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COMMENTARY

ALARP: when does reasonably practicable become rather pricey?

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ABSTRACT

The Ionising Radiations Regulations 2017 require employers to restrict radiation doses to their employees and the public to be As Low As Reasonably Practicable. This article looks at the boundary between what might be considered to be reasonable and unreasonable in protecting staff and the general public in the field of hospital-based diagnostic radiology. A simple test for locating this boundary based on a cost–benefit approach is devised and its use illustrated using hospital-based radiation protection examples. It is concluded that a cost–benefit calculation based on the legal definition of As Low As Reasonably Practicable may have some use in the support of radiation protection decision-making in the hospital environment, but only within the context of existing legal, practical and ethical considerations.

INTRODUCTION

Under Regulation 9 (1) of the Ionising Radiations Regulations 2017,[1] 'every employer must, in relation to any work with ionising radiation that it undertakes, take all necessary steps to restrict as far as is reasonably practicable the extent to which its employees and other persons are exposed to ionising radiation.' This is normally expressed as the duty to make staff and public radiation doses As Low As Reasonably Practicable (ALARP). This wording implies that some potential actions of the employer to lower radiation doses may not be reasonably practicable, and therefore that the employer is relieved of the legal requirement to take such unreasonable actions. This article looks at the boundary between what might be considered to be reasonable and unreasonable in protecting staff and the general public in the field of hospital-based diagnostic radiology.

LEGAL BACKGROUND

Many of the regulations protecting UK employees derive from the Health and Safety at Work Regulations of 1974.[2] Although these regulations place some absolute duties on the employer, other duties are qualified by expressions such as 'so far as is reasonably practicable' (SFAIRP), 'as low as reasonably achievable' (ALARA), and 'as low as reasonably practicable' (ALARP) in order to avoid the imposition of duties that no-one can fulfil.[3] These terms are substantially interchangeable[4] and the main question is what is meant by reasonably practicable? The most significant and commonly cited case is that of Edwards v. National Coal Board (1949).[5] A colliery timberman, Mr Edwards, was killed as a result of a fall of material in a partially propped and lined tunnel at Marine Colliery, South Wales. The defendants argued that it was not reasonably practicable for them to have prevented the fall, there being nothing to indicate the existence of a problem prior to the event, and that to require them to support all tunnels in the mine would be to impose on them an impossible financial burden.[6] Damages of £948 were awarded to Mr Edwards' widow in the original trial and confirmed in the subsequent House of Lords appeal. The definition set out by Lord Asquith in that appeal is that:

"'Reasonably practicable' is a narrower term than 'physically possible' and it seems to me to imply that a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether money, time or trouble) is placed in the other; and if it be shown that there is a gross disproportion between them – the risk being significant in relation to the sacrifice – the defendants discharge the onus on them. Moreover, this computation falls to be made by the owner at a point of time anterior to the accident."

As well as the definition of reasonably practicable, the latter part of this judgement is also seen as the basis of a requirement for prior risk assessments.[6]

THE TEST OF REASONABLY PRACTICABLE

Decisions on ALARP are conventionally supported by a cost–benefit analysis, in which monetary values are assigned to costs and benefits to enable a comparison of like quantities, and a decision about gross disproportion between the two can then be taken. There is no fixed factor to determine gross disproportion, since the employer needs to take account of the level of risk and severity of consequences. For a given benefit, the higher these risks, the higher the disproportion of costs to benefits has to be before being judged 'gross'. Some indication of values can be gained from the Nuclear Safety Directorate which has taken as its starting point the Health and Safety Executive (HSE) submission to the Sizewell B enquiry that a factor of up to 10 (costs to benefits) would apply for high risks, a factor of 3 for risks to workers, and a factor of 2 for low risks to members of the public.[7] It would seem reasonable to apply these same factors in the context of X-ray radiation risks in hospital departments.

APPLICATION TO RADIATION PROTECTION

The risk of death resulting from an exposure to ionising radiation can be estimated from the ICRP Report 103 figure of 5% per Sv for fatal cancer induction.[8] The monetary value of a life lost can be taken as a human cost of £1,296,000 with a financial cost to society of £449,100,[9] however an earlier HSE document includes an additional factor of 2 where death is due to cancer.[10] Applying this factor to the more recent figures gives a value of £3,490,200 per life lost which is at the top end of such valuations. How much exposure to ionising radiation, and therefore risk of fatality prevented in a given intervention can be calculated from the saving in mSv/y multiplied by the number of people affected multiplied by the time over which the intervention will apply (y). Combining the various constants, the overall ALARP calculation can be simplified as:

$$A \approx 175\, R\, N\, T\, D$$

Where: A is the limit at which the proposed expenditure is no longer ALARP (£),

R is the proposed annual dose reduction to the individual (mSv/yr),

N is the number of individuals to which the dose reduction will apply,

T is the time over which the proposed intervention will apply (yr),

D is the disproportion factor 2, 3, 10 depending on risk.

This expression relies on current valuations and a number of definitions from the literature that may not apply in all circumstances, and the more detailed financial elements of a full formal cost–benefit analysis[10] have been omitted. The simplification, however, appears to reinforce the common sense view that it is worth spending on a radiation protection measure if a significant dose reduction can be made for a large number of individuals over a significant time, or if the risk of not intervening is unacceptably high.

Example 1: reduction of radiologist/cardiologist occupational doses

Investment in various relatively expensive products could be considered to reduce the occupational radiation doses of radiologists and cardiologists. Developments aimed at the goal of 'zero dose' procedures range from floor or ceiling supported heavy lead personal protective equipment to the use of robots remotely operated by the radiologist. The Health Protection Agency 2010 review of radiation exposure to the UK population gives an average figure of 0.11 mSv/year occupational exposure for radiologists and 0.12 mSv/year for cardiologists.[11] Taking the higher figure of 0.12 mSv/year and supposing that 10 individual radiologists/cardiologists would be using the purchased equipment over a period of 5 years, then the upper limit to ALARP expenditure using a disproportion factor of 3 in the expression above is £3150 over the 5-year period, or £630 per year. It is unlikely that amounts less than this would purchase the additional radiation protection required to make the proposed dose reduction. This example essentially illustrates how well radiologist/cardiologist occupational doses are already controlled.

Example 2: design of a CT room

The designer of a CT room has calculated that Code 4 lead plasterboard will be sufficient to protect a neighboring office occupied by three employees down to the required dose constraint of 0.3 mSv/year. The designer is uncomfortable with this result and specifies Code 5 lead plasterboard instead to allow for possible future changes to equipment or workload. The change in lead thickness from 1.8 to 2.24 mm will result in lowering the yearly exposure to the three staff from 0.3 to 0.1 mSv/yr[12] for the life-time of the CT scanner, which can be taken as 7 years.[13] Using a disproportion factor of 3, the maximum ALARP cost of this intervention would be £2205. The wall extends 4 m between the floor and ceiling slabs of the building and is 5 m across. Using online quotes for lead plasterboard, the additional cost of the change from Code 4 lead to Code 5 is approximately £500, well within the ALARP cost even for single occupancy of the office. The intervention is therefore ALARP in terms of cost, and the designer could use this in support of the decision to specify protection over and above that strictly required to meet the dose constraint.

CONCLUSIONS

Most hospital radiation workers if asked would be able to say that exposure to ionising radiation exposure in their organization is restricted on the basis of the ALARP principle, but ALARP is rarely applied in a quantitative manner in hospital radiation protection. Closer examination of how ALARP is interpreted in the broader health and safety field shows that the boundary between what might be considered reasonable and unreasonable in a radiation protection intervention can be interpreted using a simple cost–benefit calculation. This definition of what is ALARP may have some use in the support of radiation protection decision-making in the hospital environment, but only within the context of existing legal, practical and ethical considerations.

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