Nuclear weapons: a beginner's guide to the threats

Dr Philip Webber, SGR, summarises the key scientific and technological information on the current threat from nuclear weapons.

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Full references can be found at:
www.sgr.org.uk/resources/nuclear-weapons-beginner-s-guide-threats

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Introduction

Governments across the world agree that nuclear weapons pose a very severe risk. In January 2022, the USA, Russia, the UK, France, and China – the five nations that have possessed nuclear weapons for the longest - issued a joint statement saying that "a nuclear war cannot be won and must never be fought" reiterating a 1985 declaration. [a] Furthermore, in November 2022, the leaders of the world's most economically powerful nations – the G20 – issued a joint statement denouncing the use, or threat of use, of nuclear weapons. [b]

These beliefs have been informed by numerous scientific studies and military simulations which find that the use of only a small number of nuclear weapons would create a global catastrophe (section 5 and section 6 of this guide).

Despite these statements, the nuclear states continue to deploy and develop even more lethal weapon systems – with most of them expanding their nuclear arsenals and some making renewed threats. In general, the nuclear states argue that they must keep nuclear weapons to deal with the threats from other nuclear-armed countries. For public consumption, they and their allies use phrases such as 'nuclear deterrence' or 'nuclear umbrella' which lull people into a false sense of safety and security. [c] The fatal flaw in this phraseology, however, is that one person's 'deterrence' or 'umbrella' is the rest of the world's threatened annihilation.

The existential threat this poses led the non-nuclear-armed countries of the world, including some which had halted their own nuclear weapon programmes (such as Brazil and South Africa) to negotiate and finally bring into law the United Nations Treaty on the Prohibition of Nuclear Weapons in 2017. [d] The treaty states that the development, production, use and threat of use of nuclear weapons, as well as any assistance of these activities, is illegal under international law. Importantly the treaty also sets out processes for states to gradually disarm. A majority of countries now support this treaty, and even some countries which are part of nuclear-armed alliances are starting to reconsider their policies. [e]

Since the Russian invasion of Ukraine in February 2022, threats to use nuclear weapons have increased and the risk of a nuclear war is widely seen to have increased. But neither nuclear weapon deployments nor deterrence have led to feelings of greater security. New Russian nuclear weapon deployments to Belarus have been criticised by the USA [f] who at the same time are deploying upgraded guided nuclear bombs to six European countries as part of co-operation under the NATO military alliance, [g] including the UK from July 2025. [h]

Such forward deployment of nuclear weapons is intended to increase the threat of nuclear use and thus 'deter' aggression. However, it increases the risks of false warnings of nuclear attack and any such use would surely lead to further nuclear escalation in a war which 'cannot be won' as agreed by the nuclear powers in 2022 (see above). As such, these weapons deployments are destabilising and dangerous.

In the following sections we summarise the latest information – for example, about the numbers and destructive capabilities of the various weapons held by the nuclear-armed states. Each section is fully referenced so that readers can dig deeper into the issues if they wish.

1. What is a nuclear weapon?

A nuclear weapon has two key parts: an extremely powerful warhead which explodes over its target; and a 'delivery system', usually a missile. Nuclear-armed missiles can be launched from an underground 'silo', a ground-based mobile launcher (basically a large truck), a submarine or by a bomber flying at high altitude. Nowadays, nuclear bombs which simply drop on to a target are very rare because of the high likelihood of destroying the bomber as well as the target. [1] Some nuclear warheads can also be fired from heavy artillery or multiple rocket launchers or placed in the ground as a nuclear landmine.

A typical modern warhead can be quite small. For example, the USA's W-80 cruise missile warhead is less than a metre long, about 30cm in diameter – about the size of a domestic waste bin – and weighs 130kg. [2]

All nuclear weapons deliver a huge destructive power by releasing the very powerful forces which hold atoms - the building blocks of all matter - together. Most nuclear weapons deployed today have explosive powers ranging from 100,000 tonnes of TNT equivalent (100 kilotonnes or kT) up to several million tonnes (MT). [3]

Many nuclear-armed missiles have an intercontinental range, in which case the warheads are launched briefly into space. These missiles carry several warheads (typically between 3 and 12). [4] Such warheads re-enter the atmosphere individually high above their target moving at several times the speed of sound, thus one missile launch can strike several targets hundreds of kilometres apart. Nuclear weapons are very robust – during re-entry they glow white hot. They can reach their targets less than 30 minutes after launch.

While comparisons are made with conventional high explosives, a nuclear warhead has many more damaging effects. It produces an intense electro-magnetic pulse (EMP) of energy which can knock out electronic equipment, a blinding flash of light, intense nuclear radiation, an intensely hot fireball capable of starting fires and causing burns at great distances, an extremely powerful blast wave and radioactive particles that can be carried for many kilometres downwind. [5] [6] [7]

2. Nuclear weapons: the basic science

To understand just how destructive nuclear weapons are, it is useful to understand the basic physics behind them.

The first nuclear weapons released enormous amounts of energy through splitting the nucleus of atoms of uranium or plutonium. This process is called 'nuclear fission'. The enormous explosion arises as a small amount of matter is converted into energy as defined by the famous equation $e = m \times c^2$ where e is the energy of the explosion (measured in joules), m is the mass of the material converted to energy (in kg) and c is the speed of light (which is 300 million metres per second). So the energy released in the nuclear explosion is 90,000,000,000,000,000 times the mass! A nuclear explosion occurs when a large enough 'critical mass' of uranium or plutonium [8] is brought together. The usual way of measuring the size of the explosion created by a nuclear weapon – called the 'yield' – is to compare it with an amount of the common explosive TNT. For example, the nuclear bomb dropped on the Japanese city of Hiroshima towards the end of World War II had a yield of about 15,000 tonnes of TNT or 15 kilotonnes (kT).

A nuclear weapon which just relies on the process of nuclear fission is commonly called an atomic bomb or A-bomb. The simplest form of this type of weapon uses purified ('enriched') uranium-235 extracted from naturally occurring uranium. An explosive nuclear reaction is created by suddenly bringing two smaller pieces of this enriched uranium together to form a critical mass. In a critical mass, a nuclear chain reaction takes place, releasing enormous energy in less than a millionth of a second. Countries which have weapons of this type include India, Pakistan and North Korea. Uranium-235 atomic bombs made with this simple design can have yields up to around 20kT, beyond which it becomes very difficult to hold a larger than critical mass together long enough to create a bigger explosion. [9]

With a bomb made using plutonium, simply creating a critical mass causes a fairly 'weak' nuclear explosion as the weapon blows itself apart before the chain reaction has gone very far. In a plutonium (or specialist uranium-235) bomb, specialist high explosives called 'shaped charges' crush a hollow sphere of plutonium into a critical mass and hold it there for a millionth of a second. Other special materials such the metal beryllium are also used to reflect very small particles called neutrons, making the explosion stronger. [10] Additional neutrons may also be fired in from another source to set off a powerful fission explosion. This type of weapon can only be made by countries with advanced knowledge of materials, high explosives, detonation circuitry and neutron generators as well as access to plutonium.

Most industrialised countries with nuclear power plants – for example, Japan, South Korea, Germany and Brazil – could build nuclear weapons within a few months, but they choose not to do so. Brazil, Sweden and South Africa once had nuclear weapons programmes, but decided to abandon them. [11]

As the USA, Soviet Russia, the UK and France developed nuclear weapons in the 1950's, scientists tested and built a new type of nuclear weapon using a combination of fission and another process called 'nuclear fusion'. This newer weapon is often called the hydrogen bomb, thermonuclear weapon or H-bomb. In this type of weapon, the lightest element, hydrogen, is fused together to form helium. This is the same process that fuels the Sun – thus every thermonuclear bomb creates a short-lived but fierce release of energy like a miniature Sun. Again, a small amount of matter is converted into enormous amounts of energy – and it is possible to build weapons with very large yields. In this weapon type, a compact plutonium-based atomic bomb is detonated, generating intense gamma, neutron and x-ray radiation. Before the radiation and explosive forces can destroy the weapon itself, the nuclear radiation is used to bombard a lightweight foam containing hydrogen causing a nuclear fusion reaction, forming helium. But crucially, in this type of weapon, very high yields can be achieved simply by increasing the amount of the fusion 'fuel'. Weapons with yields of up to 50 million tonnes (MT) have been tested. Finally, this enormous fusion reaction and explosion creates a further large fission reaction in the uranium or other heavy metal warhead casing.

Through major programmes of development work – which included hundreds of actual nuclear test explosions – the nuclear weapons possessed by the USA, Russia and several other nations are now much smaller and lighter than the first designs of the 1950's. For example, the US cruise missile warheads with yields of up to 150kT are around 30cm in diameter, 80cm in length and weigh around 130kg. [12]

3. How many nuclear weapons are there?

Nine nations have nuclear weapons: the USA, Russia, China, France, the UK, India, Pakistan, Israel and North Korea.

Altogether there are nearly 4,000 ready-to-fire ('deployed') warheads, with nearly 8,000 more held in various stockpiles (some classified as 'retired'). The current overall total number of warheads held by all nine nations is about 12,000. [13] About 90% of these are held by the USA and Russia. [14]

All nuclear nations have upgrade programmes, which include developing new warheads, new delivery systems, and/or new deployments. For example, Russia started deploying shorter-range nuclear missiles to Belarus in 2023. [f] The USA had already been deploying nuclear warheads (air-launched guided bombs) to five NATO countries – Belgium, Germany, Italy, the Netherlands, and Turkey – but, in late 2022, it started deploying its new B61 nuclear bomb (with advanced 'fusing' and targeting), with a warhead whose explosive yield is variable up to 50kT. [g] In 2023, the nuclear storage facilities in the UK at the Lakenheath air-base were upgraded, and in July 2025 multiple sources reported that the new US warheads had been deployed there too. In June 2025, the UK government has announced that they plan to purchase US nuclear capable F-35A aircraft to be deployed at the Marham air-base. These aircraft would carry these US nuclear warheads part of the NATO 'nuclear-sharing mission'. [h]

Another key issue is that only Russia and the USA have nuclear missiles ready to fire at very short notice.

The USA and Russia each have 300 to 400 missiles carrying around 2,000 warheads – on roughly 300 missiles each – ready to fire within minutes. [15] The intention is to be able to launch these missiles against a potential attacker before any incoming warheads strike their targets. This status is known as 'launch on warning'. In such a situation, there is very little time – typically less than 20 minutes – to decide if a warning is real and a President would typically have less than ten minutes – possibly as little as five minutes – to decide whether or not to fire. [16] Maintaining this launch on warning status thus creates a high chance that some sort of error - human or technological - could lead to an accidental nuclear launch.

The UK's nuclear warheads are carried on Trident missiles – leased from the USA – in nuclear-powered submarines. Currently, eight missiles can be fired, carrying 40 x 100kT warheads, with a few hours' notice from a submerged submarine. [17] The UK's total nuclear weapons arsenal has been increased to 225 – on the way to a target of 260 – following a change in government policy in 2021. [18]

The French nuclear posture is similar to that of the UK. They have 32 missiles carried on a submarine on patrol, armed with up to 160 warheads of approximately 100kT. [19] Another 50 warheads are carried on Rafale aircraft. The total French arsenal consists of 290 warheads. [20]

The four other larger nuclear-armed nations – China, India, Pakistan and Israel – do not keep nuclear weapons ready to fire as they judge that the risks of accidental launch are too risky. They store launchers and warheads separately, although some launchers may soon be made ready to fire at short notice. [21]

Of these nations, only China has missiles with the ability to hit targets in Russia and the USA. [22] In total, China has over 700 long-range missiles and about 400 warheads. Half of these missiles may be fitted with non-nuclear warheads [23]

India and Pakistan each have around 170 atomic weapons of a similar or somewhat larger size to those dropped on Hiroshima and Nagasaki at the end of World War II. [24] Their missiles are of limited range and are capable of hitting targets within the sub-continent.

Israel refuses to confirm that it possesses nuclear weapons but is believed to keep 90 nuclear warheads and missiles stored separately with sufficient range to target countries in the Middle East such as Iran, Syria or Saudi Arabia. They also have nuclear-capable submarines and aircraft. [25]

In the final case of North Korea, they have detonated several small nuclear weapons in tests and are thought to have 50 nuclear warheads of a similar size to the Hiroshima and Nagasaki weapons. North Korea has also tested missiles which have sufficient range to hit neighbouring countries such as South Korea or Japan - as well as conducting intercontinental ballistic missile tests - although it is not clear whether these missiles could carry the nuclear warheads. [26]

There are three countries – Brazil, Argentina and South Africa – who originally had covert nuclear weapons programmes but then decided to halt them, regarding nuclear weapons as more of a risk than a benefit. [27] Most countries with advanced manufacturing facilities and access to nuclear materials via nuclear power programmes could build a simple nuclear bomb maybe within a few months. Examples are Japan and Finland. This is a key point. Opponents of nuclear disarmament often state that you cannot get rid of nuclear weapons because they cannot be uninvented. Yet there are international treaties banning chemical and biological weapons, landmines and some other weapons technologies. These treaties have been essential in helping to delegitimise these weapons and moving towards their total elimination. This also is the process that has been put in place by the 2017 UN Treaty on the Prohibition of Nuclear Weapons.

4. How much destructive power do the nuclear-armed nations have?

Over cities, the consequences of exploding just one nuclear warhead are so extreme that leading medics, aid agencies including the Red Cross and Red Crescent, and several studies have concluded that an effective medical and humanitarian response would be impossible. [28] If a few tens or hundreds of warheads are detonated they would ignite huge fires in cities, oil refineries and other highly flammable targets. The resultant, persistent, high altitude smoke particles would disrupt the global climate, causing widespread agricultural collapse and famine. [29]

Modern nuclear weapons are up to 50 times more powerful than the single atomic bombs which devastated the Japanese cities of Hiroshima (bomb yield of 15,000 tonnes TNT or 15kT) and Nagasaki (21kT) in 1945. [30]

During the six years of World War II it is estimated that all the bombs dropped, including the two nuclear bombs, had a total explosive power equivalent to 3 million tonnes of TNT (3MT). [31]

The largest Russian warhead is the RS-20 with an explosive power of 800kT. This is equivalent to 40 times the size of the bomb dropped on Nagasaki. The Russian SS-18 missile (given the 'Satan' designation by NATO) can carry ten such warheads, giving this one missile a total destructive power of 8MT. In other words, this one nuclear tipped missile has a destructive power more than twice that of all the bombs dropped during WWII and of 400 times the Nagasaki atomic bomb! The Russian have 46 of these missiles ready for use and a further 507 launchers (missiles, and bombers) carrying smaller warheads. [32]

The total destructive power of Russian nuclear weapons ready to fire is approximately 510MT, equivalent to 170 times that of all the bombs dropped during WWII. [33] This is obviously an incredible level of destructive capability – and does not include weapons kept in stockpiles.

The largest comparable US warhead is the W-88 Trident-II Mk-5 with a yield of 455kT. One US Trident missile carries four of these warheads making a total destructive power of 1.8MT. This one missile is thus equivalent to 90 times the Nagasaki weapon or roughly equivalent to half of all the bombs dropped during WWII! The US have 96 such missiles ready to fire and a further 649 launchers (missiles and bombers) carrying smaller warheads. [34]

The total destructive power of the USA's ready to fire arsenal is approximately 572MT, equivalent to 190 times that of all the bombs dropped during WWII. [35] Again, this is a staggering level.

One UK Trident warhead has a yield of 100kT, and the total destructive power of all the warheads carried by a single British submarine is currently 4MT. [36] Although modest by Russian and US standards, this is still more destructive power than all the bombs dropped in WWII. Hence even the UK with its supposedly "minimum" nuclear arsenal (which is comparable to that of most of the other smaller nuclear-armed states) deploys the capability for devastation with global consequences.

Nuclear weapons are so incredibly destructive that it is very hard to hold in your head a clear picture of the levels of destruction of which they are capable. Even what are now considered to be small nuclear bombs caused incredible levels of devastation, deaths and injuries in Hiroshima and Nagasaki in 1945. [37] Nuclear weapons tests provide some insight with images and pictures of huge fireballs and shockwaves overwhelming whole fleets of (retired) battleships moored in test areas such as Mururoa Atoll in the Pacific, and the complete destruction of target housing, bridges and other civilian infrastructure. As a result, there are fairly reliable ways of estimating the casualties that would result from the use of nuclear weapons over a modern city and various military targets. This will be the subject of a later article.

5. A nuclear attack: the short-term, local effects

At a series of intergovernmental conferences starting in 2013, extensive evidence was presented of the enormous 'humanitarian consequences' should nuclear weapons ever be used again in war. We present some of the key data here.

The impacts of a nuclear weapon on people and the local environment

In a nuclear explosion, the huge amount of energy which binds together atoms is suddenly released. This can be done in two ways known as fission and fusion (see section 2 above).

The effects of nuclear weapons have been intensively investigated. Numerous studies have examined the casualties in Hiroshima and Nagasaki – the two Japanese cities where 'small' fission bombs were detonated by the United States in 1945, towards the end of the Second World War. Researchers have also examined the effects of a series of more powerful weapons tests conducted by the USA, Russia, UK, France and China. Nuclear bomb testing in the atmosphere was banned worldwide in 1963 after radioactive materials were found in a range of foodstuffs, especially strontium-90 in milk.

In nuclear fission, the heavy nucleus of the uranium atom splits into two or more smaller nuclei. This creates radioactive versions – called isotopes – of many elements important in the human body such as calcium, potassium, caesium, iodine and strontium. The radioactive elements are produced directly by the nuclear weapon which also emits intense neutron radiation during the explosion which can in turn make large areas around the point of detonation highly radioactive for long periods – at least several years.

The explosion of a nuclear weapon has the following effects.

In less than a second, an intense pulse of nuclear radiation is produced together with an intense electromagnetic pulse (EMP). The EMP travels at the speed of light and can destroy electrical circuits by generating huge voltages and currents. As a result, electrical networks, computer equipment, phone networks, car management systems, and satellites are all vulnerable and may become inoperative over areas covering hundreds of miles.

The EMP is accompanied by an intensely powerful flash of light sufficient to blind anyone looking at it by destroying their retina many miles away. Test observers not looking directly at a nuclear detonation experienced being able to see their bones imaged through their hands.

An intense pulse of nuclear radiation irradiates a relatively small area around the explosion with sub-atomic particles known as neutrons and intense gamma radiation.

The warhead then produces an intensely hot fireball - 6000 ft across for a one megaton weapon - which swiftly rises into the air. The fireball is hotter than the surface of the sun and can set fire to materials and inflict severe burns – even completely melting or vapourising people in the open. In Hiroshima, some casualties could only be detected by the shadow their body had left before it was completely burned and vapourised by intense heat.

Within 12 seconds an intense blast wave, travelling slightly faster than the speed of sound creates winds of over 200 mph – far stronger than any hurricane. This destroys houses and throws people and debris large distances. People suffer terrible blast injuries. For example, in Hiroshima, survivors still just alive were seen walking holding their eyeballs in their hands or their intestines hanging out from severe blast injuries while the fireball literally burned off the skin of those walking with it hanging in strips off their charred bodies. Similar horrendous injuries can also be created by blast from conventional explosives such as artillery shells. What is different about a nuclear weapon is the prolonged nature of the blast wave, the intense fireball lasting for minutes, and the nuclear radiation.

The initial explosion also ejects huge amounts of radioactive material into the air and the fireball carries smaller radioactive particles much higher – well above the clouds – to several miles altitude. The radioactive particles are known as fallout and start falling over the next few hours as radioactive dust.

These three intially intense effects of the nuclear explosion - heat, blast and radiation - combine to create a lethal inner ring in which no one can survive.

Further out, the most significant immediate effects are blast and burns. The warhead will also start fires over a large area. In a city, these can combine to create what is called a 'firestorm'. These were experienced during the Second World War in Dresden and Tokyo from conventional (non-nuclear) incendiary bombing and in Hiroshima from the nuclear bomb. In a firestorm, individual fires combine to create powerful up-draughts of hot air and hurricane level winds feeding it from the periphery. The fire becomes so intense that it consumes all the combustible materials within an area, in the process consuming available oxygen from the air. In Dresden, many of those sheltering in cellars and untouched by the fires were asphyxiated due to lack of oxygen.

A combination of blast damage, fire and EMP would mean that electricity, water and gas supplies would not be working. Roads would be blocked by debris, most vehicles would no longer work, and all the vital infrastructure for life would be destroyed or severely disrupted. All studies show that any effective medical or humanitarian response would be impossible in the area affected by explosion.

After the burns, blast and possible firestorm the next impact is radioactive fallout.

Radioactive dust falls from the distinctive 'mushroom cloud' many miles across and for many miles downwind covering all surfaces with radioactive material. This fallout can give people a range of radiation doses over a period typically over a few hours or days as the radiation gradually decays.

This delayed radiation dose can cause a range of symptoms and lead to death over the next two weeks or even longer. Without a radiation meter and the ability to use it no one would know what level of radiation they might have received.

Radiation directly damages vital cells in the body such as red and white blood cells, stomach and intestine linings. Radiation causes some damage at all levels including higher incidence of cancer in the longer term or short-term sterility. Typical symptoms are nausea, vomiting diarrhoea and hair loss. Other symptoms include blood spots on the skin and blindness. After a nuclear attack any medical treatment would not be available but in any case, treatment of severe radiation sickness requires blood and fluid transfusions, bone marrow transplants and other major interventions. Those who have sufficiently low doses of radiation may recover over a period of several weeks, providing that they can access water and fluids. Those receiving lethal doses will experience severe symptoms, a period of remission then followed by the return of symptoms as the body’s defences are overwhelmed. Death then follows over a protracted and painful period of as much as a month.

The young, the old and pregnant women are especially vulnerable.

In the longer-term, higher incidences of a range of cancers and foetal abnormalities are experienced.

Because of the enormous levels of harm and injury that a nuclear weapon can create – and indeed is designed to create - through its means of delivery and targeting, any use of even a single nuclear weapon is widely regarded as a crime against humanity and would breach a raft of humanitarian standards because of the disproportionate and unacceptable harm its use would cause.

A nuclear attack: the effects of one or more warheads on towns and cities

Effects of a single warhead

One study, [38] published by the organisation Article 36, was a detailed analysis of the impacts of a single modern nuclear warhead exploding over a typical city within an industrialised nation. The target was chosen to be Manchester in the UK as a model medium-sized modern city. The yield of the warhead was chosen to be 100,000 tonnes (100kT) – similar to many of the smaller warheads deployed by the US, Russia, France and UK. The immediate impacts of blast from the explosion were estimated using the city's night-time population. [39] Very conservative casualty estimates were around 210,000 people injured – many very seriously - and around 80,000 killed immediately by blast. Many of those injured would likely die from their injuries. These figures do not take account of injuries due to flash burns arising from the fireball, severe fires, a possible firestorm, or longer term health impacts. Similar casualty figures were found for a warhead exploding at ground level. This would slightly reduce the radius of blast and fire damage but instead would create a long lethal zone of radiation capable of killing and injuring people many miles downwind.

These results are based on widely accepted casualty models [40] and are therefore reasonable minimum estimates of the impacts. A range of humanitarian organisations (including UN agencies and the Red Cross) have concluded that the detonation of just one such weapon near any centre of population anywhere in the world would overwhelm the health infrastructure, making an effective humanitarian response impossible. [41]

These findings are chilling but the nuclear-armed states have many missiles with multiple warheads of much larger yields than considered in this scenario.

Effects of large warheads and multiple warhead missiles

I will briefly look at the impacts that would be caused by two of the largest US and Russian missiles.

The Russian RS-20 missile carries ten 800kT warheads. Thus the total explosive power carried by this one missile is *80 times* that of the single 100kT warhead considered above.

However, estimating the casualties that this missile could cause is more complicated than simply multiplying by a factor of 80. Each 800kT warhead obviously has eight times the destructive power of a 100kT warhead. This means the *volume* of the blast is 8 times larger. However, the equivalent *area* of the blast is only 4 times larger. [42] One would therefore expect the numbers killed by blast to scale up to 4 x 80,000, i.e. 320,000. But the blast would extend to areas of more sparse population well outside of the main built up areas, so the best casualty estimate for this one 800kT warhead dropped on a city like Manchester is 240,000 killed and 535,000 injured. [43] On top of this, one would expect large numbers of deaths and injuries due to flash burns, severe fires and conflagrations or even a firestorm. A firestorm is an extremely violent and fierce fire that creates gale force winds and consumes so much oxygen locally that people sheltering can suffocate. In summary, the use of just one 800kT warhead would kill most if not all the inhabitants of any medium sized modern city and destroy the built infrastructure.

One RS-20 missile with ten such warheads could destroy ten urban areas with total deaths of at least 2.4 million and injuries of at least 5.4 million.

Russia has 48 such missiles.

The US Trident Mk-5 missile carries four 475kt warheads. Thus the total explosive power carried by this missile is *19 times* that of the 100kT weapon. Taking account of scaling factors as above, and considering the Manchester scenario again, one 475kT warhead could cause 190,000immediate blast deaths and 450,000 casualties.

One Trident Mk-5 missile with four such warheads could therefore destroy four urban centres with total deaths of at least 750,000 and injuries of at least 1.8 million.

These are somewhat lower figures than for the Russian missile, but the US deploys twice as many – 96 – Trident missiles.

It should also be remembered that these casualty figures would only apply to the (very numerous) medium-sized cities. Nuclear warheads would be much more devastating if targeted on larger cities, such as Shanghai (population: 24 million), Moscow (12m), London (8.5m) or New York (8.5m). [44] For example, Moscow would suffer an estimated 760,000 immediate deaths with 2.7m injured from one US Trident Mk-5 warhead. For Shanghai, estimated fatalities are 3m with 4.4m injured. [45]

Targeting decisions and threats

In practice, from what we understand from various strategic nuclear war planning documents [46] released over the years, most US and Russian nuclear weapons are aimed at nuclear weapon launch sites, command centres, ports, major industry, power stations and other key targets – as well as major centres of population. As centres of population are close to ports, major industry and many command centres, even nuclear weapons *not* specifically targeted at civilians would still kill and injure many people. But the leaders of the nuclear-armed nations, when they talk of 'nuclear deterrence', talk specifically of being prepared to kill large numbers of civilians. For example, during a parliamentary debate in 2016, the UK's then Prime Minister Theresa May confirmed she would be willing to kill "100,000 men, women and children" with a nuclear weapon. [47] This number is quite consistent with our minimum assessment here and would be a clear violation of international humanitarian law [48] – as would any use of nuclear weapons by any state or other organisation against civilian populations.

Levels of global casualties

Once you take into account that there are 48 of the Russian missiles and 96 of the US missiles used in the examples above – and that both the US and Russia together have around 1800 warheads deployed – it becomes clear that use of even a very small fraction of the available arsenals could easily devastate all large urban areas in Russia, the US, Europe and many other countries depending upon targeting policies. Deaths could easily number hundreds of millions of people. [49] This would be more people killed in a few hours than in probably all the previous wars of history put together.

But even this devastation would not be the end of the story. The next section will look at the longer-term effects of a nuclear war, in particular, disruption to the global climate, the ozone layer, ecosystems and food supplies.

6. A nuclear attack: longer-term and global impacts

In the 1980s, scientific studies raised major concerns about longer-term and global environmental impacts due to nuclear war, including the possibility of a 'nuclear winter'. [50] These studies pointed out that exploding nuclear warheads over 'combustible targets' such as cities and factories would lead to widespread, intense fires that would inject massive amounts of smoke into the atmosphere leading to the formation of extensive high-altitude smoke clouds. These would cause cooling of the climate in a similar fashion to that observed after very large volcanic eruptions (for example, Krakatoa in 1883), but on a rather larger scale, threatening agriculture and hence food supplies across the world. Other effects included major damage to the ozone layer – which protects humans and ecosystems from damaging ultra-violet rays from the Sun – and the long-lived effects of radioactivity.

Climatic effects

Newer studies, performed since 2007 by scientists from the US, Russia, UK and other nations using some of the latest computer-based climate models, predict that attacks using significantly lower numbers of nuclear warheads than in the earlier studies would still cause global climate disruption. These newer studies estimate that the use of only a few tens to a hundred 'small' nuclear weapons targeted against cities would cause major global cooling, severe frosts, reduced growing seasons, drought and famine lasting up to ten years across the entire northern hemisphere. [51] The scenarios investigated in these newer computer studies included: the use of 100 small nuclear weapons used against cities in India and Pakistan in a regional conflict; the use of about 1,800 Russian and US warheads which are ready to launch at short notice; and an all-out nuclear war using all weapons capable of launch.

In the case of an India-Pakistan 'regional' conflict, the death tolls alone would be enormous as both countries have large, very densely populated urban areas in mega-cities such as Delhi, Karachi, Mumbai and Kolkata. Use of 'only' 100 Hiroshima-sized weapons has been estimated as causing 21 million deaths. [52] On top of these horrendous casualties, the very shocking finding was that even this so-called regional conflict would cause a large climatic impact.

The use of greater numbers of larger Russian and US nuclear warheads would cause even higher levels of cooling and greater impacts lasting a decade or more. The 1,800 US and Russian warhead scenario would cause a long-lasting cold period with a peak global cooling of 4°C, whilst the full scale nuclear war would cause 8°C. For comparison, the global cooling experienced during the last ice age was around 5°C. The scientists modelled the effects upon the world's key crop growing regions: wheat in Ohio and Ukraine and rice production in the Far East. Frosts, drought and monsoon disruption would severely impact crop production for several years.

Radioactivity

Various studies have been undertaken to estimate casualties from a large scale nuclear war (see earlier). Estimates of immediate deaths range from tens to hundreds of millions of people mainly depending upon the targeting scenarios considered. Nuclear weapons detonated at ground level – for example, targeted against missile silos or underground facilities such as command bunkers and centres of government, would create intense levels of radiation. Radiation levels would force any such targeted areas to be abandoned and there would be lethal 'fallout' levels tens of kilometres downwind. Radioactive particles would cause early deaths due to cancers for many decades, if not longer. However, nuclear weapons detonated at low altitude over city or infrastructure targets, whilst causing much less radiation, cause larger lethal blast and injury zones and greater areas of fire and burns.

The most severe radiation impacts would arise from strikes on nuclear power stations and nuclear reprocessing plant. These would create very long lasting radioactive fallout plumes for hundreds of kilometres in downwind directions. [53] This is because nuclear power station and waste facilities contain many very long lasting radioactive materials dangerous to health which would be dispersed downwind in addition to the radioactive materials in the warhead itself.

Other global environmental and social impacts

Finally, levels of nitrogen oxide gas and soot particles created by the nuclear explosions would severely damage the Earth's protective ozone layer. It has been estimated that 50% of the protective value would be lost. [54] This would increase the levels of ground level ultra-violet radiation and skin cancers amongst any survivors. It would also severely affect waterborne life by damaging phytoplankton which are a key part of the oceanic and freshwater ecosystems and provide a vital food supply for all larger aquatic creatures.

For all of these reasons, quite apart from the enormous casualties that would result from a nuclear war, the destruction of vital infrastructure such as health care, water, food and energy supply systems, and a complete disruption of communications and trade, the longer-term consequences for the Earth's environment would present very severe challenges for all those who survived the initial detonations. Realistically, after a large scale nuclear war, one should imagine a brutalised, traumatised shattered society violently thrown back into a pre-industrial age. Assuming that humanity at large could survive this global catastrophe, any 'recovery' would surely be measured in hundreds of years. Even after what has formerly been considered a small scale nuclear war, the consequences would still be dire across the globe, far beyond the conflict zones.

It has to be regarded a shocking indictment of our modern civilisation that current stockpiles of nuclear weapons are sufficient to cause such a global catastrophe.