Public awareness of **nuclear winter** and implications for escalation control

14 February 2023

Paul Ingram
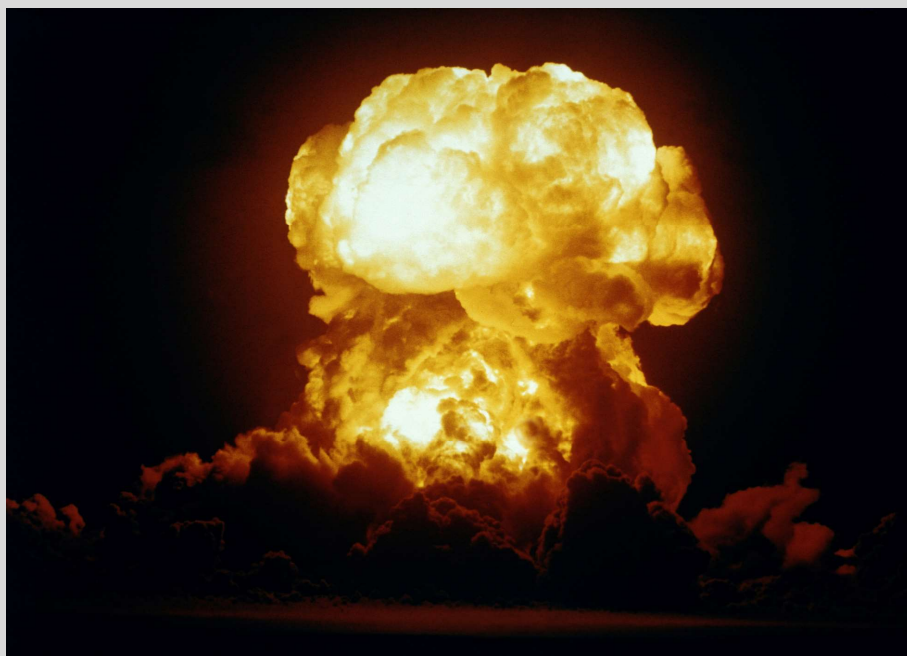
U.S. Navy nuclear test, Bikini Atoll. Credit: Getty Images

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Opinion poll published 14 February 2023

Summary

An opinion poll on nuclear winter awareness released by researchers from the Centre for the Study of Existential Risk (CSER) at University of Cambridge on 14 February suggests a low public awareness of likely global 'nuclear winter' climate effects from mass nuclear detonations, yet a strong reluctance to support nuclear retaliation in response to a fictional Russian nuclear attack on Ukraine. Support for nuclear retaliation amongst voters for the parties for the US President and UK government in this particular exercise was a full one third lower amongst participants informed of the likely global climatic consequences.
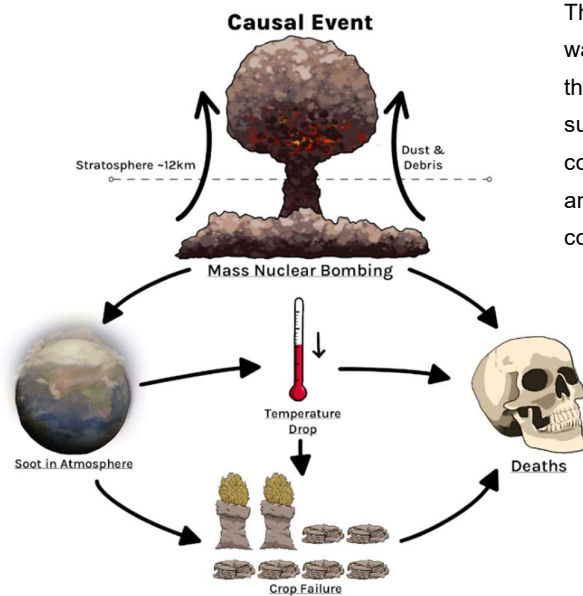
Graphic used in the poll to explain nuclear winter. Designed by Coll Ingram for CSER.

The war in Ukraine has exposed to the public the spectre of nuclear war hanging over Europe. The warnings from leaders in the Kremlin that the conflict could lead to the use of nuclear weapons and less subtle threats from Russian state media have triggered serious concerns in Washington and European capitals. Yet decision-makers and the public may be ignorant of the largest global climate consequences from a nuclear war, which could lead to global famines.

Nuclear detonations and the likely resultant firestorms would throw soot and debris into the stratosphere, *and in sufficient numbers* could block much of the sun for up to a decade, causing a mini-ice age, crop failure, and famine across the globe but particularly in the northern hemisphere. The poll suggests that there remains a general ignorance of the potential scale of this global ecological damage from a nuclear war (see the graphic on the next page). Smaller exchanges would not have this effect, but the dynamics of nuclear war are such that there is little evidence to suggest that leaderships would be capable of limiting escalation once nuclear weapons are first used.

The last time Europe experienced this level of nuclear hazard, in 1983, US and UK public engagement with the risks was far greater. These were the days of the UK TV series, *Threads*, the US feature film, *The Day After*, and anti-nuclear marches attracting hundreds of thousands of people on the streets. The poll indicates that even today people have a stronger memory of these debates around global effects from the 1980s than they are aware of more recent information on the topic.

Size of Nuclear War	Direct Fatalities	Additional Deaths from starvation
Limited war involving 100 smaller (15kT) nukes	25 Million	225 Million
Limited war involving 250 larger (100kT) nukes	125 Million	2,240 Million
Total nuclear war	400 Million	over 5,000 Million

*These figures are based upon a peer-reviewed academic paper in Nature published in August 2022 using climate models. They are controversial, and require more research to increase confidence , but should be treated as indicative of the scale of impact from a nuclear war.

Xia, L, Robock, A, Scherrer, K. et al. Global food insecurity and famine from reduced crop, marine fishery and livestock production due to climate disruption from nuclear war soot injection. Nat Food 3, 586-596 (2022).
https://doi.org/10.1038/s43016-022-00573-0

Graphic used in poll: the scale of nuclear winter according to one peer-reviewed paper. Participants were told there remains controversy over the scale of impact. Designed: Coll Ingram for CSER
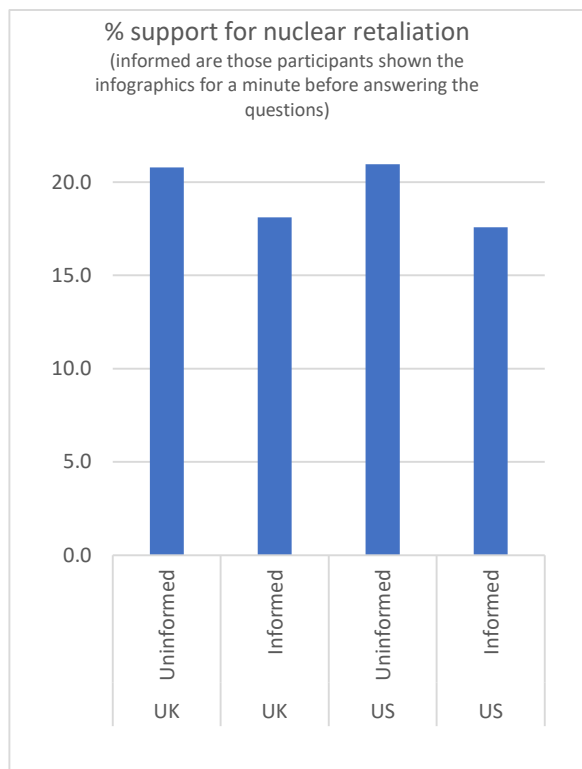
The potential scale of impacts from the 'nuclear winter' phenomenon remains controversial amongst scientists. Research using sophisticated climate modelling and observations from forest fires and volcanoes published in August 2022 suggests that even a limited nuclear war could trigger global starvation of hundreds of millions of people. It suggests that fatalities arising from nuclear winter effects over the months after the war would lead to casualty numbers many times greater than those suffered in the more immediate blast, heat, fires and radiation.

% support for nuclear retaliation
(informed are those participants shown the infographics for a minute before answering the questions)

	UK Uninformed	UK Informed	US Uninformed	US Informed
	~20.8	~18.1	~21.0	~17.6

The poll suggests a low nuclear winter awareness. It also finds that the US/UK public's risk appetite for supporting nuclear retaliation reduces when participants had one minute's sight of two infographics summarising the latest research. In the US the number of those supporting nuclear retaliation after seeing the infographics is 16% less than the number from those that are not informed (131 to 158). In the UK this is 13% (135 to 157). This effect is more pronounced amongst voters for the US President (36% amongst US Democrats, 66 to 96) and UK Government (33% amongst Conservatives, 27 to 38). This poll was conducted eleven months into a conflict in which participants will have been strongly primed to stand up against Russian illegal and brutal aggression.

It should also be pointed out that this poll focused on reactions to a fictious scenario *after* the first use of nuclear weapons. It does not address the need to prevent first use of nuclear weapons as a primary objective, the subject of considerable debate and discussion in diplomatic and strategic circles around nuclear risk and risk reduction. There are significant doubts within these communities over the ability to control escalation in any real-world scenario, so it may assumed there is a high risk of nuclear winter once any nuclear detonations occur.

The threshold of the number of weapon detonations needed to trigger nuclear winter is significantly lower than the available weapons in the world's arsenals. The US is estimated to have a total destructive force (yield) within the whole nuclear arsenal (deployed and in storage) of just under 780 MT.[1] Assuming that the Russians have a comparable total yield, then the three scenarios outlined in the infographic, account for 0.1%, 1.6% and 28% of the two states' combined total nuclear arsenals.

Although it can be distressing to consider the consequences of a large-scale catastrophe, decisions need to account for all potential consequences, to minimise the risk. Politicians in government and the publics need to be better aware of the global catastrophic risks inherent within nuclear postures as nuclear risk has risen significantly in 2022. That awareness would presumably reduce support for first use, or for nuclear retaliation if deterrence were to fail. *If decisions in crises involving the potential use of nuclear weapons are made by people less informed of the biggest consequences of using nuclear weapons the predictability and stability of nuclear deterrence could be undermined.* There is an urgent need for public education within all nuclear armed states that is informed by the latest research. We also need urgently to explore how best to collectively reduce the temptation leaders of nuclear armed states might have to threaten or use nuclear weapons in support of offensive military operations.

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[1] For estimates of the US arsenal, see 'Nuclear Notebook: United States nuclear weapons, 2023', Hans M. Kristensen and Matt Korda, *Bulletin of the Atomic Scientists* 2023, VOL. 79, NO. 1, 28–52 https://doi.org/10.1080/00963402.2022.2156686. The estimates for the Russian arsenal have significant gaps in reported yields, and so have not featured in this analysis, but are available here: 'Nuclear Notebook: Russian nuclear weapons, 2022', Hans M. Kristensen and Matt Korda, *Bulletin of the Atomic Scientists* 2022, 98-122, https://www.tandfonline.com/action/showCitFormats?doi=10.1080%2F00963402.2022.2038907
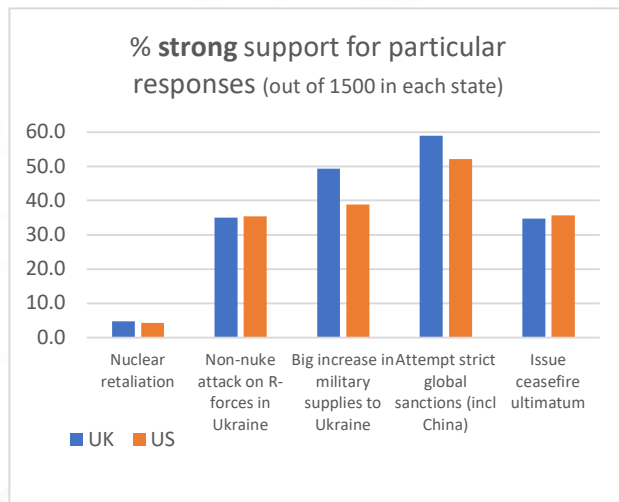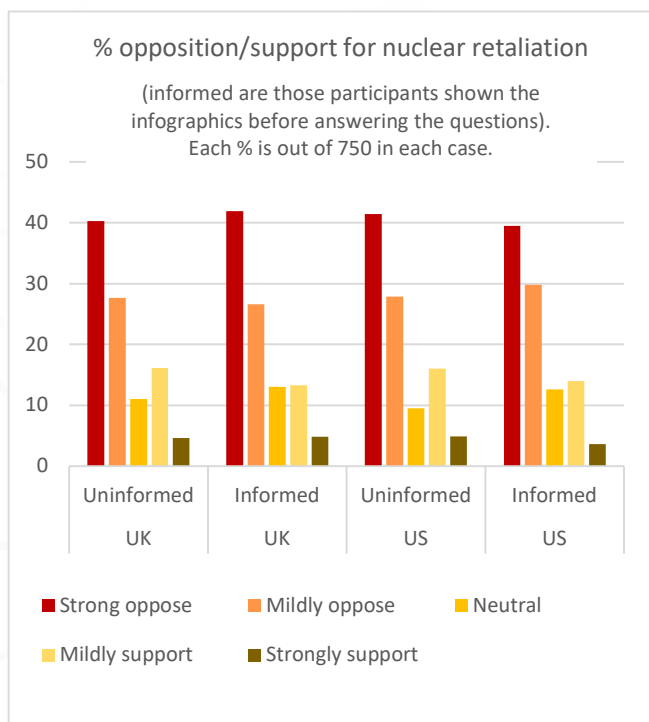
Opinion poll published 14 February 2023

Key findings

All statistics quoted in this section are statistically significant at a 95% confidence level.
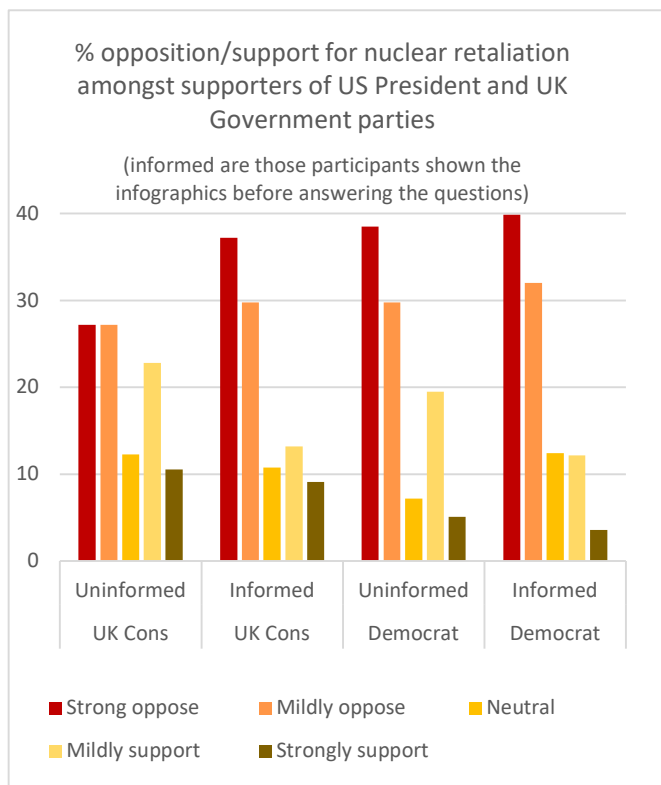
Researchers from the Centre for the Study of Existential Risk (CSER) conducted an opinion poll of publics in the UK and US on 25 January and published findings on 14 February 2023. The survey design is summarised in the last section.

% support for nuclear retaliation and for sanctions (out of 1500 in each state)
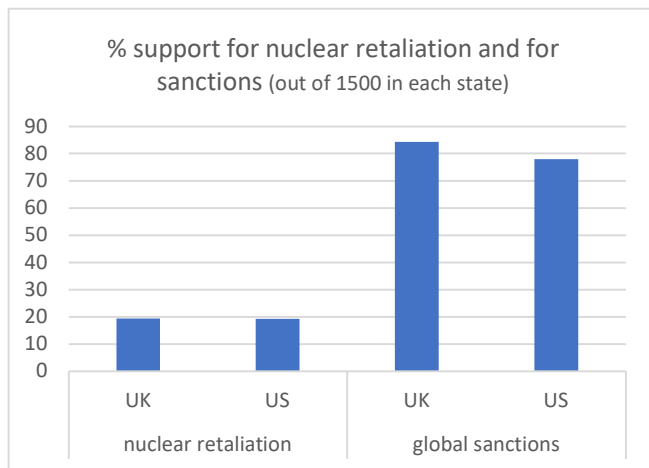
Fewer than one in five people in the UK (292 out of 1500) and the US (290 out of 1500) supported nuclear retaliation against Russian nuclear aggression in the survey's scenario (*strong* support being 4.7% (71) in the UK and 4.3% (64) in the US). 84% (1265) of UK respondents and 77.9% (1169) of those in the US were in favour of a major push for total global sanctions against Russia (58.9% and 52.1% (884 and 782) *strong* support respectively), but also the support for increasing military supplies and for launching non-nuclear attacks on Russian forces in Ukraine was much higher than for nuclear retaliation.

% opposition/support for nuclear retaliation

(informed are those participants shown the infographics before answering the questions). Each % is out of 750 in each case.

Legend: Strong oppose, Mildly oppose, Neutral, Mildly support, Strongly support

% **strong** support for particular responses (out of 1500 in each state)

Public awareness of nuclear winter (global climatic effects from nuclear war) reduces the risk appetite for supporting retaliation in a nuclear exchange. We found that support was lower by 16.1% in the US (135 to 157) and 12.9% (131-158) in the UK when participants were shown infographics based on the latest research (reproduced in the summary of this report, in the previous section).

% opposition/support for nuclear retaliation amongst supporters of US President and UK Government parties

(informed are those participants shown the infographics before answering the questions)

Strong oppose · Mildly oppose · Neutral · Mildly support · Strongly support

% by age - those that knew 'lots' about nuclear winter from the 1980s

% support for nuclear retaliation

This support for nuclear retaliation was lower when participants had been informed by 33% amongst voters for the UK Conservatives (from 33.3% to 22.3%), and 36% amongst those for the Democrats (from 24.6% to 15.8%).

% self-declared prior significant knowledge of nuclear winter by source
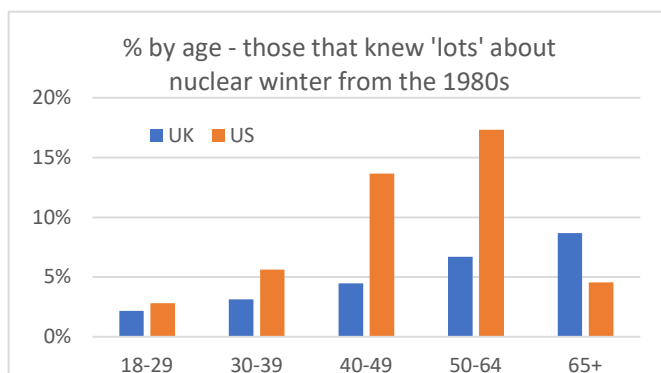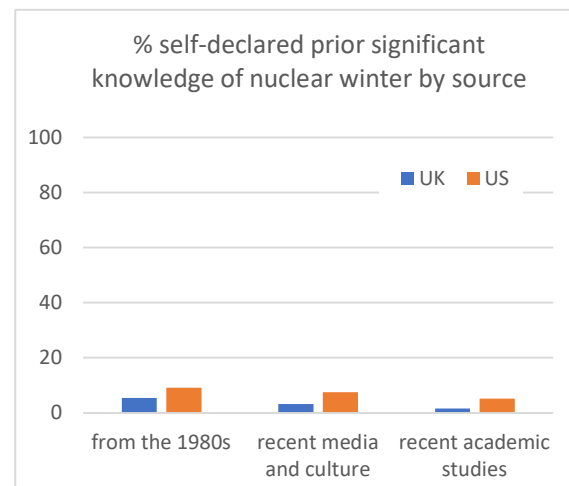
Generally, self-reported public awareness of the global climatic effects arising from nuclear weapons use appears to be very basic. 3.2% (UK) and 7.5% (US) said they had a good understanding as a result of recent media or cultural exposure, 1.6% (UK) and 5.2% (US) as a result of recent academic studies. More people had an understanding from their memories of the debate in the 1980s - 5.4% (UK) and 9.1% (US) had an understanding from their memories of the debate in the 1980s - 5.4% (UK) and 9.1% (US). Given the overwhelming consequences of a nuclear war there is an urgent need for better public education of the global effects. Knowledge and awareness resulting from such an education among the public and in government is critical to good decision-making in relation to nuclear posture and use.
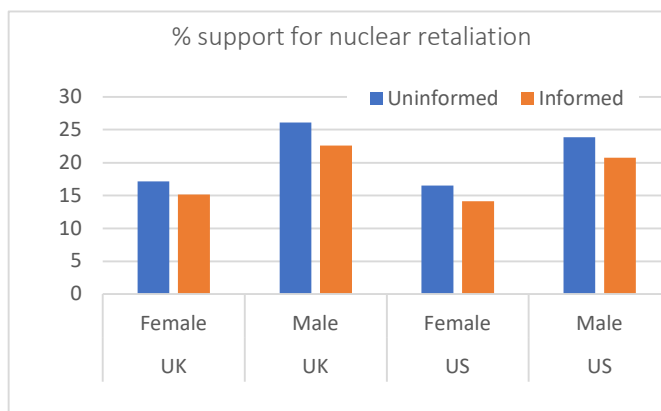
Men are more likely than women to support nuclear retaliation: 20.7% (US) and 24.4% (UK) of men compared to 14.1% (US) and 16.1% (UK) of women.

Scientific basis

For the last 75 years there has been a high awareness of the immediate effects arising from nuclear blast over cities, including effects from the shock wave, heat, fire storms, and radiation. What is generally less well known is that detonations over many cities would have a global impact on the environment and result in famine and other cascading effects with far more devastating consequences.

The idea of nuclear winter came to public awareness in the early 1980s and there is strong evidence that it had some significant impact on the thinking of Ronald Reagan and Mikhail Gorbachev when they met to discuss nuclear arms control and disarmament in 1985 and 1986. Indeed, in the poll people could better remember discussions from that period than they recalled more recent debates on the phenomenon.

A paper in 2007 focused on a limited nuclear exchange between India and Pakistan suggested that a nuclear winter phenomenon could be triggered with far fewer warheads than previously thought.[2] There were then several subsequent papers and publications from a number of different researchers expanding upon this modelling.

The scale of effects associated with the nuclear winter phenomenon remains a point of debate. Scepticism within nuclear weapon states seems to originate from a study published by researchers from the Los Alamos US Nuclear Lab in 2018.[3] It suggested that the more limited nuclear exchange modelled on a war between India and Pakistan would probably not trigger global winter effects. This paper sparked an exchange of comments and responses. A subsequent study of wildfires in Canada in 2017 showed the smoke rising to altitudes of up to 23 kilometres owing to solar heating of black carbon, and remaining in the stratosphere for more than eight months.[4] This finding, in circumstances far less extreme than nuclear detonations, strongly supports the

[2] Toon, Owen B., Richard P. Turco, Alan Robock, Charles Bardeen, Luke Oman, and Georgiy L. Stenchikov, 2007: Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism. *Atm. Chem. Phys.*, **7**, 1973-2002. https://acp.copernicus.org/articles/7/1973/2007/

[3] Jon Reisner, Gennaro D'Angelo, Eunmo Koo, Wesley Even, Matthew Hecht, Elizabeth Hunke, Darin Comeau, Randall Bos, James Cooley, 2018: Climate Impact of a Regional Nuclear Weapons Exchange: An Improved Assessment Based On Detailed Source Calculations. *JGR Atmospheres*, **123**, 5, 2752-2772, doi: 10.1002/2017JD027331

[4] Pengfei et al, 9 August 2019: Black carbon lofts wildfire smoke high into the stratosphere to form a persistent plume. *Science*, **365**, 6453, 587-590, doi: 10.1126/science.aax1748

proposition that nuclear detonations would loft significant quantities of soot high into the stratosphere.

Recent peer-reviewed research from August 2022 suggests that even a limited nuclear war could lead to the starvation of over a billion people, most of whom would be living in countries uninvolved in the conflict.[5] We used data from this study in the survey to communicate the scale of possible impacts, using infographics reproduced in the summary of this report. According to the study, a full-scale nuclear war between the US and Russia involving all their deployed warheads could cause five billion people to starve in the subsequent three years, and threaten the survival of the other three billion in the longer term.

The US Congress mandated a study from the National Academies of Sciences on the potential environmental effects of nuclear war within its 2021 National Defense Authorization Act. This study, currently in its early stages, is running late, but we might expect results next year, though much is expected to be classified. It will use state of the art modelling to simulate nuclear detonations over urban areas and the lofting of debris to assess impacts on climate, agriculture and other effects on ecosystems.

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[5] Xia, Lili, Alan Robock, Kim Scherrer, Cheryl S. Harrison, Benjamin Leon Bodirsky, Isabelle Weindl, Jonas Jägermeyr, Charles G. Bardeen, Owen B. Toon, and Ryan Heneghan, 2022: 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**, 586-596, doi:10.1038/s43016-022-00573-0 https://www.nature.com/articles/s43016-022-00573-0

Survey design
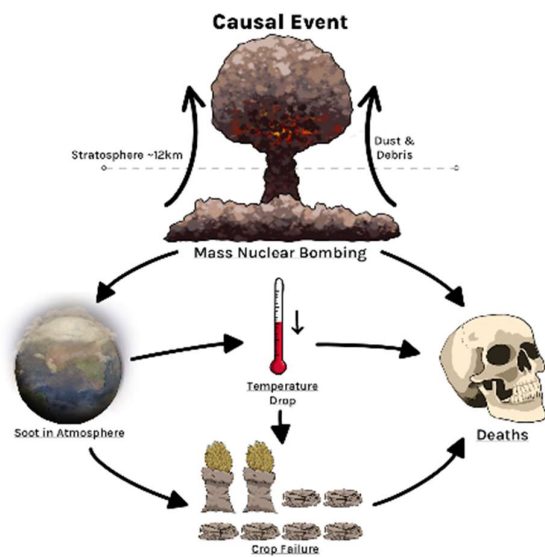
This study involved 3000 participants from the pool managed by the internet polling company **Prolific** (prolific.co), half in the UK and half in the US. Prolific has around 84,000 recently active participants online in both countries who were invited to participate. The study was submitted to, amended and approved by the Arts, Humanities and Social Sciences Ethics Committee of the University of Cambridge. Half of the cohort from each country (750 in each of the US and UK) were asked in Section 1 about their awareness of the nuclear winter phenomenon and then shown two infographics summarising the 2022 research paper and outlining its suggested scale of impact. In Section 2 they were then shown two fictitious news items from July 2023 outlining a scenario in which Russia detonated three lower yield (15kT) nuclear weapons in largely rural Ukraine. Participants were asked to indicate their support for a suite of options in response, including a nuclear retaliation, and then asked to indicate the influence of several factors on their decision.

The other half of the cohort, the control group, was only taken through Section 2, the scenario and subsequent questions. In this way we were able to assess the impact of the information about nuclear winter on the responses of the first cohort. The text of the survey is reproduced below:

SECTION 1: NUCLEAR WINTER

Q1: How much, if anything, have you seen or heard about each of the following?

(sliding scale between know a lot and never heard of it)

1. The beliefs of global nuclear winter widely held in the 1980s
2. Recent media coverage, TV or film, about the climate effects from nuclear war
3. More recent academic studies (in the last decade) on the likely impacts of nuclear explosions in several cities on the global climate

Q2: If there were a major nuclear war between the United States and Russia involving thousands of nuclear weapons, how would you expect most people to die? Please indicate your expected order of magnitude for fatalities from the following three causes:

(sliding scale for each cause by factor of ten,
from less than a million to 1bn-8bn)

1. Immediate explosive effects: blast and firestorms
2. Radiation within three years
3. Starvation within three years

SECTION 2: SCENARIO

(all participants completed this section)

The following is a <u>fictional</u> scenario based upon two mock news items in the future. It is NOT a prediction. Please try to imagine, strictly for the purposes of answering the questions that follow, how you would want your government or NATO to respond to this scenario or another similar.

NEWS: 8th July 2023 0630 BST

Major Ukrainian strike on Russia

A large volley of 40 Ukrainian missiles struck deep into Russian territory late last night, damaging critical infrastructure and an oil refinery on the Black Sea resulting in massive secondary explosions. Russian President Vladimir Putin appeared on Russian TV promising "a terrible retaliation". NATO's Secretary General, Jens Stoltenberg, has distanced the Alliance from Ukraine's attacks, and urged de-escalation on both sides.

In a debate before the strikes in Washington DC on 7th July discussing the possibility of a Russian nuclear attack on Ukraine, Dr. Waite from Rand said that, 'a proportional nuclear response would be essential to restore the credibility of the US nuclear deterrent and guarantee to Europe, and would deter future nuclear attacks'.

Professor Sykes from Harvard countered, saying, 'Analysts believe it to be incredibly challenging to avoid escalation to an all-out war when there is a limited nuclear exchange. We need to deny Russia any benefit by joining the war and ejecting its forces from Ukraine once and for all'. Dr Waite countered, saying this would show weakness and anyway elicit an immediate attack on NATO itself.

Dr Mazen from Friends' Committee suggested that the moment after a nuclear strike is critical, and Russia would be at their most open to a negotiated settlement to avoid further escalation. She also suggested that a NATO retaliation would undermine the global isolation the Russians would suffer for their nuclear use for years to come.

NEWS: 9th July 2023 0830 BST

Nuke Shockwave

Russia detonated three nuclear weapons over Ukraine soon after 0900 EEST this morning. Immediate fatalities are estimated to number at least 15,000 military and civilian dead. Each blast is thought to have been around 15 kilotons, of similar yield to that used against Hiroshima. The radioactive cloud could impact a wider local area downwind in eastern Ukraine.

NATO's North Atlantic Council met in an emergency session 45 minutes after today's detonations. US and Chinese Presidents Biden and Xi had an emergency phone call immediately afterwards.

Q1: What kind of reaction might you support from the government in response to Russian nuclear strikes?

Please note that the earlier options have a higher risk of being interpreted by Russia as a direct act of war by US / NATO, risking a broader nuclear war.

(sliding scale from strongly oppose to strongly support)

1. Nuclear strike on Russia
2. Non-nuclear strikes on Russian military infrastructure in Ukraine and Crimea.
3. Big increase in military supplies to Ukraine
4. Attempt strict global sanctions with China, India and the EU to economically cripple Russia
5. Issue ceasefire ultimatum to engage in negotiations or suffer a devastating response

Q2: For your previous answers, how much impact did each of the following factors have on your overall response?

(Sliding scale, 1 - no impact/no relevance to my choice, 2 - little impact, 3 - some impact, 4 - big impact, 5 - overwhelming impact)

1. Reduce Russian ability to retaliate
2. Punish Russia and send signal to other aggressors
3. Limit support for Russia from other governments
4. Avoid risk of killing civilians in other countries, or triggering global famine
5. Avoid risk of escalation to all-out nuclear war
6. Was there another factor, and how much impact did it have?