Abstract

The United States and the world is faced with more and worse disasters in the future compared with the present and the past. There will be both a quantatively and qualitatively worsening. There are five conditions which are responsible for this trend.

1) Old kinds of natural disaster agents will simply have more to hit and along some lines more vulnerable populations to impact;

2) There are new and increasing kinds of technological accidents and mishaps that can result in disasters and catastrophes which were almost nonexistent prior to World War II; they will particularly occur in developing countries;

3) There are technological advances that add complexity to old threats (e.g., fire prevention measures in high rise buildings that retard fires but that are highly toxic);

4) There are new versions of past dangers (e.g., urban rather than rural droughts stemming from lifeline infrastructure collapses);

5) There are new risks appearing that have not been traditionally thought of as in the province of emergency management (e.g., disasters in computer systems or biotechnological catastrophes).

The future disasters are also influenced by four other factors.

1) Natural disasters will increasingly generate technological disasters (e.g., earthquakes resulting in chemical disasters);

2) Increasingly localities will be faced with disastrous conditions from sources that are far distant (e.g., as seen in the Chernobyl radiation fallout or the Rhine River pollution episode which eventually affected seven nations);

3) Many of the future threats or risks have high catastrophic potentials by way of the casualties or kinds of injuries they may generate (e.g., radiation or toxic poisonings);

4) Some of the future disasters while occasioning relatively few casualties or physical damage will be very economically costly or socially disruptive (e.g., the effects of Three Mile Island on the nuclear power industry or the Goiania, Brazil radiation episode).

Better disaster planning can mitigate the impact of these future kinds of disasters but will not prevent their occurrence.

MORE AND WORSE DISASTERS IN THE FUTURE

As the saying goes, there is both good news and bad news.

First, as to the good news. The Disaster Research Center (DRC), as some of you know, has done considerable research on preparations for and responses to natural and technological disasters. Along some lines our field studies, which currently number over 525, report rather good news. For example, in looking at local emergency management agencies in the United States--what in the past used to be mostly called local civil defense offices--we have found that they have much better disaster planning and managing and have better personnel than they once had. Across the country, their disaster preparedness, as a whole, has markedly improved over the last 15 years or so (see Quarantelli, 1988).

A similar good picture appears if one looks around the world. In the last few decades planning for and responding to disasters has improved. Where nothing once existed, much has been created; where there was something in place it has been made better. This is equally true for developing as well as developed countries. Almost anywhere that one can look the present as compared with the past is an improvement (see Quarantelli, 1990).

But I am here mostly to talk about the bad news. If we look not from the past to the present, but from the present to the future, it is very clear that things are going to get worse. We are going to be faced with more and worse disasters in the future no matter how much disaster preparedness and personnel have or could improve. The future, insofar as disasters are concerned, is certain to produce not only quantatively more disasters, but qualitatively worse kinds of disasters than we presently have and have had in the past.

I suppose that for certain purposes one could even see this as good news for some people. For example, if the worst is yet to come, it means that people working in the emergency and disaster planning and management area need not worry that their jobs are going to disappear. They are not employed in something like streetcar transit companies or making mimeograph machines where the activities are disappearing and people are losing jobs as their work disappears. So, one could argue that there is some good news with the bad news I am bringing--the more and worse disasters of the future are going to provide job security for anyone involved in planning and managing mass emergencies and disasters (or as some have said the full employment act for emergency personnel!).

But one of the findings of disaster studies is that emergency relevant organizations tend to look backwards, at the last and biggest emergency and/or disaster to have happened in their locality. That occasion is usually taken not only as the maximum probable but as the kind of disaster that should be prepared for.

This thinking is not peculiar to disaster relevant organizations. The organizational literature is full of documentation of how most companies and industries tend to look to the past. But the literature also shows that the more successful groups are those that look to the future. That is one reason why such companies and industries are likely to have strong research and development (R&D) programs--they project into the future and organize to meet future trends and needs.

Usually researchers are asked to say something after a problem arises. They often look at a recognized problem, one already in existence, and indicate its nature and how it might be dealt with. However, another major responsibility of scientific research is to look into the future and say something about yet unrecognized problems, those that are latent and that have not fully manifested themselves so far. It is some future problems in the disaster area that I want to call to your attention.

Everywhere in the world it has been a long and difficult struggle to establish emergency planning and management programs. But I would suggest we ought to start thinking about the 21st Century, only a few years away, and ask what kind of emergency organizations ought to be in place at that time. What will be needed will depend on the kinds of disasters that are likely to occur.

Why Disasters Will Get Worst

We have already suggested we will simply have more disasters and worse kinds of disasters. There are at least five different categories of threat or conditions which I will discuss that will bring this about--the more and worse disasters. They are:

(1) old kinds of natural disaster agents that simply have more to hit, and along some lines will impact more vulnerable populations;

(2) new and increasing kinds of technological accidents and mishaps that were almost non-existent prior to World War II and that will increasingly occur in developing countries;

(3) technological advances that reduce some hazards but add complexity to old threats;

(4) new versions of past dangers; and,

(5) new risks are developing that have not been traditionally thought of as in the province of emergency planning and managing.

Let us look at each of these five in a little more detail.

We should note that the examples and statistics are drawn from various sources especially from the publications cited in the annotated bibliography by Hughes (forthcoming); some are also drawn from a forthcoming article of ours (Quarantelli, forthcoming)

1. Old kinds of natural disaster agents that simply have more to hit.

It is sometimes overlooked that natural disaster agents have consequences only in a social context. So, while such physical agents as hurricanes, tornadoes, floods, and earthquakes are probably not increasing (at least on any observable human time scale), what they can socially impact has and is changing.

For example, take hurricanes. The coastal areas of the United States and some other countries also are being subjected to unprecedented population growth, building of structures and economic development. This means that more than ever before more people and property are vulnerable to the hazards of hurricanes. By the year 2000, hurricanes can be expected to result in the greatest amount of per capita property damage in the United States. Development pressures have also accelerated the threat to lives in coastal zones; probable evacuation times in several large metropolitan areas now approach or exceed 20 hours, while state-of-the-art forecasting techniques are still striving for reliable twelve hour predictions of landfall. Given this, it is not surprising that some experts have advanced scenarios in which hurricanes could claim more than 10,000 lives in a coastal metropolitan region in this country.

As for floods, the picture is the same everywhere in the world. There are more people and settlements then ever before in riverine flood plains. Where in the past there was marsh or swampy areas, there are now housing complexes and industrial parks. The same picture could be drawn for earthquakes, tornadoes, and volcanic eruptions; there is simply more of a built environment they could impact. Where empty or sparsely populated space might have been hit in the past, in the future many people and developments will be hit. There is practically nothing of the reverse process, that is, abandonment or withdrawal from dangerous areas.

As another example, we have always had flash floods in the physical sense in the United States but they are increasingly resulting in disasters such as the Big Thompson flood where over 100 died. This is because changes in lifestyle are leading more people to be tourists in resort areas vulnerable to such events (a similar pattern is true with respect to avalanches in ski resort areas).

Along certain lines, many of the developing countries around the world because of their ever increasing populations are going to be especially more seriously impacted even if the magnitude of future disasters are the same as past ones. For instance, a tropical cyclone in 1876 devastated the shores of the Bay of Bengal (now Bangladesh) killing an estimated 100,000 people. A 1970 cyclone that struck the same area left between 200,000 and 300,000 dead (Lechat, 1990: 71).

One personal way to document the probable greater future impact is to ask the following: if the last major disaster to hit your area were to hit exactly in the same way now or in the future, would you lose more, less or the same? I think almost all of you would say more.

2. New kinds of technological accidents and mishaps that can lead to disasters.

To the category of (so-called) natural hazards has been added a relatively newer category of technological accidents and mishaps. These are the disasters resulting from human errors and collective mistakes of groups. To the so-called Acts of God, the human race has now added the Acts of Men and Women (see Lagadec, 1982). (We will ignore here for purposes of discussion that at one level all disasters can be attributed to human and group actions and decisions, see Wijkman and Timberlake, 1984; Quarantelli, 1987).

a. There are the risks associated with the production, transportation and use of dangerous chemicals. (The relative recency of these threats are perhaps attested to by the fact that when I started research about 35 years ago, they were simply not mentioned as a major or frequent danger.) There are several interesting aspects of their appearance.

For example, even localities which in the past had none or few risks from natural disaster agents, are now vulnerable to toxic chemical spills, explosions or fires, if they have any roads, railways or navigable waterways. In the United States alone about 1.5 billion tons of hazardous material are transported every year (Pavia, 1990: 2). In a sense, this has reduced the geographic selectivity of possible disaster impacts. Almost all inhabited areas of societies, except for the most rural of the developing ones, have now become vulnerable to disasters from this source.

Furthermore, the threat of greater disasters of this kind is increasing because of the greater amounts of dangerous material involved. For instance, from 1960 to 1980, not only has the number of tankers carrying petrochemicals doubled, but their shipping tonnage has increased sevenfold. So, increasingly, there is something bigger to spill, explode or burn on waterways as manifested in the <u>Exxon Valdez</u> oil spill.

To the in-plant and transportation kinds of <u>acute</u> chemical types of disasters, we have also been adding the more slowly developing and diffuse types associated with hazardous waste sites (see Peck, 1989). Love Canal and Times Beach as well as Seveso in Ital, are examples of what we may expect more of in the future. Perhaps the Title III program recently instituted in the United States will prevent this development, but if so it will be that very rare of mitigation measures--one that actually reduces dangerous incidents (there are some that can be pointed to--measures were taken in the past that very sharply reduced boiler explosions to the point now that they are very infrequent, but such success stories in the disaster area are not many).

There has been only one Bhopal type disaster so far, but it will be astounding if we do not have others eventually (see Shrivastava, 1987). The safety and accident prevention programs of the chemical industry in many developed societies are massive and impressive (although less so in developing countries). But the multiplicity and range of what can go wrong in the chemical area has so increased that, statistically, we are becoming increasingly vulnerable.

b. Then there are, of course, the risks associated with nuclear power. Three Mile Island suggested the potential; Chernobyl presented the reality. We may expect more along those lines. In June 1987, a retiring member of the Nuclear Regulatory Commission (James K. Asselstine) predicted a 45 % chance of a meltdown in a nuclear plant somewhere in the United States in the next 20 years (see, New York Times, June 7, 1987). In February, 1991, the nuclear power plant in Mihama, Japan apparently came close to a nuclear meltdown.

Apart from in-plant nuclear plant problems there is the danger that will be generated by the transport of nuclear wastes over major distances. In the United States, by the year 2000, we will have about 47,900 metric tons of spent fuel, compared to 12,900 tons in 1985, to be shipped to some deposit somewhere, at the present time this supposedly will be somewhere in Nevada. My point is that the material is eventually going to have to be transported from many places to some chosen site, and that, of course, raises the probability of some accident both in this country and elsewhere.

There are also the risks associated with the transportation of military generated radioactive material. Because of its highly classified nature in all societies, it has been little noticed as a threat (there are also the threats associated with the 17 nuclear plants in being in the United States; their operations

> make the errors in the civilian nuclear reactor program appear benign (Hohenemser, Goble, and Slovic, 1990: 25).

While the transport of civilian hazardous spent fuel is only becoming a threat, the transport of the military generated material is one that currently exists in the United States and other nuclear powers. Some estimates suggest that there may be several thousand shipments every year in this country of bomb grade enriched uranium and plutonium. In 1979 there were 1,904 separate shipments totaling 54,000 plus pounds.

Almost as ignored as the danger in this transportation is the risk in the fact that a great number of military bases have nuclear weapons on them. It is known that at least 32 accidents involving them have occurred in this country. Rather disturbing is a recent (1987) Government Accounting Report that both the Navy and the Army generally have not coordinated their planning for nuclear weapons accidents on base with surrounding civilian state and local emergency groups--it is said that to do so would compromise national security, although, oddly, the Air Force coordinates its planning with that of the civilian authorities (Preparedness for Nuclear Accidents GAO Report NSIAD-87-15).

We are, of course, assured in this report that in the United States:

> According to DOD and the Department of Energy (DOE), extensive security measures have made the possibility of an accidental nuclear detonation virtually nonexistent (Preparedness for Nuclear Accidents, 1987: 2).

Perhaps, but in 1979, just a few months before the Three Mile Island accident, the Atomic Industrial Forum published a statement that said:

> Nuclear power plants are designed and built to withstand every conceivable Act of God--and some inconceivable ones as well." (quoted in Chronicle of Higher Education 4/1/79, page 20).

Such flat and unqualified assertions of total safety are, in my mind, warning flags that one should become immediately alert for possible trouble. These kinds of statements of course are not peculiar to the United States; in 1978 a representative of the British Department of the Environment wrote that:

> the transport of spent fuel creates no significant risk...the position appeared to me to be so clear that I say no more about it (quoted in Kirby, 1988: 318).

We can not only be certain of the happening of technological disasters of this kind, but they too can be qualitatively worse than certain other kinds of disasters. For example, chemical poisonings and radiation contaminations require complex and sophisticated kinds of medical treatment. They can, and do, put much more of a strain on emergency medical services than the "ordinary" disaster. Often, in these kinds of disasters, material things, equipment, land can be polluted and contaminated in different ways than usual. The cleanup is often far more costly and requires more specialized knowledge than is usually the case, say, after tornadoes or hurricanes. Also, in some instances, there are second order effects; for example, health consequences can surface years later. There might be cancer cases which would not be the kind of long-run medical result of most natural disaster agents. So, qualitatively, these kinds of disasters can be rather different, and we are going to have more such kinds of happenings.

Also, there will not only be more impact from both natural and technological disasters, but the quality of the impact in many cases will be worse. For example, in the United States we have a society where there have been only six disasters (including two steamship accidents) where it has been fully documented that more than 1,000 persons have died. But all of the future natural disaster agents could now create dead victims well in the four or five figure range. Handling the dead, the relatively small number of dead we tend to have now, which is usually in the dozens, typically generates all kinds of problems from obtaining enough caskets to psychological after effects for those that have to deal with more than a few dead bodies (see Blanshan and Quarantelli, 1981). Future disasters with numerous dead bodies will sharply increase those kinds of problems.

Also, as another example of a qualitative change, we are increasingly getting an older population in at least the majority of developed countries around the world. In some societies the retired elderly often migrate to hazardous areas such as the state of Florida in the United States. But we know from studies that older people among other things, are more likely to be injured in disasters as noted in the following:

> Based on studies of previous tornadoes, persons aged >60 years are seven times more likely to be injured than persons aged <20 years because of factors, such as medical illnesses, decreased mobility, decreased ability to comprehend and rapidly act on tornado warnings, and greater susceptibility to injury (MMWR Morbidity and Mortality Weekly Report, January 18, 1991).

In addition older victims find it more difficult to make up for property losses; in fact, the elderly have proportionately more to lose. Disasters of the future are likely to impact more heavily simply because the impacted population is likely to be older.

The future situation is equally bad for developing countries, although for the opposite reason from a demographic viewpoint.

That is, along with the elderly, it is the very young, the infants in a society that are especially vulnerable to being killed and injured in disasters. Developing countries of course tend to have very large blocs of very young children.

3. Technological advances resulting in risks that add complexity to old threats.

There are two aspects to this--(1) preventive or protective measures which indirectly lead to possible disasters, and, (2) the scale of chain reactions possible in modern societies which can turn a little disaster into a big one.

As to the first, take this as an example. Fires in high-rise buildings, in combination with the highly combustible and toxic construction and furnishing materials we presently use, have brought an additional threat dimension to that kind of situation. We prevent people from being burned by raising the probability of their being asphyxiated. The MGM hotel fire in Las Vegas is an example of what is more likely to occur in the future.

Even plane crashes are interesting along this line. Research has shown that the ensuing fires generally kill more passengers than the crash itself. Eighty percent of those that do die from the fire actually succumb to the gas and smoke from the light weight burning cabin material! (FAA, Airline Industry, 1987: 7).

Still, somewhat in the same vein, let me quote Lee Thomas, a former FEMA official and later the head of the US Environmental Protection Agency. In May 1986 he said:

> It is entirely possible that somewhere in the country toxic metals are being removed from the air, transferred to a waste water stream, removed again by water pollution controls, converted to a sludge, shipped to an incinerator and returned to the air. (New York Times May 11, 1986).

He is pointing to the fact that many technologies that reduce or prevent the development of certain kinds of risk or environmental threats do so by solutions that often generate their own dangers or hazards. For example, in meeting the Clean Water Act of 1972 in the United States, the waste water treatment of sewage can lead to the production of sludge which will contain viruses, toxic substances and heavy metals. The sludge can be treated, but this will frequently produce methane gas and carbon dioxide. The latter in turn will contribute to the greenhouse effect which is warming the earth, which can lead to changing climatic and agricultural patterns, and may contribute to the melting of the polar ice caps and the subsequent rise of ocean levels. So, an initial good may set off a chain reaction of bad effects.

Another quotation (from a source that is unknown to me) will lead to my point about the scale of disasters. It goes as follows:

> small scale failures can be produced very rapidly, but large scale failures can only be produced if time and resources are devoted to them.

For example, we have always had, since their coming into being, electric power and telephone system failures. In fact, outages occur on a small scale almost every day. They are recognized as such and as normal emergencies by the public utilities. However, the 1965 blackout in the northeastern United States suggests how, in the modern world, large areas of a country are vulnerable to electric grid system malfunctions. There has been nothing of this scale recently, although New York City had major power blackouts in 1977 and in 1989 and so have certain other cities and places in the state of Florida. These have been relatively minor compared to what could happen given the extensive grids and networks that are involved. Not only can something in a far distant place have local effects, but the complicated linkages almost insure that sooner or later there will be large scale effects. We, of course, are assured that the 1965 happening cannot happen again; but then before it happened we also had similar assurances.

There is nothing wrong with technological advances, but they may have disastrous consequences. Let us not pretend that they do not.

4. New versions of old or past threats.

In some instances we can see <u>new</u> manifestations of old kinds of threats.

Droughts used to be thought of as a rural problem. This is no longer the case. Increasingly, in different parts of this country (as at present in California), urban and metropolitan localities have found themselves faced with shortages or reduced water supplies. So far in the United States, we have had only emergencies coped with by reducing industrial water usage, but one day there will be a disaster if a major part or all of an urban area runs out of water or has enough only for the most necessary of water need.

This is most likely to occur in this country in combination with the collapse of a major tunnel, pumping station or other critical facilities of a water supply system. This brings us also to the fact that there is increasing national attention being given to the risks associated with the deteriorating physical and public works infrastructure of lifeline systems in a large number of older American cities. The prevalence of decaying bridge and tunnel structures, crumbling highways, obsolete and overloaded waste water and sewerage treatment plants, worn out sewer and water mains, aging subway systems and stations, suggest a variety of many potential disastrous possibilities beyond the isolated and occasional accidents of the past (for the existing hazards of this nature in New York City, see Sims, 1991: 6E)..

A bridge collapse in Connecticut in 1983, in New York in 1987 and in Tennessee in 1989, a major water main break in New Jersey, the Kings Cross, London underground station fire in Great Britain, all happening in the last few years, are forerunners of far more such disasters in the future. If it be true, as a recent report stated, for example, that 45 % of the 566,443 highway bridges in this country more than 20 feet long are structurally deficient or functionally obsolete, future bridge collapses seem fairly probable.

We also have an aging fuel pipeline system in the United States (see <u>Pipelines and Public Safety</u>, 1988). The network covers one million seven hundred thousand miles. In 1986, a government report stated that many of the pipelines are 30 or more years old, which in some instances is past their normal lifetime, and that there have been more than 16,000 pipeline accidents in the last decade. So far only minor disasters have occurred, such as a rupture in 1985 that engulfed a four block area of a Minneapolis, Minnesota, suburb. These are warning signals of what may occur in the future. The recent major failure of a Soviet gas pipeline indicates that the problem may exist elsewhere.

None of the actual or potential disasters we have just mentioned are totally new, at least in the geophysical or physical sense, but they represent new versions of old threats, either because of where they occur or the number of them which will occur. Will we have a Buffalo Creek in an urban area? There are, after all, about 1,900 unsafe dams in populated areas (USA Today, 6/16/86 p. 6A).

5. Developing kinds of new risks and hazards that have not been traditionally thought of as in the province of emergency management.

Let me give four examples of future kinds of disaster risks someone ought to worry about, although you might argue that it should not be disaster planners and managers.

a. Take the AIDS epidemic. If it were a standard kind of plague such as we had several centuries ago, most people would certainly consider the happening as a disaster. But many people look askance at the notion that AIDS might be in the province of disaster planning and managing. But not even all within the area take that view. For example, in the October 1986 issue of the <u>Journal of Civil Defense</u> (Volume 9), there was a letter and an answer along the following line:

Question: AIDS? How come? I thought we were concerned with disasters, not weird diseases? Answer: Like it or not (and we do not) AIDS is not just another sickness to relegate to the laboratory. It is, as the title of the Haley-Klinghoffer presentation states, a "new plague." In addition to statistics that show AIDS to have a frightening potential as a world disaster quite soon, it is also a factor to be very seriously reckoned with in other disasters. Blood transfusions are one thing which cause great concern. It is high time it got the attention of the civil defense community.

If emergency management agencies do not get involved, who should? Many, I suppose, would argue that it should be treated as a public health problem. However, the federal government in this country has always viewed biological warfare (much of which involves epidemic-like consequences) as part of civil defense responsibility. It is also difficult to believe that, if there were some other kind of biological epidemic, emergency management groups would not be involved.

If you do not like the AIDS medical example, what about the growing recognition of the problem of an intestinal parasite, called Giardia lamblia, which in water makes people quite ill. The first large scale outbreaks of giardiasis, or "beaver fever", the disease brought about by the parasite, were first observed in Colorado in 1965. In Rome, New York, some 5,000 people contracted it in 1974. More recent outbreaks have been reported in New Hampshire, Nevada, Colorado, Pennsylvania, Montana, Washington and Missouri. A newly recognized risk is creating disaster-like epidemics. Is this merely a public health problem, or should it be part of disaster planning and managing?

b. If you do not like those examples, what about the certain disasters that are going to be produced by biotechnology, especially genetic engineering? Basically, this involves altering the blueprint of any living organism--plant, animal or human--and creating new characteristics, some of which are very useful (e.g., various kinds of oil and chemical waste eating bacteria have been created that can be used to clean up spills.)

However, there clearly are all sorts of potential disaster possibilities in this kind of situation. There can and will be the creation of, or the escape from control of, some altered organism that cannot be checked by present known means. Some of the oil-chomping organisms that have been created for cleanup purposes could go ahead and attack lubricants on all machinery. Our ability to custom design living organisms almost insures that one day there will be some almost Frankenstein-like bacteria, plant or animal let locse on the world.

This is not science fiction! I would say that the genetic engineering potential risk is in principle more dangerous than risks from nuclear power. Of course, we get constant and continuing statements that there is no danger, but as someone recently wrote in a letter:

> The advocates of recombinant DNA technology claim that it is safe because they cannot see how a disaster would occur and because no disaster has ever happened yet. That amounts to saying that the technology is as safe as the Titanic, the Chernobyl nuclear reactor or the space shuttle. (Letter of Robert J. Yaes in 1987 New York Times).

I remember giving a talk in Chicago about 10 years before Three Mile Island and saying that sooner or later it was certain that we would have trouble and a disaster in a nuclear plant. My remarks were strongly attacked by some of those in attendance who said I did not understand all the safety systems and nothing had happened anywhere up to that time (not actually correct, but little had gotten public attention). My reply was that if the technology was created by human beings and developed by social groups, it was inevitable that there would be accidents and disasters. As I said before, Three Mile Island showed the possibility and Chernobyl the reality.

I am sorry to say that I feel as confident in making the assertion that biotechnology will similarly bring us a disaster sooner or later. In fact, just as the 1970s was the time when we became aware of the nuclear power threats, the 1980s of the chemical hazards risks, the decade of the 1990s could very well be when we have a Chernobyl or Bhopal-like biotechnological disaster. I am not anti-nuclear power, anti-chemical advances, or anti-genetic engineering; the industries and activities involved have and will continue to improve human life. But the reality is that they also bring with them certain dangers that at times will produce major disasters. If so, whose responsibility is it to plan for and manage biotechnological disasters?

For a related but somewhat different kind of disasters, there was the instance of the release of biological toxins in a Soviet research center in 1979. Probably a 1,000 workers were killed and a 20 square mile area around the city of Svardlovsk was contaminated by the accidental release of very toxic anthrax spores (Thompson, 1987: 11A).

c. What about radon gas, the invisible, tasteless and odorless gas that is now probably the most dangerous source of radiation in the United States (although just a few months ago the extent and seriousness of the threat has been challenged, and it has never been taken as that much of a risk in Canada). Radon has been detected in at least 30 states, is supposedly at levels high enough in eight million of the 70 million homes in the country to warrant corrective action, and is probably responsible for 10,000 plus lung cancer deaths a year (and possibly outpacing asbestos as a killer). The gas is natural and seeps up from underground radiation through bedrock. Radon only really came to attention in 1984 with the discovery of the Reading Prong cutting across parts of Pennsylvania and nearby states. By now, high radon levels have been reported to exist in areas such as North Dakota, Florida, Maryland, Colorado, Maine, Tennessee and Washington.

This is a growing threat in the sense of being a newly discovered problem with no easy solution. Nuclear plants may present a potential radiation threat, radon gas is an actual threat. Some local emergency managers have gotten involved in planning and response for this threat. Should all not do so?

d. Then, there are all the disastrous consequences that are linked to the computer revolution. Use of computers undoubtedly have improved disaster planning and managing. But, and it is an important but, our increasing dependence on computer technology will magnify future disasters and turn some minor ones into major ones. When the technology fails, and it will fail at times, what will those who have come to depend on them do? We know of one chemical disaster where, because the computer monitoring system failed, it took hours before the surrounding population was warned; in pre-computer days, the warning would almost certainly have been issued hours earlier.

More important, many sectors of government and business are increasingly computer based for the data and information they need to function, sometimes literally from minute to minute. Thus, it has been written that:

> It is presently estimated that more than 85 % of the largest firms in the US are totally or heavily dependent on computer technology and that, on average, a business would lose 25 % of its daily revenue after the sixth day of its system breakdown, while this figure is close to 40 % for the financial, banking and public utility industries (Pauchant, Mitroff, Weldon and Ventolo, 1990: 254).

It can be predicted with certainty that such computer systems will, for various reasons, cease to function, or function incorrectly. We will then have a really new kind of disaster--a computer disaster. Many will have very complex chain reactions. One scenario of a computer failure in California indicates there would be serious problems in the international banking and financial community after 24 hours. I do not have time to develop this point further, but I think enough has been said to make you think about this new kind of technological disaster--a computer disaster.

In fact, we have come close to this on a large scale several times already in the United States. For example, on May 8, 1988 a fire disabled a major Bell telephone switching center in the Chicago area. This telephone outage affected both voice and data communications for more than a half million residents and business customers in six metropolitan suburbs for periods ranging between two days to three weeks. In addition, local and long distance communications for both telephones and computer networks were also severely affected since the Hinsdale center was an aggregation point for major telecommunication links. The outage:

> affected the normal operations of dozens of banks, hundreds of restaurants dependent on reservations, three large catalogue sales companies headquartered in the Chicago area, about 150 travel agencies, most of the paging systems and cellular telephones in the affected area, and hundreds of businesses located in the area or others not located in the affected area but conducting business with those that were... At present, a conservative estimate of the business losses and the repair costs of the accident are set at $200-300 million (Pauchant, Mitroff, Weldon, and Ventolo, 1990: 244).

A somewhat similar outage in Tokyo, Japan in 1984 affected 89,000 subscribers and may have cost $300 million dollars.

Other Factors Affecting Future Disasters

In the last part of my remarks, I would like to make four other general comments about disasters of the future.

1. There has been very little recognition given to the fact that natural disaster agents will increasingly generate or magnify concurrent technological disasters. For instance, a hurricane or a flood could hit a chemical complex; a tornado could hit a nuclear plant or a nuclear weapons depot on a military base.

As a concrete example we might cite one from the Soviet Union. In 1961, windstorms spreading radioactive material (plutonium and strontium) in the Lake Karachay region in the Southern Urals increased by about 30 to 50 % the land area previously contaminated by an earlier nuclear disaster. The technological disaster which had happened earlier was magnified by a later natural disaster agent.

This process could also go in the other direction. For example, an MIT study recently suggested that continuing pollution may result in stronger hurricanes. Continued air pollution that increases carbon dioxide levels, according to this research, could make some hurricanes up to 60 % stronger in the next century. If the atmosphere's carbon dioxide content doubles, the maximum possible intensity for hurricanes could rise 40 to 50 % generally, and 60 % in the Gulf of Mexico. Projections of when the atmosphere's carbon dioxide content will double range from about the year 2035 to 2080, according to the National Center for Atmospheric Research.

How many emergency managers plan for multiple or synergistic type disasters involving rather different agents? Such combinations will occur more in the future.

2. Increasingly, localities are facing disastrous conditions from disaster sources that may be quite distant. The radiation fallout from Chernobyl fell in various parts of the world. The even more recent examples of pollution in the Rhine River which affected about six different countries, or the Ohio River pollution which had consequences for several states (Comfort, Abrams, Camillus and Ricci, 1989), are again harbingers of what we might expect in the future. In particular, technological type disasters can reach far away (actually in both time and space, as witnessed by the PCB pesticide poisoning in Michigan which has gotten into the second generation, the children of the original victims!)

There are some interesting implications for risk or hazard assessment or analysis here. How does one conduct such an assessment of situations far distant from one's own locality?

3. Many of the future threats or risks have high catastrophic potential by way of casualties or the kinds of injuries they may generate (e.g., radiation or toxic poisonings or burns--all of them requiring complex and labor intensive medical treatment). As said earlier, American society has been fortunate in the small number of dead we have had even in our worst disasters. Even our most serious fire, chemical and radioactive material incidents have generated few or relatively low numbers of injured victims requiring special treatment. But scenarios for a California earthquake or for an liquified petroleum gas (LPG) explosion in or near a major port area have projected five figures for those that will be killed and/or injured in particular ways.

It is true that the Federal Emergency Management Agency and other government bureaucracies have taken the lead in projecting possible catastrophes in American society, but initial response will have to be at the local level. How many emergency managers have at least given some thought to planning for a catastrophe? (As we have discussed elsewhere, just as there is a qualitative difference between emergencies and disasters, so there is another qualitative jump between a disaster and a catastrophe).

4. Certain of the future disasters have catastrophic potential even if they would occasion no casualties or have physical impact. They could be very economically costly. Paul Slovic, for instance, has written:

> Some events make only small ripples; others make big ones. Early theories equated the magnitude of impact to the number of people killed or injured, or to the amount of property damaged. Unfortunately, things are not this simple. The accident at the Three Mile Island (TMI)...provided a dramatic demonstration that factors besides injury, death, and property damage impose serious costs. Despite the fact that not a single person died at TMI, and few, if any, latent cancer fatalities are expected, no other accident...has produced such costly societal impacts. The accident at TMI certainly devastated the utility that owned and operated the plant. It also imposed enormous costs (estimated at 500 billion dollars...) on the nuclear industry and on society, through stricter regulation, reduced operation of reactors worldwide, greater public opposition to nuclear power, reliance on more expensive energy sources, and increased costs of reactor construction and operation. It may even have led to a more hostile view of other large scale, modern technologies, such as chemical manufacturing and genetic engineering. The point is that traditional economic and risk analyses tend to neglect these higher-order impacts, hence they greatly underestimate the costs associated with certain kinds of mishaps.
>
> Although the reaction to the TMI accident was extreme, it is by no means an isolated example. Other recent events that have had enormous indirect impact include...the discovery of pollution from chemical wastes at Love Canal... and Times Beach...the disastrous launch of the space shuttle Challenger...Following these extreme events are a myriad of lesser incidents events varying in the breadth and magnitude of their impacts.
>
> New theories and methods of analysis are needed to forecast costly ripple effects so that they may be factored into risk-management decisions (Slovic, 1987: 280).

As a variant of this, we may note that some future disasters will be very socially disruptive, not because of the physical reality of their consequences, but because of the way they will be perceived. We had a very good example of this in Brazil a few years ago. A cancer treatment machine abandoned in a junkyard released some dangerous cesium 137. The radioactive contamination killed about four people and seriously affected about 44 others. Far more consequential was the perceived risk to anyone in the affected locality, Goiania, Brazil.

The occasion is almost a classic case of the potential negative impacts of perceived risk. Over 100,000 residents out of a total population in the locality of about 1,000,000 underwent Geiger counter examinations to detect possible contamination; it was reported that around 8,000 formal certificates were issued to counter the effects of being stigmatized as a hazardous carrier of radiation. The anxiety over potential contamination led to cancellations of conventions in Goiania. Even more interesting, hotels in other parts of Brazil cancelled reservations of residents from Goiania, buses and airplanes refused to take as passengers Goianians, and some doctors and dentists refused new patients that did not have clearing certificates. There were estimates that regional tourism fell over 40 % and it was reported that property values fell, with sales levels for the entire city and state being affected. Some estimates were that as much as 50 % of the state's export sales were lost during one month with the area's agricultural products being boycotted (or purchased at 50 % of value). Even textiles and clothing manufactured in Goiania were affected--some losing nearly 40 % of their value. (From press accounts and observations of John Petterson of Impact Assessment, Inc. in 1987.)

Clearly these kinds of future disasters resulting mostly in non-physical but massive social, economic and/or psychological disruptions will have to be dealt with by someone. But how many emergency managers would even know where to start?

I have left aside any discussion of conflict type of mass emergencies such as wars, civil disturbances or riots, terrorist attacks, hostage takings, product tampering of different kinds, and so on; all those collective situations where someone is deliberately trying to inflict injury on someone else. There is reason to think that some of these kinds of mass emergencies will also increase in the future, although not necessarily all of them. They, additionally, could present qualitative as well as quantitative differences in handling them in the future (as recently has surfaced with the oil pollution in the Persian Gulf and the massive oil fires in Kuwait).

What we can say with more certainty is that the future will bring more and worse disasters.

If, for no other reason, emergency managers ought to start thinking about this because they may be held responsible if they do not. As you may know, increasingly in American society legal liability has been attached to planners and managers if they do not have a program or take an action about certain kinds of disaster possibilities. As the disasters of the future develop, I think liability for planning for and managing them will also increase.

If forewarned is to be forearmed, I hope I have given you some armor. My hope not to be taken as a scientific Cassandra. As most of you know, Cassandra in Greek mythology was given the gift of correct prophecy of forthcoming mishaps and calamities. Apollo, a Greek deity, because of anger made certain that no one would believe her. Thus, Cassandra has become known as the bearer of evil tidings that no one will believe. It is my hope that you will believe me.

On the other hand, whether what I have projected for the future is to be viewed pessimistically or optimistically depends, I would say, on your views of a doughnut. The optimists see the doughnut--something that can be dealt with; the pessimists see the hole--nothing can be done.

I leave you with that profound intellectual observation.

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