The Role of Nuclear Energy to Address 3 E Challenges and Public Health Concerns

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Energy is essential to health and wellbeing in society. However, the provision of all forms of energy is not without risks. The key societal issue is how the risks and benefits of each energy source can be balanced in terms of producing the best scenario for health and wellbeing. Perhaps the biggest health impacts are observed in the harvesting and burning of carboniferous fuels. These impacts are related mainly to occupational health, and pollution of both indoor (through burning solid fuels) and outdoor air pollution (particulate suspension in air). In recent years, following the Chernobyl and Fukushima accidents, attention has focused on the health effects of radiation from nuclear power, and the larger health impacts from burning fossil fuels, in terms of both air pollution and climate change, have been put to the back of the public mind. As a society, we can only have a mature debate on energy policy if we learn to base our arguments on sound scientific facts rather than popular myths.

Combustion of biomass and fossil fuels results in the production of particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrogen dioxide, sulphur dioxide and a variety of organic air pollutants (1). All of these pollutants have effects on the bronchial tree, leading to both lung cancer and to cardiovascular problems as the lungs fail to maintain oxygen saturation in the blood. In poorer areas of the world, where cooking of food is carried out using solid fuel stoves, pollution of indoor air is still a contributor to reduced public health. In richer countries where solid fuel use has been replaced by cleaner energy sources for cooking, such as electricity and gas, our indoor air quality is much improved. However, by switching to a secondary energy source like electricity we have just moved the issue to one outside the home.

Forty percent of the world's electricity is generated from coal fired power stations. There are inherent health risks in coal mining, as in any mining, but there are two further salient issues with regard to health: production of the pollutants listed above and their release into the ambient air and the contribution of the CO_2 emissions from coal fired power stations. Whilst CO_2 has no direct effect on health, the combustion of coal has marked effects on the concentration on particulate matter (PM) in ambient air. The amount of air pollution from this energy source varies according to whether exhaust scrubbers, more common in developed countries, are applied to the power stations. Interestingly, there is no well-defined safe limit for PM exposure (2), yet the use of coal as method

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for the production of electricity does not seem to provoke the same outcry as the use of nuclear energy for which the same point regarding a safe limit is made. Estimations of the health costs of coal derived electricity have suggested that this lies somewhere between $62 and $523 billion annually. If worked out in terms of health costs per kWh, this exceeds the current cost of electricity in the US, suggesting that electricity production via coal is subsidized by the health budget. The costs of climate change in terms of the worldwide health economy is estimated to be $2-4 billion per year by 2030, with a larger effect being felt by countries with weaker health infrastructure, e.g. South East Asia (3).

Coal fired power stations are not solely responsible for PMs in ambient air. A significant amount of PMs are derived from burning of petroleum products in transport. However, to decarbonize transport requires production of electricity – using coal to satisfy this increased demand is unlikely to solve the issue of PMs nor the challenges of climate change. Oil and gas are not as polluting as coal, but produce the same range of environmental contaminants.

One option is to turn to production of electricity by renewable sources such as solar, wind and hydropower. Whilst all three of these technologies are useful in reducing both air pollution and CO_2 emissions, they have significant issues in regard to base load. Hydropower is dependent on geology and geography, and so is therefore not universally deployable. Solar and wind are not so restricted, but do depend on the availability of land on which to build solar or wind farms. Their biggest drawback is that they are heavily dependent on climatic conditions, and, in the case of solar, the time of day.

The argument then turns to the use of nuclear power as a source of electricity. Like solar and wind, the production of nuclear energy is low carbon. However, it is not without risk as uranium has to be mined to provide the fuel for the reactor, and therefore the occupational risks of mining have to be taken into consideration. Interestingly, although there is a small increase in lung cancer associated with inhalation of radon, a fission daughter of uranium, it is also known that other, non-radiological factors increase lung cancer in this cohort (4). Inhalation of radon in indoor air, which is the largest component of the natural background annual radiation dose, is estimated to be responsible for between 3-20% of all lung cancer deaths worldwide each year (5). Even though the estimated figure is around 99,000, this is much lower than the estimated 6,300,000 deaths worldwide per year from smoking – lung cancer and cardiovascular disease. A very large nuclear workers study recently reported increased risks of cancer, although these risks are markedly lower at the smaller doses that are currently acceptable as occupational exposure (6). It is interesting to note that studies of populations exposed to natural background radiation at a similar level to the workers in fact show reduced cancers risks (reviewed in 7) raising the possibility that as in the Uranium miners cohorts, there may be confounders present in the worker studies – including low level exposure to chemical carcinogens.

Perhaps the most concerning of all to the public at large, is the likely health effects of a nuclear accident in the population living close to the power plant. There have been a very large number of scientific studies following the Chernobyl accident, the majority of which are summarized in the UNSCEAR report of 2008 (8). There is no doubt that the release of radioiodine from this accident has caused a large increase in thyroid cancer in those who were young at the time of the accident, and that 28 emergency personnel died as a result of high doses of radiation that they were exposed to as a result of their involvement in the immediate reaction to the accident. However, the mortality rate from thyroid cancer over the next 50 years is expected to be around 1% (9), giving a likely toll of a further 160 deaths, assuming a 16,000 thyroid cancers as a result of the exposure (10). It is easy to mitigate the effects of radioiodine: uptake into the thyroid can be blocked by flooding the gland with stable iodine. The major route for exposure is through contaminated food, so the ability to cut the food chain reduces the dose from radioiodine very significantly, as was shown by the prompt actions taken by the Japanese government after the Fukushima accident.

Given the low doses from Cs-137 exposure of around 9 mSv to more than 6 million inhabitants of the area surrounding the Chernobyl Nuclear Power Plant (8), it seems unlikely that increases in other cancers will be discernible. Most people will find this difficult to believe, but we tend to forget that exposure to Cs-137 is not new. From 1945 to 1980 there were more than 500 atmospheric tests of nuclear weapons worldwide. Those tests released radioactive material into the atmosphere, which, as it fell and settled on the ground, resulting in increased exposure to ionising radiation received both externally and internally, similar to the scenario following a nuclear power plant accident. The global average individual effective dose arising from the fallout from above ground A bomb tests peaked in the early 1960s at an annual effective dose of around 0.11 mSv. A large-scale study of 11 cancer registries found no evidence that the risk of childhood leukaemia from intakes of fallout radionuclides had been underestimated (11). A study that focussed on Nordic countries (where high rainfall would have led to doses of around 1.3 mSv to the red bone marrow over the four years of highest exposure) did find a slight increase in the incidence of childhood leukaemia in the years just after fallout was at its highest when compared with children born a few years earlier or later (12). There have been a number of studies looking at risk to children living in the vicinity of nuclear power plants (reviewed in 13), and the general consensus is there is no increased risk. However, there is no doubt that the public fear of radiation exposure creates its own health risks. The major health effect (aside from thyroid cancer when no protective measures are taken) following both the Chernobyl and Fukushima accidents has been from psycho-social issues (8, 14, 15), which result from our actions to “protect” the public from radiation rather than from the radiation itself.

So, where does this leave the debate over the 3Es and nuclear power? In terms of environmental concerns and their impact on health, nuclear power has much less of an impact than generation of electricity in power plants that burn any form of carbon-derived fuel. In addition, nuclear power is able to provide a mechanism to reduce CO_2 emissions, thus reducing the health economic burden from climate change. Finally, modern medicine is energy hungry. The ability to have a reliable base load production of electricity that is there when needed, night or day, (unlike solar and wind) is essential for the type of service we have all come to expect from our healthcare facilities. A little more time spent separating the scientific facts from the more publicized science fiction, around nuclear power and its effects on health might just enable our societies to take a balanced approach to deciding our national (and global) energy policies.

〈References〉

1: Smith KR, Frumkin H, Balakrishnan K, Butler CD, Chafe ZA, Fairlie I, Kinney P, Kjellstrom T, Mauzerall DL, McKone TE, McMichael AJ, Schneider M Energy and Human Health. Annu Rev Public Health. 2013;34:159-88. doi:10.1146/annurev-publhealth-031912-11440

2: Schwartz J, Coull B, Laden F, Ryan L. 2008. The effect of dose and timing of dose on the association between airborne particles and survival. *Environ. Health Perspect.* 116:64–69

3: WHO : Climate Change and Health
http://www.who.int/mediacentre/factsheets/fs266/en/ accessed 20/5/16

4: Walsh L, Grosche B, Schnelzer M, Tschense A, Sogl M, Kreuzer M. A review of the results from the German Wismut uranium miners cohort. Radiat Prot Dosimetry.
2015 Apr;164(1-2):147-53. doi: 10.1093/rpd/ncu281

5: Kim SH, Hwang WJ, Cho JS, Kang DR. Attributable risk of lung cancer deaths due to indoor radon exposure. Ann Occup Environ Med. 2016 Feb 26;28:8. doi: 10.1186/s40557-016-0093-4

6: Richardson DB, Cardis E, Daniels RD, Gillies M, O'Hagan JA, Hamra GB, Haylock R, Laurier D, Leuraud K, Moissonnier M, Schubauer-Berigan MK, Thierry-Chef I, Kesminiene A. Risk of cancer from occupational exposure to ionising radiation: retrospective cohort study of workers in France, the United Kingdom, and the United States (INWORKS) BMJ. 2015 Oct 20;351:h5359. doi:10.1136/bmj.h5359.

7: Hendry J.H., Simon S.L., Wojcik A., Sohrabi M., Burkart W., Cardis E., Laurier D., Tirmarche M., Hayata I. Human exposure to high natural background radiation: what can it teach us about radiation risks? *Journal of Radiological Protection* 2009 29, A29

8: UNSCEAR Report to the General Assembly of the United Nations. 2008. Annex D. Health effects due to radiation from the Chernobyl accident. Available at:
http://www.unscear.org/ docs/reports/2008/Advance_copy_Annex_D_Chernobyl_Report.pdf.

9: Tuttle RM, Vaisman F, Tronko MD. Clinical presentation and clinical outcomes in Chernobyl-related paediatric thyroid cancers: what do we know now? What can we expect in the future? Clin Oncol (R Coll Radiol) 2011;23(4):268e275.

10: Cardis E, Howe G, Ron E, Bebeshko V, Bogdanova T, Bouville A, Carr Z, Chumak V, Davis S, Demidchik Yu, Drozdovitch V, Gentner N, Gudzenko N, Hatch M, Ivanov V, Jacob P, Kapitonova E, Kenigsberg Y, Kesminiene A, Kopecky KJ, Kryuchkov V, Loos A, Pinchera A, Reiners C, Repacholi M, Shibata Y, Shore RE, Thomas G, Tirmarche M, Yamashita S, Zvonova I (2006) Cancer Consequences of the Chernobyl Accident. J Radiological Protection 26: 127-140

11: Wakeford R., Darby S.C., Murphy M.F. 2010 Temporal trends in childhood leukaemia incidence following exposure to radioactive fallout from atmospheric nuclear weapons testing. *Radiat Environ Biophys* 49, 213-227. (doi:10.1007/s00411-010-0266-4)

12: Darby S.C., Olsen J.H., Doll R., Thakrar B., Brown P.D., Storm H.H., Barlow L., Langmark F., Teppo L., Tulinius H. 1992 Trends in childhood leukaemia in the Nordic countries in relation to fallout from atmospheric nuclear weapons testing. *Br Med J* 304, 1005-1009

13: Bithell JF, Murphy MFG, Stiller CA, Toumpakari E, Vincent T, Wakeford R. Leukaemia in young children in the vicinity of British nuclear power plants: a case-control study. Br J Cancer. 2013;109 :2880–2885

14: UNSCEAR report (2013): Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami, Volume 1, Annex A. Available at: http://www.unscear.org/docs/reports/2013/1406336_Report_2013_Annex_A_Ebook_website.pdf.

15: IAEA report. The Fukushima Dai-ichi accident 2015. Technical Volume 4/5. Available at: http://www-pub.iaea.org/MTCD/Publications/PDF/AdditionalVolumes/P1710/Pub1710-TV4-Web.pdf.

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Gerry Thomas has been engaged on a number of international scientific joint research projects with Belarusian, Ukrainian, Russian Scientists after the Chernobyl accident. She assumed the position of Director at the Chernobyl Tissue Bank in 1998 whilst at Cambridge University; the project is now coordinated from Imperial College London. She is actively involved in public information on the health effects of radiation through engaging with schools, universities and the print and broadcast media.