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A comparison of diagnostic radiology practice and patient exposure in Britain, France and Italy

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Abstract. Surveys have been conducted in Britain, France and Italy, using essentially the same techniques, to establish the level of provision of diagnostic radiology services, the frequencey of X-ray examinations and examples of the radiation doses delivered to patients in each country. Different national strategies for conducting some types of X-ray examination and marked differences in the general availability of this aspect of health care indicate that the justification and optimization of medical exposures is not interpreted in the same way in these countries.

While novel imaging procedures involving, for example, computed tomography (CT), nuclear magnetic resonance (NMR) and ultrasound are increasingly being applied as aids to medical diagnosis, the vast majority of examinations carried out in diagnostic radiology facilities, even in developed countries, involve well established conventional X-ray techniques. There is considerable scope for variation in the ways that these conventional techniques are used and a number of regional and national surveys have already indicated that the procedures and strategies adopted for imaging and diagnosing a given pathology can vary markedly from facility to facility and from practitioner to practitioner (Taylor et al, 1979; Harrison et al, 1983; Morris, 1983; Johnson & Goetz, 1986).

Since the average European population will receive at least 10 times more radiation in a lifetime from diagnostic medical procedures than from all other sources of man-made radiation combined (United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1982), including the Chernobyl accident, it is important that the protection of patients from unnecessary medical exposures receives as much attention as the protection of the public from other artificial sources. The system of dose limitation recommended by the International Commission on Radiological Protection (ICRP, 1977) includes two principles that should be directly applied to medical exposures: justification and optimization. Every medical exposure should be justified in relation to its benefits, or those of any available alternative, to the patient and any necessary exposures should be optimized in the sense that they should be limited to the minimum amount consistent with achieving the expected medical benefit. If attention to these principles was equally applied by medical practitioners throughout Europe a certain uniformity of practices and procedures in diagnostic radiology would be expected.

As an example of international co-operation in this field, and in the context of a joint European research programme on medical exposures, a collaborative study has been conducted by the National Radiological Protection Board (NRPB, Great Britain), the Ospedale S. Maria della Misericordia (Udine, NE Italy) and the Centre d'Etude sur l'Evaluation de la Protection dans le domaine Nucléaire (CEPN, France). Aspects of diagnostic radiology practice have been studied that provide an indication of the emphasis placed on justification and optimization of X-ray examinations in these three countries. Data indicating the levels of provision of radiology staff and facilities, the relative frequencies of different types of X-ray examination and the age/sex distribution of patients have been obtained by national or regional surveys. Five common types of X-ray examination have been selected for detailed study: pelvis, abdomen, lumbosacral spine, intravenous urography and barium meal. The radiological techniques and doses to patients associated with these examinations have been determined by detailed enquiry and by performing dose measurements directly on groups of patients using a common protocol, developed by the NRPB.

This is believed to be the first time that surveys of this type have been conducted in different countries using identical measurement techniques. The study thus enables comparisons to be made between national strategies for providing radiology services and for performing certain types of X-ray examination, and the resulting doses to patients. Some evidence for divergence in the application of the ICRP principles of justification and optimization is reported.

Survey methods

Surveys to establish the frequency of X-ray examinations and the age and sex distribution of patients were conducted on a national scale in Great Britain and France and on a regional scale in Italy.

Relevant information was collected by the NRPB on about 51 000 patients examined at 81 British hospitals, selected according to rigorous stratified sampling techniques, during a week in June 1977 (Kendall et al, 1980). These data were updated for 1983 using radiology workload figures for the 2 years published by the Department of Health and Social Security (DHSS), results from a smaller, more informal survey of diagnostic X-ray trends, and changes in demographic details of the British population reported by the Office of Population Censuses and Surveys (Wall et al, 1986). Information on radiology staffing levels for Great Britain was estimated from data published by the DHSS (1985).

In France a comprehensive national survey which gathered all the necessary information was conducted in 1981–2 by the CEPN. Initially 500 radiology departments and private clinics and practices throughout the country were approached for information on staff and equipment, and 386 replied. About one-third of these were then selected for detailed analysis of their activity during a week in June 1982. Details of 13 000 X-ray examinations were collected (Fagnani et al, 1985a, b, c).

In Italy the survey was confined to the Friuli Venezia Giulia (FVG) region in the north-east of the country. All 78 radiological departments in the region provided data for the survey and detailed information was collected on 36 000 examinations conducted in a 2-week period in 1983 (Padovani et al, 1987). Friuli Venezia Giulia is a relatively prosperous region of Italy with a population of about 1.25 million (2.2% of the total Italian population). The provision of health care services here may well be different from that in other regions of the country and the figures quoted in this report should not be regarded as typical for Italy as a whole.

Doses to patients have been determined in all three countries by direct measurements on patients. The complexity of the measurements restricts these dose surveys to smaller numbers of patients than those possible in the frequency surveys. In Britain, measurements were made on 1700 patients undergoing the five selected types of X-ray examination in a random sample of 20 hospitals around the country. In Italy, 574 patients were measured at all the public health service hospitals in the FVG region, and in France measurements were possible on a sample of 115 patients in hospitals in and around Paris. Many other estimates of dose to patients had been made in the French survey using different dosimetry techniques (Fagnani et al, 1986) but they were not included in this comparison for the reasons outlined in the following section.

Methods of dosimetry

Much confusion can arise when doses to patients in different countries are compared because of the different dosimetric techniques that are frequently used and the different ways in which the exposure of patients may be expressed. These problems have been avoided in this comparison by considering only those doses that have been measured and expressed in the same way in all three countries. The dose quantities that will be compared are the means and median values of the entrance surface dose to patients per radiograph for four common radiographic projections, and mean doses to organs for five common types of complete X-ray examination. The dose measurement surveys in Britain and NE Italy included a sufficient number of patients for the mean values to be a good indication of typical practice.

The French dose survey was not so extensive and may consequently not be so representative of French practice. Since the median value is not as greatly influenced as the mean value by doses that lie outside the main part of the distribution, it can be argued that the median provides a better indication of typical practice than the mean, especially for the smaller French survey.

Measurements of entrance surface dose to patients

The absorbed dose at the point where the central axis of the X-ray beam enters the patient was measured by attaching thermoluminescent dosemeters (TLDs) to the patient's skin. The measurement consequently includes a contribution from secondary radiation backscattered from the patient which can increase the primary X-ray beam dose by a factor of between 20% and 50%, depending on the X-ray quality and the beam area (Harrison, 1982). Lithium borate TLD pellets supplied by Alnor AB, Finland, were used in the British and French surveys and lithium fluoride pellets manufactured by the Harshaw Chemical Co., USA were used in the Italian survey. Calibration of the TLDs was traceable to the National Primary Standard in each country via secondary standard ionization chambers held by standardizing laboratories. A direct intercomparison was made between the calibration of the TLDs used in the three countries and they were found to agree to within $\pm 8\%$. The TLDs were calibrated in terms of absorbed dose in muscle (as specified by the International Commission on Radiation Units and Measurements (ICRU)) and this is the quantity in which the entrance surface doses are shown in Table IV, expressed in the unit milligray.

Doses to organs

For relatively simple examinations involving only a few radiographs and no fluoroscopy it is possible to specify the irradiation conditions fairly precisely and to use a theoretical modelling technique to estimate doses to organs. Interaction between the well defined radiation fields and a mathematical model of the human body that includes all organs of interest, can be simulated using a computer. Full details of the Monte Carlo computational techniques that were used including a description of the phantom have been published (Jones & Wall, 1985). Factors relating doses to organs to the entrance surface dose were derived for a wide range of X-ray field sizes, positions and projections and for the complete range of X-ray spectra used in the three countries. For each patient, doses to organs were calculated for each radiograph of an examination and then summed to give the total doses to organs for the complete examination. The mean values of these total doses for the groups of patients measured in each country are given in the results. Appropriate entrance surface dose to organ dose conversion factors were selected from the same set of Monte Carlo calculations for patients in all three countries.

For more complex examinations where a large number of radiographs or fluoroscopy are involved, this method for estimating doses to organs becomes impractical because of the difficulties in recording the precise position and size of the X-ray beam at all stages of the examination. Instead, the mean absorbed dose to relatively accessible organs like the breasts and the testes was measured using TLDs attached to the skin. The TLDs were kept in place for the complete examination and one attached to the thigh, next to the scrotum, was assumed to receive the same dose as the testes. One TLD was attached to each breast and the average of the doses received by these two TLDs was corrected in two ways to indicate the mean dose to breast tissue. Firstly the average dose was reduced by a factor of 0.76 to allow for a composition of 50% fat and 50% water for breast tissue (Hammerstein et al, 1979). Ratios of the mass energy absorption coefficients for this fat–water mixture and for ICRU muscle (the medium for which the TLDs were calibrated) were calculated for typical diagnostic X-ray spectra (Birch et al, 1979) and although the ratio increases slightly with radiation quality the chosen value of 0.76 involves an error of no more than $\pm 5\%$ over the complete range of X-ray spectra used in the surveys. The second correction was necessary to relate measurements made on the surface of the breast to the mean dose to the organ. Monte Carlo calculations indicated that an average factor of 0.7 was appropriate for direct antero-posterior (AP) irradiation of the breasts. For the types of examination studied it is likely that the majority of the dose recorded by a TLD on the breast will be from AP projections since the radiation from postero-anterior (PA) projections is attenuated by a factor of about 50 in passing through the body. This factor of 0.7 was consequently applied to all breast TLD readings, resulting in a total correction of about 0.5 (0.76×0.7) for the intravenous urogram (IVU) and barium meal examinations.

Doses to organs that are less accessible but fairly uniformly distributed around the body, like bone and bone marrow, can be estimated for complex examinations using Monte Carlo-derived conversion factors applied to measurements of the total exposure. In this situation a Diamentor large-area ionization chamber (PTW, Freiberg), which is mounted on the X-ray tube diaphragm housing and can be calibrated in terms of dose–area product (Gy cm^2), was used to integrate the total exposure for complex examinations. The mean dose to the bone or the bone marrow is more dependent on the overall level to which the patient is irradiated, in terms of both intensity and field size, rather than the exact position of the X-ray beam, as would be the case for more highly localized organs. Conversion factors relating dose–area product to organ dose for the IVU examinations were calculated for a general abdominal field, and for a more restricted field centred on the stomach for the barium meal examinations. Since doses to bone and bone marrow are significantly larger per unit entrance dose for PA than for AP projections, a rough guide to the proportion of each examination that was AP or PA was obtained from the ratio of doses received by pairs of TLDs on the front and back of the trunk. Conversion factors for dose to organs were calculated for the appropriate AP and PA fields and weighted according to this measured proportion to obtain a factor suitable for each patient. The mean value of the tube potentials used during each examination provided an indication of the appropriate X-ray spectra to select when choosing the most suitable conversion factors. These dosimetry techniques are described in more detail by Shrimpton et al (1986).

Results

Radiology practice

The level of provision of staff and facilities for diagnostic radiology in the three countries is shown in Table I in terms of the numbers of radiologists, radiographers and X-ray tubes available in both public and private practices per million inhabitants. Staff figures are expressed in terms of whole-time equivalents. The figure for X-ray tubes in Britain is an estimate based on data from nine regions, since national figures are not at present available from the DHSS. The provision of CT scanners has increased rapidly in France since 1982 and is currently at the Italian level of four per million inhabitants, which has remained stable. In Britain it had increased to about three per million inhabitants in 1986. It is clear that, per head of population, staff and facilities in Britain are rather less than those available in France and NE Italy.

Another major difference in radiology practice between Britain and the other two countries is shown in Table II. Private practice can be seen to occupy a far larger percentage of general radiology in France and

Table I. Level of provision of medical radiology staff and facilities in the three countries

Staff and facilities	Number per 10^6 inhabitants		
	Britain (1983)	France (1982)	NE Italy (1983)
Radiologists	28	91	84
Radiographers	143	340	330
X-ray tubes*	198	244	310
CT scanners†	1.7 (3)	1 (4)	4 (4)

*Excluding those of private dentists and CT scanners.
†Numbers in parentheses refer to 1986.

Table II. Percentage of private radiology practice in the three countries

Practice	Percentage of examinations carried out in private hospitals, clinics or offices		
	Britain	France	NE Italy
General radiology	3	42	12
Mass chest screening	2	2	0
Dental radiography*	92	98	63

*Dentists' surgeries are regarded as private offices or clinics.

Italy than in Britain. More private practice than that indicated in Table II for NE Italy is thought to take place in the south of the country, and the figure for dental radiography is probably an underestimate due to a poor response from private dentists in the Italian survey. In Britain, general dental practitioners who are independent contractors to the National Health Service were regarded as practising in private offices or clinics as well as the true private dentists.

The relative frequencies of X-ray examinations in the three countries are shown in Table III. In terms of the total number of medical X-ray examinations (excluding mass chest screening and dental radiography), France performs approximately twice as many per 1000 inhabitants per year as Britain (825 compared with 444), and NE Italy about 1.5 times as many (665). These ratios are approximately maintained for most of the individual types of medical examination shown in Table III. Exceptions to this rule are examinations of the urinary system, obstetric X-ray examinations and angiographic examinations for which the relative frequency in France compared with the other two countries is even higher than that for the other examinations. This is also true for mass chest screening and dental radiography which are indicated separately at the bottom of Table III. The practice of mass chest screening is thought to have dropped dramatically in France since 1982 (Le Gales et al, 1985) but dental radiography is not expected to have fallen and probably still comprises some 30% of all X-ray examinations in France as it did in 1982. Italian practice also shows some exceptions to the above rule with examinations of the spine and biliary tract and barium studies being twice as frequent as in Britain. It is interesting to note that the relatively straightforward examinations of the limbs, particularly the arms, which probably involve least in terms of clinical judgement, have very similar frequencies in all three countries.

The figures for the total numbers of X-ray examinations of all types per 1000 inhabitants per year indicate that in the early 1980s for every British person there was, on average, one X-ray examination every 19 months, for every Italian, one every 14 months and for every French person, one every 8 months. The figures also indicate, when combined with the data in Table I, that each radiologist was reponsible for approximately 16 000 examinations per year in Britain, 10 000 per year

Table III. Relative frequency of different types of X-ray examination in the three countries

Examination category	Annual number of examinations/1000 inhabitants		
	Britain (1983)	France (1982)	NE Italy (1983)
Head	35	71	44
Cervical spine	13	23	30
Thoracic spine	5.6	17	17
Lumbosacral spine	20	47	41
Pelvis	18	} 62	24
Hips	11		16
Upper limb girdle	10	21	19
Upper limbs	51	45	49
Lower limbs	66	100	70
Abdomen (plain radiograph)	18	30	22
Chest (lung, heart and ribs)	149	276	243
Mammography	4.0	4.8	6.5
Barium meal (oesophagus, stomach and small intestine)	13	20	24
Barium enema (colon)	5.5	16	11
Biliary tract (choles)	5.9	12	13
Urinary system (IVU, cysto-urethro, etc.)	9.6	38	14
Obstetric/pelvimetry	0.4	6.0	<1.0
Angiography	2.5	16	2.8
Computed tomography	4.1	5	13
Others	2.5	15	4
Total (Medical)	444	825	665
Mass chest screening	12	166	81
Dental (intraoral film)	138	514	85
Dental (pantomography)	27	31	33
Total (Dental)	165	545	118
Total (Medical + screening + dental)	621	1536	864

in France and 9000 per year in Italy. Radiographer workload, on the other hand, would appear to be more evenly matched, British radiographers each handling 3200 examinations per year, French 2900 per year and Italian 2300 per year. The more extensive use of fluoroscopy in France and Italy, reported in the next section, would require the presence of the radiologist at a higher proportion of examinations than is the case in Britain and might, in part, account for the lower number of examinations per radiologist in France and Italy.

There are also some significant differences in the age distributions of patients undergoing diagnostic radiology in the three countries. Age distributions for male and female patients are shown in Figs 1–5 for all types of examination (excluding mass chest screening, CT and dental radiology) and for examinations of the

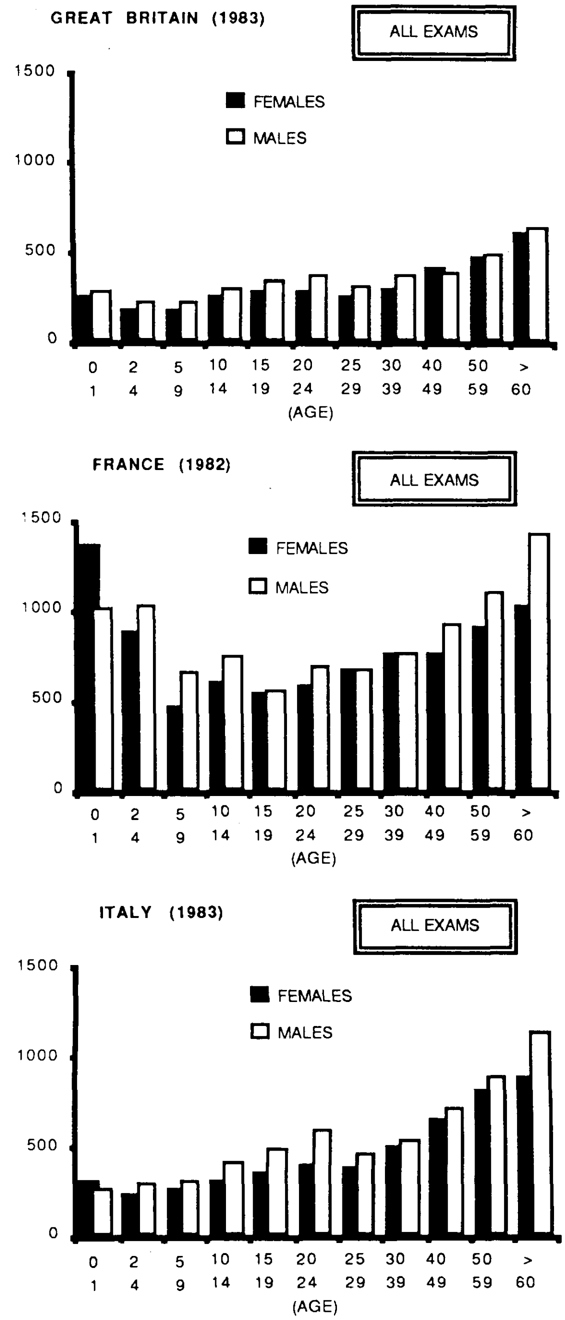

Figure 1. Bar charts illustrating the age and sex distribution of patients in Britain, France and NE Italy for all types of X-ray examination.

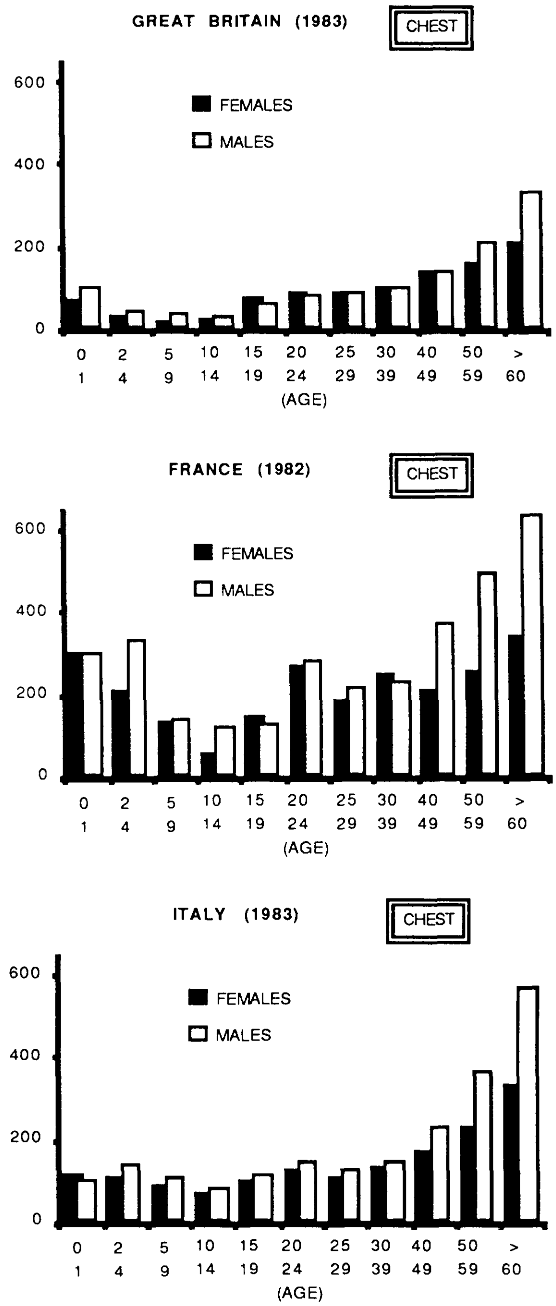

Figure 2. Bar charts illustrating the age and sex distribution of patients in Britain, France and NE Italy for chest X-ray examinations.

chest, pelvis, urinary system and gastrointestinal tract. A very marked preference for radiological examination of the newborn in France is evident from these figures, primarily due to the practice of taking routine radiographs for congenital hip dysplasia. Two-thirds of all French girls and one-quarter of all French boys in fact undergo a pelvic X-ray examination in the first year of life, the higher rate for girls reflecting their higher susceptibility to the disease (Lefaure et al, 1986). Barium contrast studies of the gastrointestinal tract also

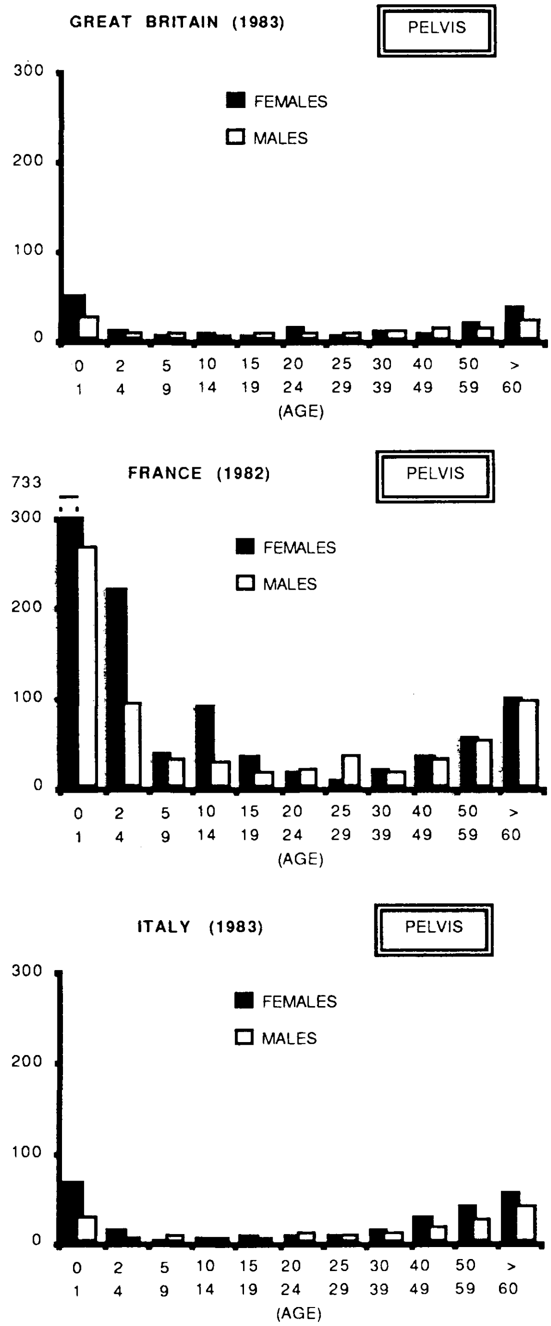

Figure 3. Bar charts illustrating the age and sex distribution of patients in Britain, France and NE Italy for pelvic X-ray examinations.

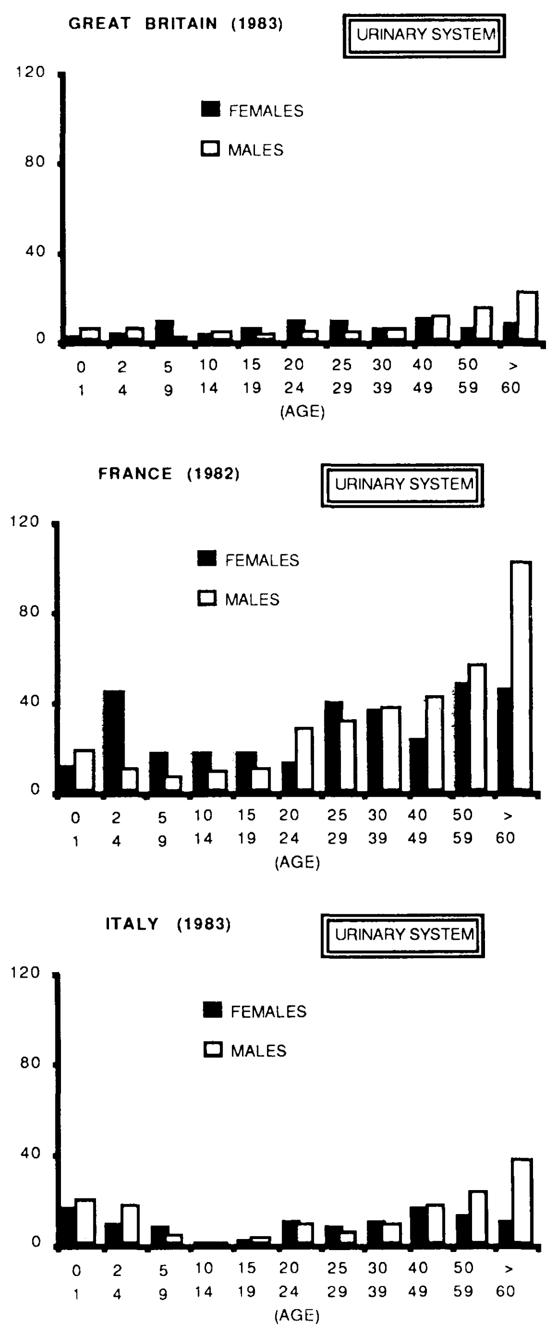

Figure 4. Bar charts illustrating the age and sex distribution of patients in Britain, France and NE Italy for urinary tract X-ray examinations.

appear to play a much larger part in the management of congenital abnormalities in French babies than in those from Britain or Italy. Once beyond the first few years of life, trends in examination frequency with age and sex follow similar patterns in all three countries.

Doses to patients

Entrance surface doses (including backscatter) for AP lumbar spine, lateral lumbosacral joint and AP abdomen and pelvis projections are shown in Table IV. Mean and median dose values for the samples of

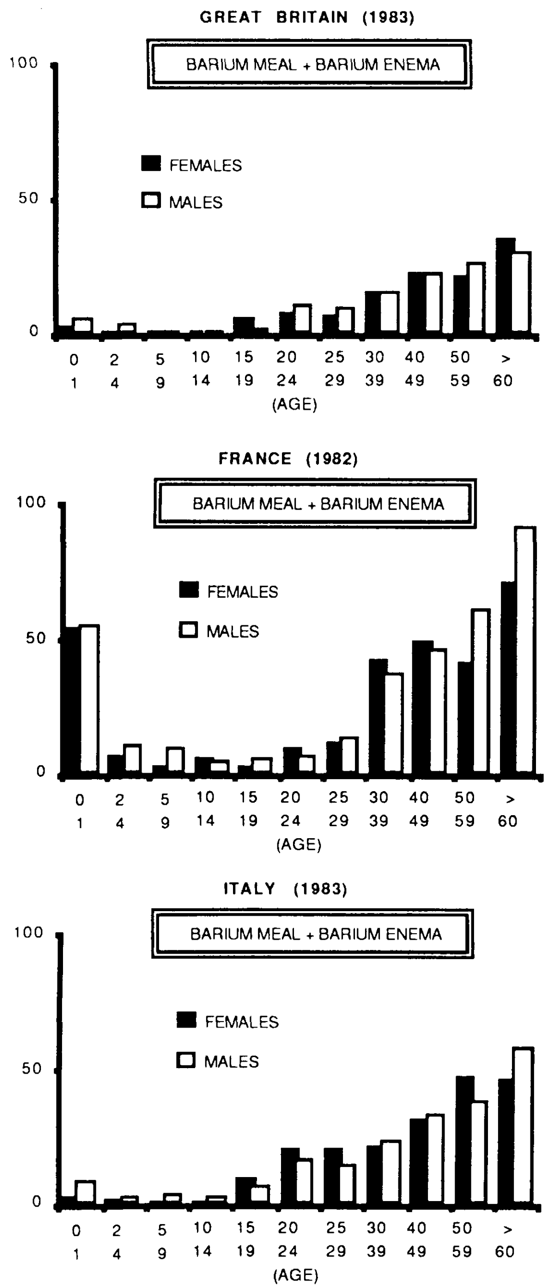

Figure 5. Bar charts illustrating the age and sex distribution of patients in Britain, France and NE Italy for barium meal and barium enema X-ray examinations.

patients measured in each country are shown in the last two columns of the Table. The first column of figures indicates the relatively small size of the French survey, but using the median dose values rather than the mean does not serve to pull the relatively high French doses more into line with those from the other two countries. A few extremely high, unrepresentative values are consequently not likely to be causing the high mean doses in the French survey.

Some indication of the radiographic techniques and equipment that might influence the entrance surface doses is given in Table IV in the form of mean values of tube potential and beam filtration and the percentage of observations in the surveys for which rare-earth screens and antiscatter grids were used.

The mean doses to organs for five different types of complete X-ray examination are shown in Tables V and VI. Results for simple radiographic examinations of the lumbosacral spine, abdomen and pelvis are given in Table V including the average number of films used in each country for the separate projections that make up these examinations. Similar numbers of films per examination are seen for all three countries for abdominal and pelvic examinations, with some differences evident for lumbosacral spines. British and Italian doses to organs are similar and French doses to organs are a factor of up to three times higher per examination, in line with the higher entrance surface doses seen in Table IV and slight differences in film use.

Table VI contains results for more complex examinations of the urinary system and the gastro-intestinal tract that involve the use of contrast media, larger numbers of films and often fluoroscopy. Mean values for the dose–area product (Gy cm^2) derived from Diamentor measurements and for doses to four different organs are shown. Details of examination technique included in the Table indicate that the French use considerably more films than the British or Italians during intravenous urography, but the Italians have a more marked preference for tomography. The French are also seen to utilize fluoroscopy for the majority of IVUs, while the Italians use it in only one-quarter of cases and the British hardly at all. On the few occasions that it is used in Britain, fluoroscopy takes considerably longer than in the other countries, indicating that it is selected only for difficult cases. This selective use of fluoroscopy is seen to extend to other types of examinations in the further examples given in Table VII. The very short fluoroscopy times used in France for the simple examinations of the chest and abdomen indicate that fluoroscopy is probably being used for alignment of the X-ray beam during radiography on the remote-control X-ray equipment that is popular in France.

Discussion

The mean values of tube potential and beam filtration shown in Table IV would indicate a general preference for softer X-ray spectra in France which would require a higher entrance surface dose to the patient for the same dose to the image receptor. Entrance surface doses are also affected, inter alia, by the sensitivity of the film–screen system and the use of antiscatter grids.

Rare-earth intensifying screens, for example, are generally more sensitive than conventional calcium tungstate screens and can reduce doses to patients by

Table IV. Mean values of applied potential, total beam filtration and entrance surface dose to skin for four common radiographic projections in the three countries

Radiographic projections	No. of observations	Use of rare-earth screens (%)	Use of antiscatter grids (%)	Mean potential (kV)	Mean filtration (mm Al)	Mean entrance surface dose (mGy)	Median entrance surface dose (mGy)
AP lumbar spine							
Britain	428	16	100	75	2.70	9.2	7.68
France	26	9	100	70	2.50	25.3	22.4
NE Italy	210	100	100	78	2.65	9.5	6.94
Lateral lumbosacral joint							
Britain	388	23	100	94	2.72	39.0	34.5
France	37	12	100	81	2.50	55.0	49.3
NE Italy	58	100	100	93	2.60	25.0	20.2
AP abdomen							
Britain	427	20	100	75	2.74	8.4	6.68
France	26	12	100	70	2.50	16.3	14.8
NE Italy	79	100	100	75	2.38	8.1	7.30
AP pelvis							
Britain	359	14	100	73	2.73	6.6	5.67
France	24	8	100	68	2.50	13.7	11.2
NE Italy	118	100	100	67	2.63	11.0	6.04

Table V. Film usage and mean doses to organs for three types of radiographic examination

	Lumbosacral spine			Abdomen (plain radiograph)			Pelvis		
	Britain	France	NE Italy	Britain	France	NE Italy	Britain	France	NE Italy
No. of examinations observed	354	30	124	322	21	74	338	19	93
Mean no. of films/ examination:									
AP	1.2	1.1	1.7	1.3	1.4	1.1	1.1	1.3	1.3
PA	0	1.8	0	0.1	0	0.3	0	0	0
Lateral	2.3	1.3	1.5	0	0	0.05	0	0	0
Mean doses to organs (mGy):									
Breast	0.07	0.24	0.07	0.03	0.06	0.02	*	*	*
Lung	0.29	0.99	0.31	0.08	0.18	0.06	*	*	*
Red marrow	1.4	2.0	1.0	0.40	1.0	0.44	0.18	0.36	0.27
Bone	1.6	2.9	1.3	0.54	1.3	0.57	0.32	0.52	0.50
Thyroid	*	*	*	*	*	*	*	*	*
Ovaries	4.3	3.6	3.6	2.2	4.2	1.6	1.2	2.3	1.9
Testes	0.06	0.06	0.06	0.40	0.83	0.29	4.6	9.2	8.4

*Denotes < 0.01 mGy.

factors of between two and five. Antiscatter grids, on the other hand, inadvertently absorb primary radiation as well as reducing scatter, and their use requires doses to patients of three to eight times higher to produce the same dose at the image receptor. It can be seen in Table IV that while antiscatter grids were used throughout the surveys in all three countries, only in Italy were rare-earth screens used all the time. In the French survey they were used about half as frequently as in the British survey but for none of the radiographic projections considered did their use in Britain exceed 23%. These differences in practice may partly explain the higher French entrance surface doses but do not appear to account for the general agreement between British and Italian doses. It may be relevant that the great majority of French X-ray equipment comes from a single manufacturer (CGR), whereas many different manufacturers supply the other two countries.

The precise effect of the differences in technique shown in Table VI on the doses to the radiosensitive organs is difficult to predict. It is not strictly necessary for the breast or testes to be irradiated directly during intravenous urography but the size of the measured doses indicates that this frequently occurs. The extent to

Table VI. Film usage, fluoroscopy time and doses for intravenous urography and barium meals

	Intravenous urography			Barium meals		
	Britain	France	NE Italy	Britain	France	NE Italy
No. of examinations observed	357	35	130	342	10	153
Mean no. of films/examination:						
AP	8.2 (AP, PA, Lateral, Oblique combined)	11.1	9.4	7.8 (AP, PA, Lateral, Oblique combined)	16	14
PA		1.3	0.3			
Lateral		2.5	0			
Oblique		4.4	0.3			
Percentage of tomographic films	6	9	16			
Percentage of fluorographic examinations	2.3	92	25	100	100	100
Mean time of fluoroscopy (s)	150	55	78	193	247	337
Mean dose × area (Gy cm^2)	30	90	—	19	20	38
Mean organ doses (mGy):						
Breast	3.9	13	8.7	2.3	7.8	1.5
Red marrow	1.9	3.0	1.4	2.6	1.9	3.8
Bone	2.6	4.4	2.3	3.7	2.9	5.8
Testes	4.3	23	7.5	0.30	1.7	0.12

Table VII. Percentage of examinations involving fluoroscopy and the mean fluoroscopy time in the three countries

Examination category	Percentage involving fluoroscopy			Mean time of fluoroscopy (s)*		
	Britain	France	NE Italy	Britain	France	NE Italy
Chest	0.7	7	2	192	15	78
Abdomen	3.7	28	20	150	29	80
Cholangiography	8.6	67	43	163	73	96

*The mean was obtained only for those examinations where fluoroscopy took place.

which X-ray beam size limitation is practised will probably influence the dose received by these organs during this type of examination more than any other technical factor. Generally, British techniques would appear to result in the lowest doses.

For barium meal examinations the mean values of dose–area product (Gy cm^2) measured by Diamentor ionization chambers indicate a considerably higher level of exposure for Italian patients compared with British or French. The longer mean time for fluoroscopy in Italy could account for this. It is, however, difficult to account for the similarity of the British and French values of dose–area product in view of the smaller number of films and less time spent doing fluoroscopy in Britain than France, unless British radiologists use larger X-ray fields. The lower values for doses to breast or testes in Britain might be taken as an indication that this is not so. However, because of their anterior position in the body, the doses to these organs depend not only on the degree of field collimation but also on whether the radiation is predominantly AP or PA. The much higher proportion of remote-control fluoroscopy units with undercouch image intensifiers in France (40%) (Maccia et al, 1985) probably leads to more AP projected X-ray beams in these examinations and hence larger doses to breast and testes for the same value of dose–area product. On the other hand doses to bone and bone marrow will be lower in France due to their predominantly posterior position in the trunk. This is seen to be the case.

Conclusions

These observations on national radiology practice provide only a limited insight into the attitudes adopted by the different countries towards the justification and optimization of medical radiology. Criteria for selecting both patients and examination techniques will be influenced by the different rates at which developments in diagnostic imaging and in the clinical management of patients have been introduced and accepted by the radiology professions in the countries concerned, and possibly by different national patterns in the prevalence of disease. The structure and organization of the health services and the division between public and private funding vary markedly and can have a significant effect on the level of provision of services and the rate of introduction of new technology. Private practice may, for example, influence the amount of fluoroscopy in comparison with radiography if there are financial advantages, such as lower running costs and tax allowances on capital investment, for one practice rather than the other.

It has not been possible in these surveys to obtain sufficient information to clarify the reasons for the divergences observed in staffing levels, and in the frequency and choice of examinations. Some of the main differences in radiology practice, however, occur for procedures whose efficacy or optimization has already been questioned. Excessive reliance on fluoroscopy, screening against congenital hip dysplasia by radiography in the first year of life, obstetric radiography and mass chest screening, are all procedures whose value has been reduced by the availability of alternative, less hazardous techniques or a decline in the diseases for which they were initially indicated (World Health Organization (WHO), 1983; Department of Health, Education and Welfare (DHEW), 1980).

The intention of this paper has been to highlight the major differences in practice that have been observed and to encourage the medical professions in the countries concerned to consider the justification and optimization of their national strategies. Although higher levels of patient exposure have been reported for France (albeit for a very limited survey), without comparisons of the image quality as well as the patient doses it is difficult to verify whether optimal conditions have been achieved in any of the countries studied. The introduction of quality assurance programmes in diagnostic radiology, which is being actively encouraged in Europe by the Commission of European Communities (CEC), will help to establish and maintain optimal procedures in this field. The surveys reported in this paper have provided a baseline of data concerning practices and doses delivered in diagnostic radiology against which the effects of future quality assurance programmes and reassessments of the need for certain procedures may be judged.

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