactical nuclear weapons use, as compared to large-scale nuclear war? How could policymakers map different consequences and their policy implications emerging from (1) an individual use of a tactical nuclear weapon; (2) regional nuclear war; or (3) large-scale global nuclear war?

Despite overall reductions in worldwide nuclear arsenals since the 1980s, the risk of catastrophic nuclear use has risen in a rapidly changing and unpredictable geopolitical environment. Meanwhile, our prevailing fundamental theories and understandings of nuclear deterrence have remained unchanged and detached from considerations of new information regarding long-term downstream effects of nuclear use. A fuller consideration of these global effects should be a key factor in the strategic security considerations of nuclear-armed states now and in the future.

Additional Resources

"Understanding the Global Effects of Nuclear Conflict in the 21st Century: Reading List." August 2022. https://www.nti.org/wp-content/uploads/2021/09/Nuclear-Effects-Reading-List_August-2022.pdf.

"Global Nuclear Effects Conference Summary." June 1–2, 2022. https://www.nti.org/wp-content/uploads/2021/09/Global-Nuclear-Effects-Conference_Summary-2022.pdf.

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