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By Antonietta M. Gatti and Stefano Montanari

Nanopollution: The Invisible Fog of Future Wars

Pollution from nano-scale particles expands traditional battlefields and extends warfare's impacts to innocent victims, including future generations. Two nanopathology experts examine what may become a dangerous new way to wage war.

The wars that ended the twentieth century and launched the twenty-first brought a mysterious, unexpected side effect. Why would otherwise healthy, uninjured soldiers come home deathly ill? Why would soldiers who never set foot in a war theater but were employed in firing grounds, contract the same illnesses as the soldiers who actually went to war? Why are civilians likewise affected who live in or near war theaters?

Other postwar pathologies, such as soldiers' malformed offspring and the illnesses of peacekeepers deployed to former battlefields, also raise crucial questions.

Other than coming up with a name for the collection of symptoms expe-

rienced by veterans of the first two Gulf Wars and the war in the Balkans, doctors have little understanding of Gulf War syndrome's causes.

One early suspect was depleted uranium contained in some weapons and scattered in great quantity all over the war theaters. Depleted uranium (DU) comes from the leftovers of the enrichment of uranium, and in the 1970s the armament industry began using it. But workers developing DU-based weapons did not experience the same symptoms as those exposed to them in the field.

Other hypotheses included the organophosphates sprayed against possible biological attacks the soldiers were exposed to, the inhalation of the fumes and soot coming from oil well fires, the multiple vaccinations squeezed into what was most probably too short a time, and possible vaccine contaminations.

Nanopathology: Impacts of War And Pollution

The solution to these medical mysteries may be found in a new word: *nanopathology*, the study of diseases caused by micrometric and nanometric particles. Dust at the nanoscale (smaller than one-thousandth of a millimeter) can elude physiological barriers and easily enter the bloodstream, where it is very likely to reach all internal organs and tissues. It has already been proven that inhaled 100nm particles can negotiate the lung barrier within 60 seconds, then show up in the liver and other internal organs within an hour.

The blast of DU and of other high-technology weapons induces a very high temperature—more than 3,000°C for DU and about 5,000°C for tungsten—thus reducing to an aerosol all the matter involved in the blast: bomb, tank, buildings, etc. In a matter of seconds and far away from the blast, those same vaporized substances recondense into tiny, hollow, spherical particles. In this way, new alloys are created that are not found in any metallurgical handbooks. Modern war has thus given birth to a novel kind of pollution that never existed before and whose effects on human and animal health are unknown.

It is hard to deny that nanopollution from war actually represents an additional, significant risk for both soldiers and the population affected by the war. The newly created nanoparticles can rightfully be defined as invisible bullets, since no sensors or instruments have yet been used to detect them in the bombed territories.

Environmental pollution has long been known to be responsible for some lung and cardiovascular diseases, and, because of that, specific laws were enforced to limit the amount of particulate matter in breathable air. But the dust created by high-technology bombs can be much finer than the proposed maximums.

From what we have observed in our laboratory, nano-scale particles can interact with proteins, bacteria, and viruses to potentially cause not-yet-studied phenomena and develop new diseases with unusual symptoms. We have already photographed nanoparticles in contact with DNA; they have the ability to negotiate the cell membrane, leaving it intact, and reach as deep as the nucleus. A "mild" interaction between them and the DNA can create DNA breaks that would cause the cell to reproduce with an irreversibly modified genetic pattern. This could trigger the onset of a cancer in different areas of the organism, as we see both in soldiers and in people never involved in any war.

In our laboratory, using scanning electron microscopy, we can clearly detect those pollutants in the biopsied samples of ill soldiers and ordinary people, and analyze their chemistry. The images obtained from about 1,000 cases show how widely inorganic particles can be disseminated throughout the body, not sparing the brain or even seminal fluid.

The presence of nano-scale, biologically incompatible foreign bodies in seminal fluid can offer an explanation to the so-called burning semen disease, a pathology that can spread to the soldiers' spouses or sexual partners. In such a situation, ovum fertilization is still possible, but contamination of spermatozoa and the area where the ovum is developing could lead to miscarriages, fetal malformations, or other phenomena that may become visible only much later.

The Consequences of Nanopollution and Nanoweapons

Today's science has no experience with the novel, nano-scale environmental pollution caused by the innovative technologies of twenty-first-century wars. This nanopollution can interact with humans and animals alike, as we inhale contaminated air and ingest food grown in the contaminated environment.

The situation suggests the following conclusions.

- **War's immediate impacts will spread far beyond the battlefield.** These "invisible bullets" we have been studying can contaminate not just the soldiers, civilians, animals, and land where the battle has actually occurred, but also the inhabitants of distant territories, as the con-

taminants can be carried by the wind. Most of these inorganic particles are not degradable, either by nature or by man. The immediate consequence is that, once pollution has occurred in a territory, it stays there virtually forever, and no cleaning is possible.

As these inorganic particles drop to the ground, they pollute fruits, vegetables, corn, and grass, to be ingested by humans and animals. For example, when Sarajevo was besieged and very little or no electric power was available, only the tobacco factory kept working, since only the sun's energy was needed to dry the tobacco. When we checked the cigarettes produced there at that time, we detected huge quantities of inorganic dust that got inhaled along with the cigarette smoke. So, nanopollutants have an opportunity to interact within the organism in totally unexpected ways.

• **The new type of war will have unexpected social consequences.** The invisible bullets can be brought home by the soldiers, hidden in their bodies and, in particular, in their seminal fluid, thereby potentially contaminating their unsuspecting partners. As women learn of this danger, one consequence may be a new kind of social alienation of the veterans.

• **Wars' financial costs will need to be recalculated.** In not too far a future, governments will be bound to consider in their cost estimates of war the compensation due to soldiers and their partners and children, as well as to environmental refugees—people who must leave their irreversibly contaminated environments, even though these territories were not technically involved in the war. Those who created such a nanocontamination will be requested to clean it up, a task likely costing huge amounts of money and achieving barely visible results.

• **New defense techniques will need to be developed.** If the new high-tech weapons are to be used in spite of all the problems they pose, military leaders must adapt their tactics to the new situation. When, after the usual shelling, a land is invaded, troops will need to be adequately protected with proper masks and filters. You can bring your weapons from home, but not the air you breathe.

• **The time-scale of "war" will lengthen and its scope broaden.** Enemies are in no hurry; their aim is to win the war, not just single battles. On September 11, 2001, two aircraft incinerated when they crashed into the Twin Towers. One consequence was a huge amount of pollution caused by a mixture of concrete, steel, asbestos, glass, electronics, and almost anything else one can think of. All those things vaporized and recondensed after a short while as tiny toxic nanoparticles. Slightly fewer than 3,000 people died on the spot, but many others, certainly in excess of 200,000, grew ill of pathologies very similar to those affecting the veterans of the latest wars. Among them were not only firefighters and other people who took part in the rescue operations, but also many ordinary people who will show symptoms in years to come.

To an enemy in no hurry, this is a very easy and cheap way to fight a war—one that is not limited to the present generation and upsets the opponent's economy extremely effectively. If those achievements were unintentional before 9/11, they could become the war-waging technique of choice for cash-strapped enemies. If so, how can we defend ourselves against such future wars?

Mitigating the Risks Ahead

Nano-war is a real risk that is already with us, even if governments seem to be unaware of it. Now the big question is what we can do about it.

The obvious (but overly simplistic) solution is to stop making war. The second best solution is to stop pretending nanodust either doesn't exist or is harmless. As early as 1978 the U.S. Army had identified depleted-uranium projectiles as responsible for the formation of very fine, nonbiodegradable particles, and officials warned against the danger those particles were likely to be for environment and health. Leaders who continue to make war must find new ways to do so that spare the environment as well as people who have nothing to do with the war, including future generations.

Academia should help, but in too many cases the problem is with money. Some researchers in this field are funded with the sole aim of finding nothing and, in order to pursue their object, they have no other choice but to follow a way that leads nowhere.

So it is up to NGOs and common people to educate themselves about the situation and to speak up, telling politicians and military authorities that we can no longer afford to ignore the potential effects of nanopollution and nanowars. After all, as is the case in many circumstances, a solution can be found in awareness and in truth, the cheapest and most effective of weapons. ❑

About the Authors

Antonietta M. Gatti, a physicist and bioengineer, is chief of the Laboratory of Biomaterials of the University of Modena and Reggio Emilia (Italy). She served as consultant for the Second and Third Italian Governmental Commission on Depleted Uranium and Related Diseases of Soldiers. Her address is Laboratory of Biomaterials, Department of Neurosciences, University of Modena and Reggio Emilia, via Campi, 213/A, 41100 Modena, Italy.

Stefano Montanari is a pharmacist and the scientific director of Nanodiagnostics, Via Enrico Fermi, 1/L - 41057 San Vito di Spilamberto (Modena), Italy. Web site www.nanodiagnostics.it or www.stefanomontanari.net.

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