disorder have been found to contribute to the development of post-traumatic disorder, particularly at lower levels of stress.[9]

Like the police, medical and hospital workers are often seen as immune to stress because of their training. In fact, they are equally likely to be affected but may not have access to support programmes. Studies of debriefing programmes provided after the Hillsborough disaster, where 95 people were crushed to death, showed that hospital staff could benefit: 139 out of 205 people attending debriefing programmes found them helpful, though some did not. Those who remained distressed six to nine months later had had higher levels of exposure, showed more distress symptoms on systematic measures, and were concerned about personal and organisational performance. Nevertheless, as with other rescuers, an appreciable minority found the experience positive, with a renewed appraisal of the value of life.[10]

The increased interest in the reactions of rescue workers has been accompanied by the development of programmes such as critical incident (or stress) debriefing. This is usually provided in groups by mental health professionals and peer support workers in the first 24-72 hours after the disaster.[11] Anecdotal evidence suggests that it is effective, though no controlled trials have been performed. Clearly also it should be only one part of a range of organisational, educational, and support responses.

Emergency organisations need policies that identify stressful circumstances and teach their staff to cope with them. They should also provide an effective safety net of debriefing and counselling when disasters occur. The support should be based on the expectation that workers will master their own stress. The aim is to help the worker through his or her experience to a "good enough" retrospective integration of it. When this policy fails workplace and health services must be aware of the potential impact on health, the nature of post-traumatic morbidity, and effective rehabilitation. Such policies of understanding and support also provide a positive environment for the smaller disasters that confront such workers every day.

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Lessons of Chernobyl

Psychological problems seem to be the major health effect at present

The accident at Chernobyl resulted in the largest short term release of radioactive materials to the atmosphere ever recorded from a single source. The major radionuclides released to the environment included isotopes of iodine, caesium, strontium, and plutonium and also highly radioactive fuel fragments or hot particles. The human impact of the accident has been immense. Hundreds of thousands of rescue workers took part in the clean up operation, more than 100 000 people were evacuated, and for many more restrictions on activities and foodstuffs have had a major impact on everyday life in three Soviet republics.

One legacy of Chernobyl is that surface contamination with caesium-137 in about 25 000 km^2 of land and about 2225 settlements is now at least 185 kBq/m^2 (5 Ci/km^2), with smaller areas having much higher levels or appreciable levels of strontium or plutonium. Minimising the effects of such massive contamination will pose challenging problems to Soviet scientists for many years. Technical problems, however, are not the only ones troubling the affected areas. Social tensions are also rife. Clearly perestroika, food shortages, and ethnic unrest all play their part, and these have been fuelled by inappropriate official secrecy: the first maps summarising environmental contamination were drafted in July 1986, three months after the accident, but they were not published until March 1989. Furthermore, ignorance about the likely effects of exposure to radiation has resulted in even local doctors attributing to the accident a wide variety of diseases never previously associated with radiation. Such was the atmosphere of mistrust directed at the authorities and at many Soviet scientists and doctors that the Soviet government asked the International Atomic Energy Agency (IAEA) to evaluate the consequences of the accident and the measures taken to protect the population that continue to live in the afflicted areas. These events led to the establishment of the International Chernobyl Project, whose final report was published last month.[1]

Much of the project was concerned with the health of people living in villages 30-300 km from Chernobyl that have appreciable caesium contamination. The report's major conclusion was that the largest effects on health currently attributable to the accident are psychological. For example, 45% of people in the surveyed villages agreed with the statement, "I think I have an illness due to radiation." These beliefs were not, however, substantiated by the IAEA team, who found no differences between the contaminated villages and nearby uncontaminated control villages in a wide variety of clinical observations and laboratory measurements, including the prevalence of thyroid abnormalities and haemoglobin concentrations. Additionally, people are concerned about continuing to live in areas with radiation because they feel trapped and their children's future seems uncertain. These fears are reinforced by the many restrictions on eating foodstuffs and on other activities which, ironically, the IAEA judged to have been too extensive. Many of the measures

taken were unjustifiable on grounds of radiological protection, while some that were worth while, such as taking stable potassium iodide in the month after the accident to prevent uptake of radioiodine by the thyroid, were implemented by only about a fifth of the population.

Although the IAEA project found numerous health problems unrelated to Chernobyl, it found no health effects, other than psychological ones, that could be confirmed as directly attributable to radiation. This is not surprising for several reasons. The project's remit excluded those likely to have received the highest doses—namely, rescue workers, workers at the plant itself, and those who had been evacuated. Only about 1350 people currently living in the area and readily available were included in the survey. This number is big enough to identify major discrepancies between contaminated and control villages in the prevalence of common disorders or in the average value of variables such as haemoglobin concentration, but it is too small to detect a modest increase in cancers or other serious but rare disorders. Furthermore, many effects would not yet have had time to appear. Other studies of the effects of exposure to radiation have found the highest relative increase for leukaemia occurring within five years of exposure,[2] but for many other cancers increases even five to 10 years after exposure are modest compared with those in later years.[3] Hypothyroidism may also take many years to manifest itself.

Risk estimates based on the experience of other exposed populations provide a rough guide to the likely ultimate toll from Chernobyl in those continuing to live in contaminated areas.[4] With IAEA project estimates of dose in the 70 years after the accident and a dose rate reduction factor of 2 for cancers other than leukaemia, the estimated increase in the overall risk of fatal cancer is about 2-4% in the contaminated area, with the possibility of larger proportionate increases in the incidence of thyroid cancer and also in some cases of hypothyroidism. Accurate forecasting is, however, difficult. Official Soviet procedures for dose assessment often resulted in overestimates, typically by factors of 2-3. The largest doses are thought to have been thyroid doses resulting from shortlived radioiodines. These had completely decayed before the IAEA project, thus preventing any refinement of initial Soviet estimates. Furthermore, although much is known about the effects of radiation, the Chernobyl experience differs from other events that have been studied intensively to date: a substantial proportion of the dose was from internal irradiation, dose rates were low, and thyroid doses were of a mixture of shortlived radioiodines. In view of all these uncertainties monitoring of the population, such as has started in the Ukraine,[5] seems desirable even though the data may require careful interpretation.

The IAEA team found Soviet scientists and doctors battling against a complex administration with inadequate resources, often in isolation from recent scientific developments, and in an atmosphere of public mistrust. They need our patience, sympathy, and any real help we can give them.

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Artificial blood

Mostly on the drawing board

The term "artificial blood" is loosely applied to substitutes designed to replace the oxygen carrying capacity of human red cells. Clinically acceptable solutions for replacing plasma volume have been available for many years, but the quest for a replacement to red cell transfusions continues. Its potential advantages are considerable—no risk of transmissible disease, no need to cross match, a shelf life of years rather than weeks, and an unlimited supply manufactured on demand.

Research has focused on two main approaches: developing synthetic oxygen carrying compounds and producing solutions of haemoglobin. Progress has been slow, for two main reasons—toxicity and brief intravascular dwell times.[1-5]

The development of genuinely artificial blood substitutes began dramatically with the finding that submerged mice survived in oxygenated solutions of perfluorocarbon.[6] Perfluorocarbons are biochemically inert and in their liquid form have a high solubility for oxygen, proportional to the partial pressure of oxygen. Their main disadvantages are the need for very high inspired oxygen concentrations (with the attendant dangers of oxygen toxicity) and their insolubility in water. This is overcome by producing emulsions, but these are unstable and must be stored frozen at −20 C. Reconstitution, warming, oxygenation, and the administration of a test dose to assess tolerance are then required before the solution is ready for intravenous infusion. The reticuloendothelial system quickly clears the microdroplets of emulsion from the circulation, resulting in a short intravascular half life of only 8-24 hours. Excretion occurs over seven days, mostly through the lungs. Uptake by the reticuloendothelial system and the possibility of "immune blockade" has raised concerns about safety. Intravenous infusion of certain emulsions also seems to activate complement and stimulate the release of cytokines, resulting in transient "allergic" reactions such as hypotension, leucopenia, and chest pain.

Fluosol DA20 was the first perfluorocarbon produced commercially for human use, delivering 5 ml oxygen/100 ml perfluorocarbon at 100% oxygen,[7] and animal studies also showed that Fluosol DA20 could sustain life at "zero" packed cell volume. Unfortunately, in surgical patients with acute severe anaemia (haemoglobin 30-40 g/l) who could not be given transfusions for religious reasons, Fluosol DA20 was ineffective in delivering sufficient oxygen to sustain life at the doses permitted (40 ml/kg).[8,9] Another use has, however, been found for it. Fluosol DA20 reduces ischaemic damage to the myocardium during percutaneous transluminal coronary angioplasty (presumably because of its small particle size and low viscosity at low rates of blood flow in small blood vessels),[4,5] and is licensed for this indication in the United States. Although not licensed in Britain, it has been used successfully on a named patient basis.