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COMARE Statement on the publication 'Low doses of ionising radiation: Definitions and Contexts'

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COMARE members have identified a need for clarity on definitions of what constitutes a low dose of radiation, noting that the term is used differently according to context. An information paper was prepared by COMARE members to encourage a more coherent and consistent use of descriptors when communicating the significance of given levels of exposure in different circumstances. The note was subsequently published in the Journal of Radiological Protection (Harrison et al 2024).

The terms 'high' and 'low', and similar descriptors are relative terms and may refer to different ranges depending on context. UNSCEAR (2012) and ICRP (2021) have defined levels of dose from high to low to negligible, in the contexts of the underlying scientific evidence and its application to doses and estimated risks to patients from medical diagnostic procedures. In the cases of planned exposures of workers and members of the public, different considerations apply and the level at which dose can be considered low will be successively lower. The note concludes that while a low dose may be below 100 mSv for diagnostic exposures of patients, low dose might be a reasonable description of doses below dose limits for workers and members of the public. In each case, dose is being used as a surrogate for risk – risks at low doses are uncertain and estimates may change but order of magnitude considerations are sufficient in most cases.

The United Nations Scientific Committee on the Effects of Ionising Radiation (UNSCEAR 2012) has defined low absorbed doses of ionising radiation as below about 100 mGy, and low dose rates as below 0.1 mGy min^{-1} (6 mGy h^{-1}). These values relate to the interpretation of scientific evidence from epidemiological and biological studies. The International Commission on Radiological Protection (ICRP 2021) has used similar values of 100 mSv and 5 mSv h^{-1} and applied this categorisation directly to the specific situation of patients undergoing diagnostic procedures: doses below 100 mSv were referred to as 'low' and doses below 10 mSv as 'very low'. Consideration of other exposure situations suggest that the same terms can be used for exposures received by emergency workers. However, for workers and members of the public in planned exposure situations, it is suggested that the term 'low dose' applies to doses below 10 mSv and 1 mSv, respectively – that is, below the dose limits. In each case, dose is being used as a surrogate for risk – risks at low doses are uncertain and estimates may change, but order of magnitude considerations are sufficient in most cases. Doses of < 100 mSv, < 10 mSv and < 1 mSv correspond to life-time cancer risk estimates of the order of < 10^{-2}, < 10^{-3} and < 10^{-4}, respectively.

In general terms, the highest doses and risks will be incurred by emergency workers as one-off exposures during the emergency response, and by patients for whom the benefit will outweigh the risk. The lowest doses and risks will apply to members of the public for whom the exposure may continue over many years and there is no direct benefit to the exposed individuals. Occupational exposures in planned situations represent an intermediate case in which doses may continue over many years but the exposed individuals gain direct benefit from employment.

Table 3 from Harrison et al (2024), reproduced below, compares the application of descriptive terms to bands of effective dose and corresponding risks for different circumstances of exposure. In this illustration, low doses and risks are below 100 mSv for medical patients undergoing diagnostic procedures and also for emergency workers, but low dose is below 10 mSv for workers and below 1 mSv for members of the public. In both these cases, then, low dose falls below the dose limit. The protection system requires optimisation of protection below dose limits and the setting of constraints that will not normally be exceeded, as fractions of the respective dose limits. In each case, doses are in addition to those received from natural sources in the environment, which in the UK are average of about 2.3 mSv effective dose per year (PHE 2016).

The rationale for setting dose limits developed in ICRP Publication 26 (1977) was to refer to acceptable levels of risk for fatalities generally, with values of 10^{-4} y^{-1} for workers and 10^{-6} - 10^{-5} y^{-1} for members of the public, at which time the mortality risk from radiation was estimated as about 10^{-2} Sv^{-1}. In its 1990 recommendations, ICRP (1991) applied a more complex multi-attribute approach to the setting of dose limits as the boundary between “unacceptable” and “tolerable”, including the temporal expression of risk following exposure as well as probability of attributable death. As a result, the increased estimate of overall stochastic risk by a factor of five to 5 x 10^{-2} Sv^{-1} was accompanied by a smaller reduction in the occupational dose limit from 50 mSv to 20 mSv, although there was a five-fold reduction in the public dose limit from 5 mSv to 1 mSv, the reasoning being not completely clear despite lengthy analysis. The occupational dose limit was additionally recommended to apply as an average of 100 mSv over 5 years with no year exceeding 50 mSv. These dose limits were included in UK legislation (IRR 1999, 2017; IRR (Northern Ireland) 2000, 2017). The 2007 recommendations did not make large changes to risk estimates and dose limits remained unchanged (ICRP 2007). The Health and Safety Executive (HSE 2001) in Britain has assessed maximum tolerable risks of fatality as 10^{-3} y^{-1} for workers and 10^{-4} y^{-1} for members of the public; the current occupational and public dose limits are in line with these values.

Table 3 from Harrison et al (2024): Illustration of variation in the use of terms to describe individual dose levels, depending on circumstances of exposure.

Effective dose, mSv	***Cancer risk****	***Medical patients, Emergency workers***	***Workers, planned***	***Public, planned***
100 - 1000	10^{-2} - 10^{-1}	Moderate	High	Very high
10 – 100	10^{-3} – 10^{-2}	Low	Moderate	High
1 – 10	10^{-4} – 10^{-3}	Very low	Low	Moderate
0.1 - 1	10^{-5} – 10^{-4}	Minimal	Very low	Low
0.01 – 0.1	10^{-6} – 10^{-5}	Negligible	Minimal	Very low
< 0.01	< 10^{-6}		Negligible	Minimal

* Risk bands are lifetime detriment adjusted cancer incidence to nearest order of magnitude

Many commentators, including ICRP (1977), have referred to the context of exposures to natural sources of radiation, most recently estimated as an average of about 2.3 mSv y^{-1} in the UK (PHE 2016). ICRP (1977) concluded that differences in doses received from natural background sources should not “affect acceptable levels of man-made exposure, any more than differences in other natural risk should do”. If as intimated in early deliberations by ICRP (1977), it is deemed that an imposed risk needs to be reduced to between 10^{-6} to 10^{-5} per year to be acceptable, as distinct from tolerable, by members of the public, this corresponds to effective doses of around 10 - 100 µSv per year, even though this is a very small variation in natural background dose.

1. References

Harrison JD, Hill MA, McCready-Shea S, Smith GM and Sutton DG 2024 Low doses of ionising radiation: definitions and contexts. J Radiol Prot 44 043003

HSE 2001 Reducing Risks, Protecting People. HSE's decision-making process. Accessed via: https://www.hse.gov.uk/foi/internalops/hid_circs/permissioning/spc_perm_37/

ICRP 1977 Recommendations of the International Commission on Radiological Protection. ICRP Publication 26. Ann ICRP 1(3)

ICRP 1991 1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Ann ICRP 21 (1-3)

ICRP 2007 The 2007 recommendations of the International Commission on Radiological Protection. Ann ICRP 37(2-4)

ICRP 2021 Use of dose quantities in radiological protection. International Commission on Radiological Protection Publication 147. Ann ICRP 50(1)

Ionising Radiations Regulations 1999. UK Statutory Instruments. https://www.legislation.gov.uk/uksi/1999/3232/contents

Ionising Radiations Regulations 2017. UK Statutory Instruments. https://www.legislation.gov.uk/uksi/2017/1075/contents

Ionising Radiations Regulations (Northern Ireland) 2000. UK Statutory Instruments. https://www.legislation.gov.uk/nisr/2000/375/contents

Ionising Radiations Regulations (Northern Ireland) 2017. UK Statutory Instruments. https://www.legislation.gov.uk/nisr/2017/229/contents

PHE 2016 Ionising Radiation Exposure of the UK Population: 2010 Review. Centre for Radiation, Chemical and Environmental Hazards, Public Health England, PHE-CRCE-026, Public Health England. © Crown copyright 2016

UNSCEAR 2012 Sources, Effects and Risks of Ionizing Radiation. Annex A: Attributing health effects to ionizing radiation exposures and inferring risks. United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations, New York.