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How Should Governments Address High Levels of Natural Radiation and Radon? Lessons from the Chernobyl Nuclear Accident and Ramsar, Iran

S. M. Javad Mortazavi, M. Ghiassi-nejad, Azam Niroomand-rad, P. Andrew Karam, and John R. Cameron *

Introduction

The 1986 Chernobyl accident evoked worldwide concern and played an important role in limiting the development of nuclear power production in a number of countries. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has recently approved its most recent report to the General Assembly.[1] The report is a detailed assessment of radiation sources and health

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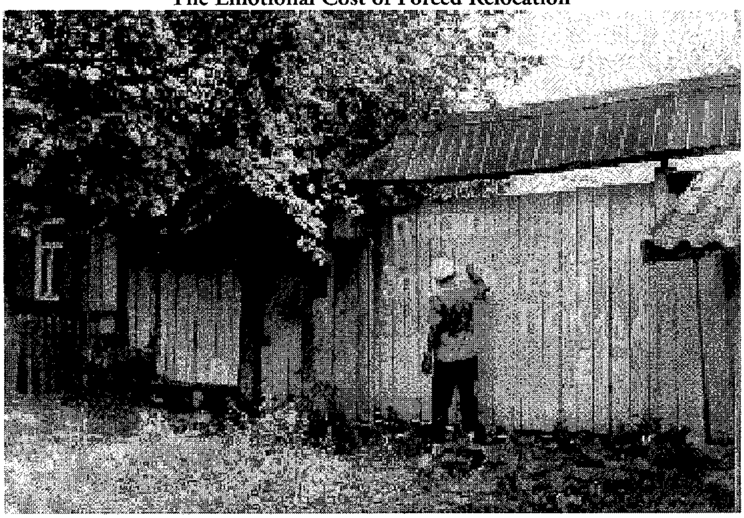
Note: There has been a great deal of discussion regarding possible terrorist use of radiological weapons. Under most imaginable scenarios, such weapons could cause widespread contamination, but very low radiation exposure with no expected incidents of radiation injury to the population. Nonetheless, excessive fear of radiation could lead to unnecessary deaths as people flee the site of a radiological attack or from pregnant women choosing to terminate their pregnancies, as happened in the wake of the Chernobyl accident. It would be ironic if radiation phobia, fed in part by factors such as those we described in this paper, would cause more deaths than the actual attack.

1 United Nations Science Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation: 2000 Report to the General Assembly* (2000).

effects. Particular emphasis has been given to the evaluation of exposures and health consequences of the Chernobyl accident.

It is particularly instructive to note that many residents of the areas surrounding Chernobyl were forcibly relocated at great monetary and social expense, and in many cases, these residents were exposed to lower radiation levels than those that exist in Ramsar, Iran, and other areas of elevated background radiation levels. It is possible that these forced relocations were not necessary, in light of the apparent absence of adverse health effects among high background radiation area (HBRA) residents, and the costs incurred by such forced relocations should not be liberally undertaken by any government. Figure 1 shows one example of the emotional and social toll of the Soviet relocations.

Figure 1
The Emotional Cost of Forced Relocation



A farmer from Uvel'e wrote on the gate of his home before leaving for the Koluga region: "Forgive us, Paternal Home, for leaving you!"

Ramsar: A High Background Radiation Area

Life evolved in a greater radiation environment than exists today, and background radiation levels are lower than at any time in the history of life on earth.[2] Natural background radiation levels on earth

2 P. Andrew Karam & Stephen Leslie, *Calculations of Background Beta-Gamma Radiation Dose Through Geologic Time*, 77 **Health Physics** 662 (1999).

vary by at least two orders of magnitude today, so humans and other organisms are consequently subjected to a wide range of background radiation levels. Some relevant information about Iran and the Ramsar is provided in Table 1 while the natural background radiation doses in some areas of the world are provided in Table 2.

Table 1
External Exposure Rates from Terrestrial Gamma Radiation in Iran

Iran's Important Radiological Data	
Population in 1996 (10^6)	69.98
Average absorbed dose rate in air (nGy h^{-1}): outdoors	71.00
Average absorbed dose rate in air (nGy h^{-1}): indoors	115.00
Indoors/outdoors ratio	1.6

Source: Survey of natural radiation exposure, UNSCEAR 2000.
Note: 1 nGy hr^{-1} gives an annual radiation dose of 8.8 μGy

Table 2
Mean and Maximum Annual Natural Terrestrial Radiation Doses
to the Inhabitants of Some Areas Around the World

Country	*Area*	*Approximate Population*	*Absorbed Dose Rate in Air*[a] *(nGy h^{-1})*
Brazil	Guarapari	73,000	90-170 (street) 90-90,000 (beaches)
Iran	Ramsar[b]	2,000	70-17,000
India	Kerala	100,000	200-4,000
China	Yangjiang	80,000	370 (average)

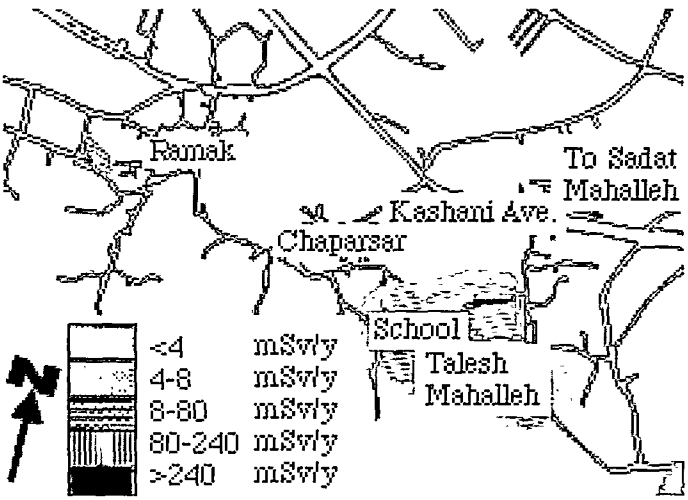
[a] Includes cosmic and terrestrial radiation.
[b] It should be noted that the monazite sand beaches in Guarapari, Brazil have a higher dose rate, but these areas are uninhabited. Therefore, it can be claimed that Ramsar has the highest level of natural radioactivity for a populated area studied so far.
Source: UNSCEAR 2000.

These doses do not include those to the lungs from inhaled radon progeny, which are even greater than the doses shown when the radiation weighting factor of alpha particles is taken into account. As shown, areas with unusually high background are found in Yangjiang, China; Kerala, India; Guarapari, Brazil; and Ramsar, Iran. Some areas of

Ramsar, a city in northern Iran, have among the highest known background dose rates in the world. Figures 2 and 3 are maps of Iran, showing the location of Ramsar, and the HBRAs in Ramsar itself.

Figure 2
Location of Ramsar in Iran

Figure 3
Ramsar HBRAs



The high background radiation in the "hot" areas of Ramsar is primarily due to the presence of larger than normal amounts of Radon-226 and its decay products, which were brought to the earth's surface by hot springs. Groundwater is heated by subsurface geothermal energy and passes through relatively young and uraniferous igneous rock. Radium is dissolved from the rocks by hot ground water. Uranium is not dissolved because the groundwater is anoxic. When the groundwater reaches the surface at hot spring locations, travertine (a calcium carbonate mineral) precipitates out of solution with dissolved radium substituting for calcium in the mineral. A secondary cause of high local radiation levels is travertine deposits with a high thorium concentration.[3] Because soils are derived from the weathering of local bedrock, radioactivity in local soils and the food grown in them is also high. There are at least nine known hot springs with various concentrations of radioactivity around the city. Residents and visitors use these springs as health spas. Residents of these "hot" areas have also used the travertine of the hot springs as building materials to construct houses. The indoor and outdoor gamma radiation dose rates in various areas of Ramsar range from 5 to 90 microGrays per hour (µGy/h). The annual dose to monitored individuals ranges up to 132 milliGrays (mGy), and we have calculated maximum credible annual radiation exposures of up to 260 mGy.[4] These dose rates are among the highest background levels known on the earth's surface.[5] The recommended dose limit for workers in Iran is 20 milliSieverts per year (mSv/y); thus some residents in the Ramsar area receive a much higher annual radiation dose (up to thirteen times as high) than is permitted for radiation workers.

The people who live in these high radiation areas of the world are of considerable interest because they, and their ancestors, have been exposed to abnormally high radiation levels over many generations. If a radiation dose of a few hundred mSv per year is detrimental to health, causing genetic abnormalities or an increased risk of cancer, it should be

3 Medhi Sohrabi, *Proceeding of International Conference on High Levels of Natural Radiation Recent Radiological Studies of High Level Natural Radiation Areas of Ramsar* 39 (1990).

4 There are inhabited areas in which average radiation levels are nearly 30 µSv hr^{-1} and some people living in these areas live in houses with average radiation levels of this magnitude. Persons living and working in radiation fields of this level will receive an annual dose of 0.030 mSv hr^{-1} x (24x365) hrs yr^{-1} = 260 mSv yr^{-1}.

5 Sohrabi, *supra* n. 3, at 39.

evident in these residents. The preliminary results of our studies of residents in high background radiation areas of Ramsar show no observable detrimental effect.[6]

Chernobyl and the Fear of Ionizing Radiation

In a 1996 report, ten years after the Chernobyl accident, the Ministry of Russian Federation on Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters (the EMERCOM of Russia) stated that "the decisions on resettlement were made under intense pressure of public opinion and legislative bodies. From today's viewpoint one can affirm that under conditions when resettlement could not be avoided because of social and psychological reasons, it would be worthwhile just to provide people with opportunities to leave contaminated territories."[7] This report confirmed that responsible organizations (e.g., USSR's National Council on Radiation Protection and Measurements, the World Health Organization, the International Atomic Energy Agency) focused on hypothetical radiological problems and could not properly assess social, psychological, and political factors.[8]

It is well known that the possibility of being exposed to radiation causes considerable anxiety, especially among pregnant women.[9] Furthermore, after the Chernobyl accident, it has been reported that living in areas with elevated radiation levels and/or the stress and fear of living in contaminated areas can lead to significant increases in nervous disorders, cardiovascular diseases, and other problems.[10] It has been shown that the most significant increase was in the suicide rate.[11] The

6 S.M. Javad Mortazavi, *Proceeding of International Conference on Radiation and Its Role in Diagnosis and Treatment — Biological Effects of Prolonged Exposure to High Levels of Natural Radiation in Ramsar, Iran* (2002).

7 Vladimer A. Vladimirov, *Chernobyl Accident: Ten Years On, Problems and Results of Elimination of the Consequences of the Accident in Russia,* National Russian Report at 13 (Ministry of Russian Federation on Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters 1996).

8 *Id.*

9 Frank P. Castronovo, *Teratogen Update: Radiation and Chernobyl,* 60 Teratology 100 (1999).

10 J. Robbins, *Lessons from Chernobyl: The Event, The Aftermath Fallout: Radioactive, Political, Social,* 7 Thyroid 189 (1997).

11 Z. Kamarli & A. Abdulina, *Health Conditions Among Workers Who Participated in the*

epidemiological studies pertaining to the mental problems in the Gomel region in the republic of Belarus indicated that dysthymia, general anxiety disorder, adjustment disorders, and not otherwise specified syndromes made up almost two-thirds of the observed morbidity. A higher prevalence of mental health problems was observed among people who have been evacuated and in mothers with children less than eighteen years of age.[12] Three years after the Chernobyl accident, the International Atomic Energy Agency (IAEA) evaluated the medical and psychological health of residents living in areas identified as being contaminated with radioactive fallout.[13] IAEA clinical staff members could not identify any health disorders in either the contaminated or nearby (uncontaminated) control villages that could be attributed directly to radiation exposure. However, they noted that the levels of anxiety and stress of the villagers appeared to be disproportionate to the biological significance of the levels of IAEA-measured radioactive contamination. Almost half of the adults in all of the villages were unsure if they had a radiation-related illness in spite of the fact that the levels of radiation exposure to which they were exposed were not sufficient enough to cause harm.[14]

Dose Limits for Natural Radiation: Radon

The International Council on Radiation Protection (ICRP) reports thirty-six recommended dose limits for the public which only apply to artificial radiation exposure and have no relevance to natural radiation exposure.[15] However, ICRP reports that there may be thirty-nine confirmed levels of natural radiation, which may have to be controlled, to the extent practicable, in much the same way as for artificial sources.[16] Currently, radiological authorities in many countries have

Cleanup of the Chernobyl Accident, 49 World Health Stat. Q. 29 (1996).

12 Jan M. Havenaar et al., *Mental Health Problems in the Gomel Region (Belarus): An Analysis of Risk Factors in an Area Affected by the Chernobyl Disaster*, 26 Physchol. Med. 845 (1996).

13 *International Atomic Energy Agency Bulletin* 25(2) (June 1989).

14 Harold M. Ginzburg, *The Psychological Consequences of the Chernobyl Accident — Findings from the International Atomic Energy Agency Study*, 108 Public Health Rep. 184 (1993).

15 International Commission on Radiological Protection (ICRP) Publication 36, *Protection Against Ionizing Radiation in the Teaching of Science*, 10(1) Annals of the ICRP 2 (1983).

recommended radon action levels to limit the indoor radon concentrations and, hence, the annual doses to the general public,[17] based on recommendations found in ICRP reports 65[18] and 82.[19] This is due to the recognition that radon and its progeny are the major contributors to natural radiation. The U.S. Environmental Protection Agency (EPA) recommends homes be fixed if an occupant's long term exposure will average 4 picoCuries per liter (pCi/L) or 148 Becqueral per m^3 (148 Bq/m^3) or higher.[20] The EPA recommends testing all homes below the third floor for radon. The average cost to install radon-resistant features in an existing home is estimated to be from $800 to $2,500. In Ramsar, Iran, the levels of Radon-222 were found in 437 rooms which were located in 350 houses, and in 16 schools located in high background and normal background radiation areas.[21] Thus, as shown in Table 3, the mean radon levels in some of Ramsar's regions are much higher than the recommended acceptable radon exposure limit. Therefore, if Iranian regulatory authorities accept recommendations similar to those of the EPA, new construction would not be permitted in many regions of Ramsar and immediate remedial action would be required for many houses. In addition, radiation exposure of many Ramsar inhabitants exceeds the international recommendation for radiation exposure to radiation workers of 20 mSv per year.[22]

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16 ICRP Publication 39 *Principles for Limiting Exposure of the Public to Natural Sources of Radiation*, 14(1) Annals of the ICRP 2 (1984).

17 John K. Leung et al., *Radon Action Level for High-Rise Buildings*, 76 Health Physics 537 (1999).

18 ICRP Publication 65, *Protection Against Radon-222 at Home and at Work*, 23(2) Annals of the ICRP 22 (1993).

19 ICRP Publication 82, *Principles for the Protection of the Public in Situations of Prolonged Exposure*, 29(1-2) Annals of the ICRP 14 (1999).

20 Victor Evdokimoff & D. Ozonoff, *Compliance with EPA Guidelines For Follow-Up Testing and Mitigation After Radon Screening Measurements*, 63 Health Physics 215 (1992); *see e.g.* Ying Wang et al., *Radon Mitigation Survey Among New York State Residents Living in High Radon Homes*, 77 Health Physics 403 (1999).

21 *See* Sohrabi *supra* n. 3, at 39.

22 *See* ICRP Publication 60, *1990 Recommendations of the International Commission on Radiological Protection*, 21(1-3) Annals of the ICRP 20 (1991).

Table 3
Mean and Maximum Radon Levels in Different Regions of Ramsar, Iran and Their Comparison to U.S. and Swedish Regulatory Recommendations

Regions	*No. of Rooms Tested*	*Mean (Bq/m³)*	*Maximum (Bq/m³)**
Talesh Mahelleh	137	615	3,700
Chaparsar	65	326	1,983
Ramak	49	246	1,459
Ramsar Schools and HBRAs	63	258	1,572
USA, EPA Level		148	
Sweden Level			
New Houses		70	
Renovated Houses		200	
Existing Buildings		400	

* 37 Bq/m^3 = 1 pCi/L

Ramsar Preliminary Findings

Our preliminary cytogenetic studies, below at Figures 4 to 6, show no significant differences between residents in high background radiation areas (HBRAs) compared to those in normal background radiation areas (NBRAs) in the areas of life span, cancer incidence, or background levels of chromosomal abnormalities.[23] Further, when administered an in vitro challenge dose of 1.5 Gy of gamma rays, donor lymphocytes showed a significantly reduced sensitivity to radiation as evidenced by their experiencing fewer induced chromosome aberrations among residents of HBRAs compared to those in NBRAs. Specifically, HBRA inhabitants had 44% fewer induced chromosomal abnormalities compared to lymphocytes of NBRA residents following this exposure. Similarly, data obtained from studies on HBRA inhabitants of Yangjiang, China[24] and Kerala, India[25] show no harmful impact induced by regional natural radiation, although one study suggests that the incidence of dicentric and ring chromosomes increases with increasing age in some HBRAs.[26] In these

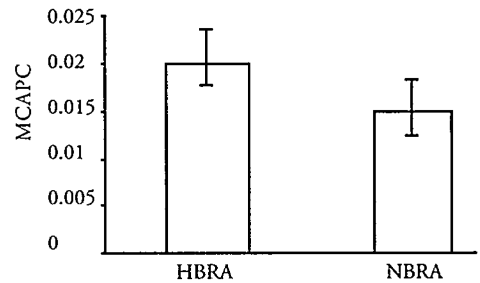
23 Mehdi Ghiassi-nejad et al., *Very High Background Radiation Areas of Ramsar, Iran: Preliminary Biological Studies*, 82 Health Physics 87 (2002).

24 Y.R. Zha et al., *Epidemiological Survey in a High Background Radiation Area in Yangjiang*, 17 Chung Hua Liu Hsing Ping Hsueh Tsu Chih 328 (1996).

25 M.K. Nair et al., *Population Study in the High Natural Background Radiation Area in Kerala, India*, 152 (6 Supp.) Radiat. Res. § 145 (1999).

studies, cancer mortality (from 1,008,769 person-years in HBRA and 995,070 person-years in the control area), hereditary diseases and congenital malformations (from 13,425 subjects in HBRA and 13,087 subjects in the control area), human chromosome aberrations, and immune function of the inhabitants, were statistically identical.[27] These results suggest that exposure to elevated levels of natural radiation in these areas does not result in increased chromosomal damage and is not detrimental to the health of the residents of HBRAs.

Figure 4



Mean chromosome aberrations per cell (MCAPC) among 35 inhabitants of high background radiation areas (HBRA) and 14 living in normal background radiation areas (NBRA). Note that the 95% confidence intervals for these two populations overlap, indicating there is no statistically significant difference in the level of background chromosomal abnormalities in these two populations.

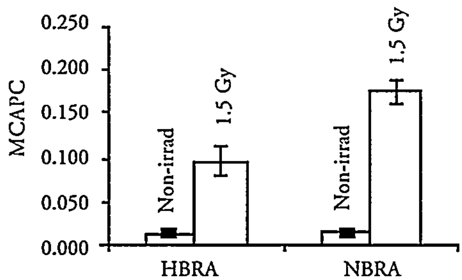
One argument used in support of increasingly strict radiation dose limits is that every incremental reduction in radiation exposure carries with it a net benefit to the public health. This hypothesis is also frequently cited by those with a seemingly irrational fear of radiation as justification for their fears, and the continued use of the linear, no-threshold (LNT) hypothesis helps to feed radiation phobia. Abandoning this hypothesis or explaining that it over-predicts risks at

26 T. Sugahara et al., *Dose-effect Relationship of Dicentric and Ring Chromosomes in Lymphocytes of Individuals Living in the High Background Areas in China*, 41 J. Radiation Research 63 (2000). We note that the levels of cumulative radiation exposure among the members of this study are much less than those of the people studied in Ramsar; 31-360 mSv cumulative exposure as compared to lifetime doses of 300 to over 10,000 mSv among those studied in Ramsar.

27 Zha et al., *supra* n. 24.

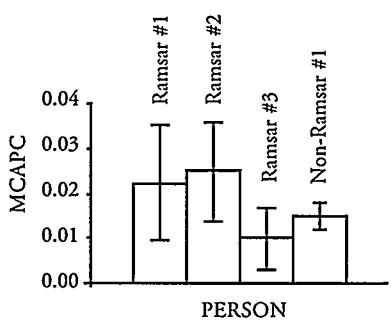
low levels of radiation exposure, if supported by appropriate scientific studies, may help alleviate radiation phobia.

Figure 5



MCAPC in irradiated and non-irradiated cells from inhabitants of HBRAs and NBRAs. Samples from inhabitants of both areas were examined for chromosomal abnormalities before and after irradiation with 1.5 Gy. Although there is no statistically significant difference in chromosomal abnormalities in both populations before irradiation, there is a statistically significant difference in post-irradiation abnormalities. In this case, cells from inhabitants of the HBRAs have fewer chromosomal abnormalities than those of inhabitants of NBRAs. An adaptive response has previously been noted in organisms exposed to acute conditioning doses at relatively high exposure rates; these results suggest that chronic exposure to lower exposure rates may stimulate an adaptive response as well.

Figure 6



MCAPC among individuals who live in the Ramsar HBRA and the average of 14 from a nearby control area. Persons 1 and 2 are married and live in a house with radiation levels of about 20 μGy hr^{-1} in the bedroom, giving an average annual radiation dose of 58.4 mGy yr^{-1} simply from sleeping. Person 3 has a hot spring in her house with radiation levels of up to 50 μGy hr^{-1}. Each data point is based on analysis of 200 cells per person obtained during two separate sampling events. Note that, as in Figure 1, the 95% confidence intervals all overlap, suggesting that the number of background chromosome abnormalities in these people is statistically similar.

Some data suggests that there is no detectable chromsomal damage from the high levels of natural background radiation found in Ramsar and other HBRAs, contrary to the predictions of linear, no-threshold or supra-linear models of radiation dose-response.[28] This further suggests that linear extrapolation of radiation risk from very high doses at high dose rates (e.g., A-bomb survivors) to moderate doses at natural low dose rates is scientifically invalid. Given the apparent lack of ill effects to the populations of HBRAs, this data further suggests that current dose limits are overly conservative. However, the available data does not yet seem sufficient to cause national or international advisory bodies to change their current conservative radiation protection recommendations; for this to happen, more definitive data is needed.[29] We are currently conducting an epidemiological study of the inhabitants of both high and normal background radiation areas. This study complements another research project examining the cellular biology and cellular radiation response of Ramsar inhabitants, again looking at inhabitants of high and normal background radiation areas. We hope that these projects will provide data of sufficient quality to assist in resolving the current controversy.

Implications for Public Health Policy

If, indeed, low levels of radiation exposure are confirmed to be harmless or even beneficial, then we would conclude that our current public health policies regarding the control of low levels of radiation exposure are overly conservative. In fact, it is probable that these policies could be relaxed to some extent, while still maintaining a safety margin to ensure that the public is not exposed to levels of radiation that are harmful. In addition, governmental recommendations regarding radon mitigation could be relaxed, offering financial relief to residents in areas with high radon levels. We would also find it is unnecessary to consider the relocation of residents in HBRAs such as Ramsar.

These policy changes, in aggregate, would result in considerable cost savings to governments and affected members of the public. These savings, in turn, could be designated for the mitigation of other risks

28 Ghiassi-nejad et al., *supra* n. 23, at 87.

29 J. Roth et al., *Basis of Radiation Protection*, 126 Schweiz Med Wochenscht 1157 (1996).

that can be addressed more cost-effectively. The net result should be an effective reduction in societal risk at little or no extra cost. In fact, using the LNT model, it has been shown that reducing radiation dosage is a far more expensive way of saving lives than virtually all other life-saving measures.[30] If the LNT model is shown to be incorrect, as we believe to be the case, the money spent on low-dose radiological risk abatement becomes even less effective than previously thought. It is an irony that monies spent to address the perceived health risks from natural radiation are currently taken from other, more effective risk reduction strategies, with the net result that such funds are making society less safe. In particular, we note a publication by Keeney suggesting that every $7 million to $12 million in cost distributed across society may cost one life because that money is not available for other risk-reduction activities.[31]

The U.S. Nuclear Regulatory Commission recommends spending up to $2,000 to avert one person-rem (10 person-mSv) of radiation exposure. According to the National Academy of Science's BEIR V report, the hypothetical LNT risk of developing a fatal cancer from this level of exposure is about five in 10,000.[32] Currently, over one million residents in the Denver area annually receive about 1 mSv (100 mrem) higher radiation dose than their counterparts along the coast of the Gulf of Mexico. Using NRC guidelines, then, the U.S. could justify spending up to $200 per person per year to reduce their radiation exposure for a total expenditure of roughly $200 million annually. Using the LNT hypothesis and assuming the average person lives about 70 years, this would result in a total reduction of about seven million person-rem (70,000 person-Sv) over the combined lifetimes of the currently living residents, and would save about 3,500 lives. Using Keeney's relationship, this would cost upwards of 1,400 lives, simply by distributing this cost among society in the form of higher taxes. The actual cost might be higher, indeed, if this money came from very cost-

30 Tammy O. Tengs et al., *Five Hundred Life-Saving Interventions and Their Cost Effectiveness*, 15 Risk Anal. 369 (1995).

31 Ralph L. Keeney, *Decisions About Life-Threatening Risks*, 331 New England J. Med. 193 (1994).

32 *See* National Academy of Sciences, *Health Effects of Exposure to Low Levels of Ionizing Radiation* (Natl. Acad. Press 1990).

effective interventions such as immunization or highway safety programs, which Tengs showed are much more efficient at saving lives.[33] This suggests that, even under the most conservative LNT conditions, spending money to relocate residents of high background radiation areas would not generate the highest net benefit to society. The fact that the cancer rate in Denver is actually lower than in the Gulf Coast states further suggests that such measures would be a counterproductive way of reducing public risk.

Further, it should be noted that the Health Physics Society has recommended against calculating risk at cumulative radiation doses of less than about 10 rem (0.1 Sv) because of the uncertainty of radiation effects at such low doses.[34] In addition, the HPS also recommended against calculating risks based on low levels of radiation exposure to large populations for similar reasons because of a recognition that the LNT may not be applicable at low doses and that, accordingly, it is simply not possible to determine the existence of a benefit from averting such low doses.[35] Finally, the preliminary results presented here, along with the apparent good health of residents in HBRAs, further suggest that it is not in the public's interest to spend societal resources to relocate populations exposed to even the relatively high levels of radiation found in Ramsar and other HBRAs.

Conclusion

Preliminary results of our studies (mentioned above) suggest that there would be no public health advantage from relocating Ramsar's inhabitants, and studies performed on the inhabitants of other HBRAs, like Yangjiang, China, indicated that there is no harmful impact induced by natural radiation. Furthermore, after the Chernobyl accident there were widespread psychological reactions to the accident that were due to fear of the radiation, not due to the radiation doses. Considering the ill effects of relocating residents of areas contaminated after the Chernobyl accident, it can be concluded that relocation of

33 *See* Tengs et al., *supra* n. 30, at 369.

34 *See* Health Physics Society, *Risk Assessment: Position Statement of the Health Physics Society* (1995).

35 *See* Health Physics Society, *Radiation Risk in Perspective: Position Statement of the Health Physics Society* (1996).

inhabitants of high background radiation areas of Ramsar not only is unnecessary, it could lead to considerable social, economic, and psychological problems. In addition, if future studies show that low levels of radiation exposure are indeed harmless or beneficial, governments and their citizens may allocate considerable sums of money to measures that reduce actual risks. This, in turn, would have a significant positive impact on overall public health while simultaneously reducing the irrational fear of radiation that drives many public policies.

Risk welcomes Elizabeth J. Baker as the Interim Editor-in-Chief for the Spring of 2002. Ms. Baker was formerly a Student Editor-in-Chief for the journal. She is presently a licensed attorney in the State of New Hampshire and is a law clerk for Associate Justice John T. Broderick, Jr., at the New Hampshire Supreme Court.

Congratulations to Jaime Ackerman and Elizabeth Hochberg, *Risk's* 2002-2003 Student Editors-in-Chief.

Finally, congratulations to *Risk's* graduating staff:

Steven Bunker Jason Carrier

Marie Devlin

Jay Franklin Joel Shaw