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Medical concerns of the current nuclear reality

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The purpose of this article is an objective analysis of the current world nuclear reality after the apparent end of the diminished probability of the global nuclear strategic confrontation. Several important aspects of the nuclear legacy at the end of the first century of the discovery of radioactivity are brought up in the context of the current nuclear arsenal, military strategies and civil defense policies of current postcold war era. Physical and medical consequences of the military and industrial impact on the biosphere are discussed from the viewpoint of the concerns of the viability of the tactical nuclear war and nuclear industry accidents. A particular emphasis focused on the social, economic and psychological consequences of a major accident with a brief overview of Chernobyl update

The prospect of a nuclear nonconfrontation and development of the more safe nuclear power plants does not diminish global current concerns of the legacy of radioactive waste. The disposal of the high level, transuranic and low level nuclear waste presents a major ecological concern with no foreseeable resolution in the near future. It has been discussed in detail in order to emphasize a nuclear legacy facing the world at the end of this century.

The ultimate concern of the misuse of the weapon ready nuclear fuel and small yield nuclear weapons for the purpose of the nuclear terrorism is addressed by the objective analysis of the current post cold war shifts of the nuclear fuel and the state sponsored nuclear terrorism. This necessitates a uniform multinational global cooperation to counteract the possibility of the environmental catastrophes that might be a consequence of a global nuclear terrorist threat. The ultimate goal of the community of the nations of utilizing nuclear energy for the improvement of all aspects of life compatible with the ecosystems will necessitate multinational collaboration on the peaceful use of nuclear energy in the industry, science and medicine.

Key words: medicine, nuclear reality

The strategic nuclear battlefield is a concept related to the war scenario from far behind the conventional confrontational lines of battle by the use of long range delivery systems of nuclear weapons to attack deep into enemy territory. It is distinctly different from tactical nuclear warfare, wherein short range delivery systems may be used to deploy the nuclear weapons with the situations of a more conventional battlefield.

This paper addresses several key questions regarding current nuclear reality, where many uncertainties prevail after an apparent end of the Cold War. An essential question is the future of the process of democratic changes in the former Soviet Union and the future development of dealing with the nuclear arsenal in the Russian Republic and the independent countries that have seceded from the Soviet Union, still containing a considerable number of nuclear weapons and weapon grade materials, such as Belarus, Ukraine and Kazakhstan. The smuggling activities of Uranium and Plutonium nuclear fuel into the countries with potential regional conflicts and still unresolved issues of the political future of the previous Soviet Bloc necessitates a concern of a question of what kind of nuclear weapons will be involved, what the military strategies are, whether the civil defense is possible, what the consequences of a nuclear confrontation on tactical or less likely strategic scale would be and ultimately, what its ecological, social, economic, psychological and medical consequences would be.

An important aspect of this paper also deals with the issue of the emergency preparedness in the event of the major accidents involving nuclear industry, transportation of nuclear materials, disposal of high-level radioactive waste and nuclear terrorism.

CURRENT GLOBAL NUCLEAR STRATEGY

Nuclear weapons have evolved from the prototype fission bombs deployed in Japan at the conclusion of the World War II to the awesome arsenal of thermonuclear warheads with constantly updated and increasingly sophisticated delivery systems.

The combined arsenal of the United States and previous Soviet Union include more than 50,000 nuclear warheads with a total combined yield of approximately 15,000 megatons (explosive power of one million tons of TNT) or the equivalent of one million Hiroshima bombs (2).

The majority of strategic nuclear weapons are deployed by the use of ballistic missiles which are launched into space and can orbit intercontinental distances within the time of minutes. Land based intercontinental ballistic missiles (ICBM) are deployed in underground silos encased in various types of reinforced concrete.

The land-based intercontinental missiles are often fitted with multiple warheads, targetable independently on sites that are hundreds of miles apart. They comprise the group of multiple independently targetable reentry vehicles (MIRV). The largest part of the nuclear arsenal is deployed in submarine launched ballistic missiles (SLBM). The Trident submarines carry 24 SLBM with a maximun range of close to 5,000 miles when equipped with eight 100 kiloton MIRV warheads (34). The advantage of the ICBM systems is mainly contained in their capacity of being highly mobile and non-targetable. The disadvantage of ICBM systems is that they are targetable and as the accuracy of delivery systems improves, the containment silos become more vulnerable to directhits by the enemy warheads (2).

Strategic war can also be waged by aircraft. Bombers are frequently equipped with short range attack missile systems (SRAM) with a range of hundreds of miles or long range cruise missiles hwich can be navigated thousands of miles into the enemy terrytory. Cruise missiles can also be launched from submarines and battleships (34).

The most recent advent of the nuclear military concerns includes highly sophisticated bombers designed to evade radar detection (e.g. Stealth) and still experimental use of the laser equipped satellites in outer space designed to target and destroy missiles in flight (Strategic Defense Initiative) (35).

Mutually assured destruction (MAD) has evolved as a declared United States policy, being a focal point of the strategic relationship between superpowers during the cold war era (25). Military strategists, on the other hand, have developed the concept of Nuclear Utilization Target Selection (NUTS), which includes plans for using nuclear weapons against specific selected targets. Current United States and Russian target selection, although recently modified by non-targeting each other, has been derived from a countervalue policy that identifies objects of a national value such as military installations, industrial areas and population centers. The premise for this policy is that a military destruction of the enemy's command and control facilities limits the capability for a retaliatory strike (38). The concept of mutually assured destruction has acted as a powerful deterrent to the armed conflict among the superpowers. Although strategists assume that nuclear war can be waged on a limited scale, there is a high risk of rapid escalation with both sides fearing the other will be first to deliver a cripplig preemptive strike. Unfortunately, however, given the diversity, decentralization and mobility of nuclear arsenals, an attack of this nature will almost cerrtainly lead to a massive retaliation with devastating consequences (34).

CIVIL DEFENSE POLICIES

The civil defense policies propagated in the United States during the 1950's and the 1960's have gone into a deep decline. This is largely due to the greater technical sophistication, reach and magnitude of the current nuclear arsenal, increased awareness of the limited liability of protective measures and a sense of resignation in face of a total destruction likely to be wrought by a nuclear war (20). Although the Federal Emergency Management Agency (FEMA) has been advocating increased spending for civil defense, planning for protective measures in case of nuclear war has received rather little support. This is likely due to an overwhelming feeling among the officials that no meaningful social survival will be possible after a nuclear attack. Some have argued that a strong civil defense preparedness policy would invite a nuclear attack because the enemy may assume that the other side is preparing for an offensive and would therefore be more likely to launch a pre-emptive strike. Others contend that sturdy civil defense would only serve as a future de-terrent (20).

Many analysts have concluded that the evacuation planning is unrealistic giving the massive traffic congestion which would be an inevitable result. FEMA considers that three days would be the minimum time required for evacuation of Boston and Philadelphia and four days for New York City.

However, given that in the event of nuclear war there is no safe place for this population to go, the level of cooperation with such plans is likely to be minimal. Furthermore, mass evacuation would be immediately apparent to the enemy through the satellite surveillance and intelligence network and would only serve to escalate tensions which might in turn increase the risk of the attack (20).

MEDICAL CONSEQUENCES OF NUCLEAR REALITY

An explosion of a one megaton nuclear weapon releases energy equal to one million tons of TNT. The first use of the atomic bomb was justified as a "terror weapon of the last resort" and sought to place the use of this new military technology under international control (41). This energy release creates the blast, thermal radiation, ionizing radiation and radioactive fallout. When a one megaton weapon is detonated within 1.000 meters above the surface of the earth, photons are emitted within the time of one millionth of a second. Most of these X-rays are absorbed into the air around them producing an incandescent fireball. The fireball reaches the temperature of 100 million degrees centigrade, five times higher than that of the center of the sun (45).

Approximately three percent of the energy is released as a prompt nuclear radiation, consisting of X-rays, gamma rays, and neutrons which are lathal to approximately 1.7 miles of ground zero (20). Forty to fifty percent of the energy released by a one megaton bomb is in the form of light and heat. This thermal pulse travels at the speed of light and ignites fires as far as ten miles away. Buildings, people, plants and animals will absorb most of the heat within a second of detonation (45).

The radioactive material carried into the atmosphere by the dirt debris taken up by the negative pressure in the fireball is heavier than the fission materials of the bomb and begins falling back to the earth as black rain. The lighter materials are carried higher into the atmosphere and fall down farther downwind of the explosion. Radioactive fallout containing several hundreds of different fission products may integrate into the biosphere causing delayed degenerative, genetic and neoplastic disease long after detonation of the nuclear weapon (45).

Primary blast effects include injury and death from traumatic events as structures collapse causing internal and external traumatic alterations as a consequence of the sudden pressure changes producing a pressure of millions of pounds per square inch. Some authors suggest that such objects may have an impact velocity at a range of almost fifteen miles, sufficient to have a 50 percent probabilitiy of causing a fracture to the human skull (21).

Thermal effects include flash and flame burns. As the probability of massive fires is great, such effects may lead to the various injuries including asphyxia and lung damage from carbon dioxide and toxic fumes, as chemicals, fuels and contents of the buildings continue to burn. Looking at the fireball would produce blindness in some cases and mass casualties of heat exhaustion.

Radiation injuries would vary accoriding to the size of the bomb and the victim's proximity. Estimates are difficult because of the differences between the ground and surface bursts, the variation in wind patterns, type of radiation received and the age and general health af victims. However, it is probable that at least 30 percent of the population of the northern hemisphere would receive doses of at least 2,5 Gy with the entire population being exposed to 1 Gy.

Whether the source is the initial burst, fallout exposure or the effects of the low level radiation during the post attack period, the degree of illness depends on whether the exposure is local or a total-body, as well as whether radiation deposited is from external penetrating radiation or internal contamination. The letter is determined by the pathways of entry into the internal environment of the organism, by inhalation, ingestion or traumatic lesions (13)

Lethal doses are considered to be in the 4-4.5 Gy ranges. Such patients die within the weeks from one of the radiation induced syndromes. Bone marrow (haematopoietic) syndrome (2-10 Gy) produces loss of coagulation factors leading to various forms of the manifestation of haemorrhagic diathesis whit an impairment and loss of specific and non-specific immunological mechanisms due to depletion of the lymphocytes and polymorphonuclear leukocytes.

Gastrointestinal syndrome (800-3,000 cGy) involves a damage to the intestinal mucosa causing severe fluid and ion loss as well as septicemia by the entry of the intestinal microflora into the intravascular compartment, leading to lethal outcome within days to weeks. Neurovascular syndrome (over 5,000 cGy) leads to death within hours, diminated by the clinical picture of hypotension, hyperthemia, projectile emesis, severe diarrhea, ataxia, disorientation, circulatory problems, edema, elevated intracranial pressure, cerebral anoxia, oliguria and coma.

Additional effects of ionizing radiation include damage to the skin, lungs, gonads and eyes. In the general scenario of mass exposures to at least 100 cGy there are also delayed effects such as cataracts, vascular damage, genetic changes, and most inportantly malignant alterations. One out of 80 persons would likely develop fatal cancer, whereas two in 80 persons would develop non fatal previously described consequences of ionizing radiation (10).

Considering various injuries as independent entities may be misleading besause of the synchrony of the moneostatic mechanisms and the effests of the combined injuries. Synergistic effests of the injureis that would lead to the fatal outcome in the case that would not be fatal by the radiation alone, reduce LD/50 to the lower values then 300-450 cGy (28).

In the event of a nuclear war, madical services would suffer almost total paralysis. The vast majority of the hospitals and physicians tend to be concentrated in large urban centers, which would constitute target areas where destruction and fatalities would be highest. Even in the least adverse conditions where only a single major city had been bombed, there would not be enough medical resources in the United States to provide the adequate care for survivors (47). It must also be noted that even in the improbable event that medical services remained intact, professionals would be severely hampered by their total inexperience in handling radiation casualties.

ENVIRONMENTAL REALITY

Regardless of scenario and inherent uncetainties of predictions, there is a concensus within the international scientific community that even a relatively small scale nuclear war would lead to global climatic and environmental consequences of catastrophic proportions (40,48)

Multiple nuclear explosions would result in millions of tons of fine (a megaton blast carries approximately 200,000 tons of dust) being injected into the upper atmosphere. In addition an estimated 50 to 150 million tons of smoke would be generated from the fires caused by the explosion (15), If these particles were spread over half of the northern hemisphere, only 50 percent or the solar energy and light would pass through to the earth's surface for a period of weeks (24).

This phenomenology has been extensively studied as a scenario that might lead to nuclear winter, which would cause the temperatures in the northern hemisphere to drop between 5 and 22 degrees centigrade within a few days, causing freezing conditions even in summer, with a projected decrease of precipitation by as much as 80 percent (24).

Long term effects include an average annual temperature decrease of a few degrees and the reduction of light by 5 to 20 percent (46). Nitric oxide is generated by the nuclear fireball (a megaton explosion generates 5,000 tons of nitric oxide) which combines with the very heated smoke residies in the stratosphere. It would reduce the ozone layer by 50 percent causing ultraviolet radiation (UV) to be increased by 40 to 100 percent for serveral years (46). The rising smoke could also displace the ozone layer toward the southern hemisphere, The nitrogen oxides combined with the sulphur oxides from the fires would greatly increase the acidity of rains. The release of large amounts of taxic chemicals and gases during the blasts and fires would cause serious local pollution of water, air and soil.

Ecological effects arising out of environmental changes induced by nuclear war cannot be fully determined because synergistic effects are greater than any of the subcomponents of a nuclear weapon deployment. Global mass starvation of human population would occur due to disturbances of ecosystems together with agricultural production and distribution. The availability of the fresh water supplies would be restricted amont other factors due to freezing. Contamination by the radionuclide products of nuclear fission of the fresh water and oceanic supplies and the introduction of the fission products into the food chain would lead to further death and diseases as a consequence of altered immune system in humans and animals (50).

Whether concidering effects on ecosystems such as fresh water, oceanic or terrestrial, it is of primary importance to recognize that disruption of sunlight affects photosynthesis, the transfer mechanism through which all life forms derive their energy. Thus, any assault on an ecosystem, as a whole or in part, would compromise its existence or its ability to function. This could further lead to increased incidents of mutations, pandemias and death (8,17,43,44,51,)

In addition to the diminished light, all surviving forms of life after a nuclear attack would be exposed to other physical stressors such as ultraviolet light, ionizing radiation, radionuclide contamination, cold, varied precipitation, acid rain, fires and pollutants. The extent to which these stressors would diminish and qualitatively reduce the life forms would depend to a large extent upon the combination, duration, timing and length of exposure. Different studies of all of the weather and climate modelling, although containing some uncertainties, agree in general on the overall effects of the consequences of a nuclear weapon deployment, including generation of nitrogen oxides, reduction of the ozone layer, increase of ultraviolet solar radiation, for several years with a long time impairment of the planet's ecological systems, including the marine plankton and the food supplies from the oceans. However, different models including TTAPS, NCAR and Russian theories contain certain defferences, with a Russian view that after initial cooling the temperatures may rise above normal. Various models are being integrated in the international committees such as SCOPE (Scientific Committee on Problems of the Environment) for the ongoing continuous studies (18)

SOCIAL AND ECONOMIC CONCERNS

Without the ability to relocate people from the high-risk areas, it has been estimated that less than one half of the population of the United States would survive the Russian first strike (39). Since the social systems with which we are familiar would suffer an instant collapse, the survivors would depend on each other and follow the leadership of those demonstrating the most knowledge about survival, as it was the case in Hiroshima and Nagasaki.

Reconstruction of the society is largely dependent upon resources outside the areas of impact. The magnitude of destruction likely to result from the strategic nuclear confontation would make an outside assistance improbable. Medical assistance to the victims of the combined injuries would be limited because of disintegration of the community and the post-disaster recovery would be tied with close kin relationships (39). Relocation would depend on the areas remaining intact for placement of evacuees, transportation systems and food supplies. The family unit will be the most likely componant of the foundation of rebuilding of the societal structure and function. Communication between government and citizens would be compromised due to the missing chain of command and inoperable equipment. Transportation hindrance on a large scale is anticipated because of the non-availability of vehicles, rapair parts and fuel. This would be an additional impediment of distibution of basic commodities such as food, water and medical supplies.

Strategic war's obliteration of the economic infrastructure in an industrial society would be immediate, complete and indiscriminate (27). Organized econimic operations would be annihilated due to the focus of impact on urban areas and strategic centers. Industrial production would cease, since there would be no replacement for essential machinery that performs basic functions relative to economic viability of the society. Transportation from storage facilities (primarily located in remote areas) would be unavailable for the distribution of basic commodities, contrary to the information provided in the report of the Civil Preparedness Agency of the United States (6). The temperature decrease and radioactive fallout would eliminate economic potential in agriculture.

Society after a strategic nuclear war would undergo extreme fundamental changes with the availability of goods and services reduced to the bare minimum and total disappearance of the activities that are taken for granted in a normally functioning society (6). The government and political structures would be dramatically impaired due to the authorities inability to respond to an emergency. Compatition for leadership at the local level could impede relief efforts. The strain of large scale damage and physical deprivation would lead to greater disaffection and hostility toward government and its representatives (24).

PSYCHOLOGICAL CONCERNS

Current research attempts to address the complexity of psychological impact by drawing historical analogies from man-made and natural disasters.

Several common behavioral changes apparent in survivors of catastrophes are that survivors suffer from a loss of meaning, loss of will to live, profound apathy and general depressed motivation state (5, 16, 19, 30). At the family level, a small and very independent unit, a varying combination of post disaster stressors (i.e. degree of destruction, disorganization and casualties) introduce multidimensional consequences. Research investigating the effects of war upon children since World War II suggests that children model parental response to trauma (10, 33). Post-traumatic symptoms include psychosomatic complaints, insomnia, nightmares, chronic fatigue, fear of recurrence, fear of people and regressive and overt aggressive tendencies (10, 33, 42).

It is generally acknowledged in the literature that psychological disturbances following a nuclear disasters will be associated with the state of a marked anxiety, characterized by apprehension, fear, confusion and irritability (12). Survivors of Hiroshima and Nagasaki were observed to display characteristics of physical numbness, survivor's guilt, mental decompensation, various psychoneurological disorders, permanent fear and uncertainty, a lifelong identification with the dead and fear of radiation and contamination of future generations (5). It is clear psychological reactions of survivors may continue for months or years following a nuclear exchanges (5). Long term effects could include demoralization and severe disruption of the social structure.

Finally, the issue of assistance available to survivors of a nuclear attack needs to be addressed. Several researchers outline the following factors that have to be considered: the number of victims with mental and behavioral disturbances, the number of mental health professionals available to provide treatment following a nuclear confrontation, the amount of time required for treatment, the availability of treatment facilities and availability of the pharmaceutical supplies needed for treatment (12). It seems apparent that no adequate treatment would be available for the vast number of psychological casualties.

THE CONCERNS OF THE VIABILITY OF NUCLEAR WAR

Thermonuclear weapons have radically changed the nature of the strategic battlefield. With the development of highly accurate delivery systems, multiple warhead missiles and huge arsenal of weapons, the opposing sides in any nuclear conflict face the real prospect that their countries could be subjected to attack and unprecedente destruction.

Continued theorising in defense establishments about strategies for fighting and winning a nuclear war seems to be contradicted by the inescapable realities of the nuclear battlefield for some of the following reasons.

1. No effective defense against nuclear weapons has been developed and even with the advent of Strategic Defense Initiative none is anticipated in the foreseeable future. Current Civil Defense planning does not offer any reasonable prospects for protecting civilian population in the event of a nuclear exchange.
2. Neither side could avoid substantial retaliation in a nuclear war even if it succeeded in carrying out a relatively successful first strike. Non-targetable, mobile launchers, such as submarines at sea and aircraft in the air, would ensure that even the victorious side in such a scenario will sustain hundreds, if not thousands of strikes on its cities, industrial facilities and military bases and installations.
3. It is a matter of considerable doubt whether any nuclear war, once initiated, could remain limited or be readily contained or ended. Once either side has sustained, a serious attack, the pressure, both political and military, to counterattack would likely be irresistible. Moreover, current counter-command strategies (i. e. targeting the other side's leadership for early strikes), might well ensure the elimination of anyone with a sufficient authority to quickly halt an exchange.
4. The consequences of any substantial nuclear exchange would be a massive destruction to both sides, including:
   · the obliteration of major urban centers
   · hunderds of millions of direct and indirect fatalities
   · severe injury to surviving population, including radiation syndromes, combined injuries and radionuclide contamination
   · destruction of medical facilities and the disruption of health care, resulting in high mortality among the injuried and pandemic spread of infectious diseases
   · the widespread destruction of agricultural and industrial production, communication networks, transportation systems and economic infrastrukture
   · mass psychological damage to survivors
5. Extensive scientific research in recent years has indicated that even a "modest" nuclear exchange is likely to have a severe and lasting impact on the biosphere. It now seems clear that these effects would be so serious and pervasive that even in an unlikely event that one side could attack first and completely escape retaliation, the "winner" will experience disastrous levels of environmental damage and millions of fatalities.

As on-going research expands our understanding of the probable inpact of the nuclear war, the viability of thermonuclear weapons as "usable" instruments of war is increasingly thrown into question. In contrast to the myth of the winnable nuclear war, the reality of the strategic nuclear battlefield remains mutually assured destruction.

NUCLEAR INDUSTRY ACCIDENTS AND CHERNOBYL UPDATE

Industrial accidents involving radioactive sources include medical institutions, research facilities, private industries that employ radioactive isotopes and nuclear power plants (1, 7, 22, 23, 31, 49). The meticulous reference material on all of the types of the industrial accidents is well compiled and recorded (54).

By far the most significant current global concern of the possibility of nuclear accidents of mass casualties involves the potential disasters at the nuclear power plants. Between 1970 and 1981 fifty US nuclear reactors released into the environment over 40 million Curies of radionuclides, equivalent to the Chernobyl disaster in 1986. The misleading contention that a Chernobyl type accident is not possible in the United States is illustrated by a probability of an explosion following a loss of coolant which may lead to contamination of fuel with water in a reactor wessel. It was testified before the congressional subcommittee in 1986, that in then existing 100 nuclear reactors in the USA a probability of an accident would range between 12 and 45 percent. The most significant nuclear power plant accidents occurred at NRX Reactor in Chalk River, Canada in 1958, Windscale, England in 1957, McKeesport, Ohio in 1960, Idaho Falls in 1961, Detroit Fermi Reactor in 1963, Hanford N Reactor in 1970, Calvert Cliffs emission in 1975, Browns Ferry, Alabama in 1975, Rancho Seco, California in 1978, Pilgrim Reactor, Plymouth, Massachusettes in 1981, Ginna Reactor in Rochester N.Y. in 1982 and Shipping port Reactor, Pennsylvania in 1971.

The worst accident involving nuclear power plants in the United States occurred at the Three Mile Island Unit 2 reactor in Pennsylvania, resulting in 40 cGy/hour exposure in the nearby town of Goldsboro only two miles from the plant. An average estimate of 16 million Curies of radioactive noble gases and only 14 Curies of iodine-131 escaped into the environment. The controversy still exists about the incidence of cancers, leukemia, stillbirths, spontaneous abortions, hairloss, thyroid disease and numerous other disease entities among the humans and farm animals. The clean-up of the plant has been in the multibillion dollar range. Over 150 tons of radioactive waste has been transported to the Idaho Falls awaiting its final repository. Over ten thousand temporary workers have been involved in the clean up process with an estimated 13,000-46,000 man/rem doses to be apsorbed with still ongoing scientific debate of the probability of genetic defects.

The worst radiation accident in the history of nuclear power occurred on April 26, 1986 at Chernobyl Nuclear Power Plant in Ukraine, when due to the human error in a RBMK type nuclear reactor the emergency core cooling system was shut off in an experiment (7). In several seconds reactor power exploded shattering the fuel rods and turning water to steam, followed by the second explosion probably caused by hydrogen, blowing the radioactive material and burning graphite in the biosphere (52). Over 18 tons of radioactive material escaped into the environment. 30 kilometers exclusion zone was established around the plant, 140,000 people were evacuated within 11 days and approximately 17 million people received radioactive contamination including 2.5 million children under 5 years of age. The ongoing research indicates a significant increase of lymphocytic leukemia, multiple myelo and thyroid disease. Although it is too early to estimate the ultimate outcome, the most recent BEIR V (Biological Effects of Ionizing Radiation) report pointed out that the received radiation doses might be higher than initialy considered. The current research provides still ongoing analisys of data optained on the follow-up of Chernobyl children in different centers around the world, one of the most prominent being the medical and epidemiological analysis of the evacuated children in Kfar Chabad Center in Israel. The total amount of radioactive organotropic radionuclides released into the environment has not yet been determined with certainty. The most recent data indicate that Chernobyl accident released total radioactivity of 1-2 EBq, excluding noble gases as xenon and krypton (26). Cesium-137 emitted into the environment represents at least 30 percent of the total cesium-137 inventory in the core of the damaged reactor (3).

LEGACY OF RADIOACTIVE WASTE

Radioactive waste is created in basically two diferent ways, one being fragments of nuclear fision form eighter nuclear power plants or nuclear weapons. The other major category of nuclear waste is spent nuclear fuel. When the fuel rods are irradiated in a nuclear reactor and withdrawn from use, the remaining fuel is still highly radioactive, containing over 600,000 Curies per metric ton. The current accumulated radioactivity in the US in spent fuel alone is over ten billion Curies. Radioactive decay from this fuel generates close to 40 Magawatts of heat (29). By the year 2000 it is anticipated that over 73,000 metric tons of spent nuclear fuel will be accumulated in the United

States. The permanent storage sites for the spent fuel in the US is still an unresolved isue.

High level radioactive waste remains after uranium and plutonium are extracted from spent nuclear fuel during reprocessing. Military programs utilize reprocessing for recovering plutonium from the production of nuclear weapons and as a part of the fuel cycle of naval reactors. The current inventory of high level waste is over 300,000 cubic meters at the end of the year 1990. In the United States there are four sities of storage of high-level waste, including the Hanford reservation, Washington State, Savannah River Plant, South Carolina, Idaho Fals and West Valley, New York State.

Another category is transuranic waste, mainly including uranium, plutonium, neptunium and americium from nuclear reactors. Most transuranic wastes are being created by the military programs. In 1980, 24 million cubic ffet of these wastes were buried at 8 of the government and 4 commercial sities in this country alone.

The last categry is low-level waste, including radioactive materials not created from reprocessing or tailings and having wery low transuranic contents, including medical and research wastes, control rods from the reactors, residues from uranium conversion, enrichment and fabrication and contaminated items used in handling of radiation. In the US there are 6 low-level waste sites operated by DOE and three commercial sites in operation, mostly buried in shallow trenches. In 40 years from now, all of the 111 commercial reactors and 93 military and research reactors will be too contaminated to continue operation, not counting 126 reactor-driven naval vessels that will all become part of the discarded low-level waste.

There are three basic strategies of managing radioactive waste. The first category is to retain them until decay to the harmless state-mainly intended for the short half-life radionuclides. The second categry is to dilute and disperse them over a wide area. The third category is to concentrate them and prevent their migration in the environment, mainly intended for the waste of long half-life radioactive materials. Concentration of radioactive wastes can be achieved eighter by the evaporation of excess liquid, by their precipitation as a solid matter from a large volume of material or by the process of burning the materials, retaining the ashes and filtering the gases.

The radioactive wastes of the United States have been studied for disposal by the numerous methods. The main approach includes the storage in underground tanks. However, it has been found prone to early leakage and contamination of the environment. In addition, they require an elaborate cooling system and constant attendance for the integrity of the containment. Aboveground storage has also been found impractical for the long-lived radioactive waste, although their cooling systems have certain advantages over underground tanks. Burial in the ocean floor, capped deep cracks or in the bottom silt was based on the dilution and has encountered considerable environmental controversies owing to concerns of permanent contamination of waters.

Permanent removal of radioactive waste from the biosphere by the rocket launching into the space, appeared impractical from the viewpoint of the cost of over a billion dollars per launch (36) and the risks of catastrophic concequences for the environment in the event of an explosion of a launch vehicle.

Another suggestion of disposal of the radioactive waste in the ice of Antarctica (37) although attractive, remains an area of considerable controversy because of disruption of the ecosystems.

Several other methods have been entertained, including transmutation of the radioactive waste by the neutron bombardment, the creation of the zones as national waste monuments, separation of the high and low activity waste, deep geologic burial six to ten miles below the surface of the earth, or 3,000 meters in the hard rocks, horizontal burial in the shafts of the mountains, burial on the lonely islands, soldification in the stable mineral matrix, the burial in canisters in mines and glassification of the radioactive waste, which is currently used in France. Grouting has been proposed as mixing of radioactive waste with cement and burial in shallow pits, a process being developed in Australia to incorporate waste into a mineral matrix of synthetic rock. Calcination is a proposed process of atomizing the wastes and drying them at high temperatures. The current approach in this country is the Waste Isolation Pilot Project in Carlsbad, New Mexico, which has been challenged by the possibility of leakage. WIPP has encountered the resistance from the States of Colorado, Idaho and New Mexico. At present, the problem of radioactive waste remains unresolved. This particuraly refers to not even addressed waste amounts of radioactive waste in the former Soviet Union including ecological disasters of uncontrolled disposal sites in the Ural mountains, Chelyabinsk, Kyshtim and numerous undisclosed sites, including decommissioned military installations. This problem will remain the major global concern for the biosphere viability

NUCLEAR TERRORISM

The risk of weapon-ready nuclear fuel being illegally acquired and made into actual nuclear weapons is a viable global concern, especially after 1980's which was declared a decade of terrorism. In June 1985 a conference was held in Washington D.C. under the sponsorship of the Nuclear Control Institute and State University of New York Institute for Studies of International Terrorism that addressed The Nuclear Dimension of International Terrorism. The concluding guidelines of the conference included organizing an International Task Force for the Prevention of International Terrorism.

Following the demise of the Soviet Union, the smuggling of nuclear fuel activities has been significantly enhanced for the reason of lesser control of the borders and easier availability of the purchase of nuclear fuel. The theft of fissionable materials or nuclear weapons is routinely reported in the press, with a conclusion that plausibility of using nuclear material in terrorist actions increases with the increased accessibility to the theft and transportation of fissionable materials. The Gallup poll opinious consistently indicate that nuclear incidents involving terrorist acts are more plausible than even a tactical nuclear confrontation. It appears greatly enhanced by the State sponsored terrorism, where the financial resources, intelligence, transportation and technical expertise add to the possibility of terrorist go nuclear. Recent, much publicized threats of Serbian self-styled government in occupied Bosnia is an example of a declared intent to attack a nuclear power plant in Slovenia in the event of the tactical necessity in their war of aggression. Over 260 nuclear power plants throughout the world are the prime targets of sabotage, including the facilities of fuel enrichment reprocessing and fabrication plants and transportation routes. In 1978, the CIA emphasized the nuclear arsenals in Western Europe as potential target for the terrorist attacks, since a theft of a nuclear weapon would be an easier task for a terrorist act than the process of building the bomb. This report necessitates physical security of the weapon production and storage facilities as a primary concern for the security of over 50,000 nuclear weapons currently present in the world, and all in the possession of the superpowers, particularly after the end of the Soviet Union. Two major routes of smuggling of nuclear fuel have been identified as Asian and European, mainly through Kazakhstan and Germany, respectively, including highly enriched uranium (HEU) and separated plutonium. Since both of these materials are being used in the world of commerce as civilian fuels for the research reactors (HEU) and power reactors (Pu-239), it is quite conceivable that shipment of nuclear fuel may become the target of terrorist hijacking. In October 1984 alone, there was the transportation of United States originated plutonium from France to Japan, enough to produce over 30 nuclear weapons. The original shipment plans were so poorly planned that the shipment had to be delayed for two years until synchronized by the US, French and Japanese military kommands at the cost of multimillion dollars security improvements. Regardless of increased awareness of the risk of theft of weapon-grade fissionable material and relative ease of producing a nuclear weapon, in the year 1981 alone there was an unaccounted missing of over 409.9 kg of fissionable material. This issue still remains unresolved, while in Russia and independent republics of the Soviet Union there is not even a basic database on the missing weapon-grade fuel inventory. Hundreds of smuggling activities have been intercepted in the past several years, allowing a conclusion of much greater number of successful smuggling of the weapon-grade material, since it is not difficult to smuggle nuclear explosives across international borders. The black market value of a kilogram of cocaine is approximately the same as a kilogram of uranium. The psychology of treason is not always ideologically exemplified, as in the recent cases of the US Navy personnel who betrayed the military secrets not for ideological reasons, but for financial gains. Philosophical reasons, such as political and religious fundamentalism, may play an equally important role in nuclear terrorism. In September 1976 it was reported that Yugoslav officials assisted the international master terrorist Carlos escape apprehension with a small nuclear bomb, intended for terrorist operations (11). The hoaxes of a threat of nuclear terrorism have been effectively used as a psychological weapon and they have been handled by the US NEST team (Nuclear Emergency Search Team), which acts in cooperation with other international agencies, as exemplified by the NEST-Canadian operation in locating and cleaning up debris of a Soviet nuclear satelite in 1978. Since 1978, the US NEST team has responded to over 80 nuclear bomb threats. The bombing of the World Trade Center in 1992 resulted in an awareness of a need of better preparedness for detection of nuclear weapon-grade materials which are virtually undetectable by the means of conventional gamma detectors, being mostly alpha and beta emitters. The emerging times appear more serious than the decade of terrorism in 1980's, because of an easier access to fissionable material and higher probability for state-sponsored terrorism (9).

Nuclear terrorism is not limited to the weapons alone, since it is easier to use radiological weapons such as plutonium dust, which even in the amount of 84.4 grams could provide a lethal effect for a building as World Trade Center if evenly dispersed through the air conditioning system.

Release of radioactivity in the biosphere by targeting nuclear power plants as a form of nuclear terrorism has already been mentoined as a tactical weapon of renegade terrorist governments, as exemplified by the threat of Bosnian Serb leadership to the Slovenian nuclear power plant in Videm-Krško in 1994.

The International Task Force on Prevention of Nuclear Terrorism organized by the Nuclear Control Institute in Washington D.C. outlines a number of ways by which terrorists can go nuclear, including a theft of nuclear weapons, interception of a shipment of fissionable material, acquisition of the fissionable material in the reactors or waste sites, or using the radiological weapons as dispersal devices (4). The Task Force presents a view of an increase in likelihood of nuclear terrorism because of growing incidence of conventional forms of terrorism, state support of terrorist groups, laxity in the global safeguards at the nuclear materials sites, increasing use of civilian nuclear programs and an increase in the black market availability of fissionable materials. According to the Task Force, there have been at least 155 attacks and violent demonstrations at the sites of civilian nuclear installations in the past 20 years, although none of them caused any accident of a significant impact (52).

Antinuclear terrorism preparedness must include bilateral and multilateral cooperation among the nations. The best example of a national program to cope with a nuclear catastrophe has been established in Switzerland, where the civil defense program was formed as a part of national defense. The key elements of nuclear safety include both prevention and emergency preparedness, illustrated by the virtual absence of any major nuclear accident in China in the past 30 years. This has been further accomplished by the implementation of the nuclear emergency program of China (CNNC) after Three Mile Island and Chernobyl accidents (53). Crisis management of nuclear terrorism must include three essential components: readiness, response and recovery. Public awareness of the nuclear terrorist threat must be synchronized with a realistic and responsible media coverage with more emphasis on prevention than handling an actual crisis (32). The world governments have to be prepared to take terrorist threats seriously, by identification of the sources, analysis of the motives, and a total military style of their annihilation (14). At present, it remains a source of global nuclear reality in the light of well-demonstrated incapability of the community of nations to cope even with the state sponsored non-nuclear terrorism.

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Sažetak

MEDICINSKI ASPEKTI DANAŠNJE NUKLEARNE STVARNOSTI

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Cilj ovog rada je objektivna analiza današnje svjetske nuklearne stvarnosti u svjetlu smanjene vjerojatnosti globalnog strateškog nuklearnog sukoba. Istaknuto je nekoliko važnih aspekata nuklearne ostavštine na kraju stoljeća u kojem je otkrivena radioaktivnost u kontekstu postojećeg nuklearnog arsenala te vojnih strategija i koncepcija civilne zaštite u današnjem post-hladnoratovskom razdoblju. Raspravlja se o fizikalnim i medicinskim posljedicama vojnog i industrijskog utjecaja na biosferu sa stajališta i dalje prisutne moguće opasnosti od taktičkog nuklearnog rata i nesreća u nuklearnim industrijskim postrojenjima. Posebno se naglašavaju socijalne, ekonomske i psihološke posljedice velike atomske nesreće, uz kratki pregled najnovijih podataka o Černobilu.
Izgledi da do nuklearnog sukoba neće doći te razvoj sigurnijih atomskih centrala ne umanjuju globalnu zabrinutost zbog nasljeđa radioaktivnog otpada. Odlaganje transuranskog, visoko i niskoradioaktivnog otpada predstavlja ogroman ekološki problem, čije se rješenje ne nazire u bliskoj budućnosti. O tome se u radu detaljno govori kako bi se naglasili razmjeri nuklearne ostavštine s kojom je svijet suočen krajem ovog stoljeća. Napokon, naglašava se problem zloupotrebe oružja namijenjenog nuklearnog goriva i nuklearnog oružja male snage u svrhu nuklearnog terorizma, uz objektivnu analizu post-hladnoratovskih promjena nuklearnog goriva i državnog nuklearnog terorizma. Sprečavanje prijetnje globalnog nuklearnog terorizma i njegovih posljedica u obliku ekoloških katastrofa zahtijeva jedinstvenu multinacionalnu globalnu suradnju. Konačni cilj zajednice naroda - korištenje atomske energije za poboljšanje svih aspekata života u skladu s ekosistemima - uvjetovano je međunarodnom suradnjom u miroljubivoj upotrebi atomske energije u industriji, znanosti i medicini.

Ključne riječi: medicina, nuklearna stvarnost