The Chernobyl accident and radiation risks: dynamics of epidemiological rates (morbidity, disability and death rates) according to the data in the national registry

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In 1986, immediately after the Chernobyl accident, the Ministry of Public Health of the then-USSR adopted a large-scale programme to establish the All-Union Registry of persons exposed to radiation. Towards 1992 (by the time the USSR collapsed) the data base of the Registry comprised medical and dosimetric information for 659,292 people including that for 284,919 emergency workers (EWs or "liquidators"). All republics of the former USSR as well as a wide range of scientific and practical institutions were involved in the establishment of the Registry.

At present, in accordance with the Decree of the Government of Russia (1948 of 22.09.93), the National Radiation and Epidemiological Registry (NRER) operates in the country. The general client of the Registry is the Ministry of Emergency Situations. The lead organization is the Medical Radiological Research Centre of the Russian Academy of Medical Sciences (RAMS) responsible for sampling primary medical and dosimetric data through 24 regional centres.

The NRER involves 3 main data bases: the Registration List of persons exposed to radiation which was established on special dosimetric criteria according to Decree 1948 of the Government of Russia; the Chernobyl Registry (since 1992 the Russian National Medical and Dosimetric Registry - RNMDR); and the Registry of Interdepartmental Expert Councils.

In this article we will enlarge on radiation-related epidemiological analysis of the Chernobyl Registry of Russia (RNMDR).

Current status of the Russian National Medical and Dosimetric Registry

Fig. 1 presents information on the growth of the number of registrants in the RNMDR from 1986 to 1995. As Fig. 1 shows, during all these years of its existence the data base of the federal level of the RNMDR kept accumulating medical dosimetric information and as of 01.09.95 comprises data on 435,276 people from throughout the Russian Federation.

The RNMDR registrants are divided into 4 groups:

Registration group 1 – emergency workers – 152,325 (35.0%);
Registration group 2 – evacuees and the resettled – 12,889 (3.0%);
Registration group 3 – residents (persons living or having lived in monitored territories) – 251,246 (57.7%);
Registration group 4 – children born to emergency workers of 1986-1987 – 18,816 (4.3%).

Fig. 2 demonstrates the distribution of persons registered in the RNMDR, based on their representation in regional centres. The registry of the Central Region does not include 4 contaminated oblasts (provinces) – Bryansk, Kaluga, Orel and Tula – as each of them has its own regional centre.

The maximum number of people registered in Bryansk Oblast (158,182) is determined by the total population living in the territory with the highest levels of radioactive contamination in Russia. Among regional centres established along territorial-administrative divisions of Russia, the maximum number of registrants is in the North-Caucasus Region (28,513 people) determined by the number of emergency workers living there.

Sex-age composition of the contingent registered in the RNMDR is as follows: men – 281,775

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Fig. 2
Regional distribution of registrants in the Russian National Medical and Dosimetric Registry (RNMDR)
Répartition régionale du nombre d'inscrits au Registre médical et dosimétrique national de Russie, 1986-1996

435 276 persons – personnes

- Northern - Nord
- Northwest - Nord-Est
- Central - Centre
- Volgo-Vyatksy
- Central Chernozem - Chernozem central
- Povolzh
- North Caucasus - Nord Caucase
- Ural - Ourals
- Western Siberia - Sibérie occidentale
- Eastern Siberia - Sibérie orientale
- Far East - Extrême est

Note: RG = Registration group – Groupe d’inscrits.

(64.7%); women – 153 501 (35.3%); children – 83 598 (19.2%); adolescents – 16 906 (3.9%); total adults – 334 772 (76.9%).

Mortality, morbidity and disability among emergency workers: factual data and forecasts
Fig. 3 illustrates the distribution density f(D) of external exposure doses for emergency workers included in the RNMDR system. As is seen from Fig. 3 the distribution of doses is complicated and is characterized by the presence of several peaks (1, 5, 10 and 20-25 cGy). This distribution was obtained using superposition of distributions of the various dates at which each emergency worker began working in the radioactive contamination zone.

With regard to the age distribution of emergency workers (the average age at the time of the accident was 33 years) and dosimetric data, Table 1 shows projections of excess mortality from malig-

Table 1
Predicting late effects of radiation on mortality from malignant neoplasms among emergency workers 20 years after the exposure (Russia, 1995)

<table>
<thead>
<tr>
<th>Year of employment in the zone – Année d’emploi dans la zone</th>
<th>Number of emergency workers – Nombre d’agents de secours</th>
<th>Mean absorbed dose (cGy) – Dose moyenne absorbée (cGy)</th>
<th>Collective dose (men x Gy) – Dose collective (hommes x Gy)</th>
<th>Excess cancer deaths due to the exposure – Mortalité cancéreuse exécutaire due à l'exposition</th>
<th>Natural cancer deaths – Décès par cancer naturel (%)</th>
<th>Attributive risk – Risque d’attributio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>46 575</td>
<td>15.9</td>
<td>7 405.4</td>
<td>22</td>
<td>45</td>
<td>32.8</td>
</tr>
<tr>
<td>1987</td>
<td>48 077</td>
<td>8.95</td>
<td>4 302.9</td>
<td>11</td>
<td>45</td>
<td>19.6</td>
</tr>
<tr>
<td>1988</td>
<td>18 208</td>
<td>3.3</td>
<td>600.9</td>
<td>2</td>
<td>17</td>
<td>10.5</td>
</tr>
<tr>
<td>1989</td>
<td>5 475</td>
<td>3.2</td>
<td>175.2</td>
<td>–</td>
<td>6</td>
<td>7.4</td>
</tr>
<tr>
<td>1986-1989</td>
<td>118 335</td>
<td>10.5</td>
<td>12 483.1</td>
<td>35</td>
<td>113</td>
<td>23.6</td>
</tr>
</tbody>
</table>

With while statist. quart., 49 (1996)
nant neoplasms among emergency workers 20 years after exposure. Excess radiation-induced mortality (attributive risk) from all malignant neoplasms was found to be 2.8%; the corresponding figure for leukaemia cases was 23.6%.

As is evident from Table 1, the data on collective and mean doses of external radiation are estimated on the basis of the information about radiation doses received by Russian emergency workers recorded in official documents of the Ministries and Departments which sent them to work in the 30-km zone.

Fig. 3
Distribution (f(D)) of external exposure doses (D) for emergency workers registered in the RNMDR

Figs. 3a-3f. Distributions (f(D)) for different dates of arrival in the contaminated areas (1986, 1987, 1988, 1989 and 1990) are shown separately, with the number of workers (sample size) indicated inside the oval.

Note:
Fig. 3a. Distribution (f(D)) for all emergency workers - Distribution (f(D)) pour l'ensemble du personnel d'intervention.

Figs. 3b-3f. Distributions (f(D)) for different dates of arrival in the contaminated areas (1986, 1987, 1988, 1989 and 1990) are shown separately, with the number of workers (sample size) indicated inside the oval.

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workers from malignant neoplasms does not exceed the control rate. No dose dependence of mortality from malignant neoplasms is seen here. Therefore, the relative risk of mortality from malignant neoplasms among emergency workers who received doses higher than 25 cGy amounts to 1.4. However, the 95% confidence interval of this estimate is within the range of 0.61-2.16 (i.e., it includes the value of 1.0) and does not allow one to make a conclusion about dose dependence. It should be noted that in spite of significant growth in the mortality rate from all causes among emergency workers in 1990-1994 this index does not exceed the control values (Fig. 5). Thus, the health effects on mortality rates (from all causes and malignant neoplasms) actually observed during the 9 years since the CNPP accident are in agreement with forecast estimates.

The more complicated problem relates to the prediction and interpretation of actual data by morbidity and disability rates for emergency workers (3).

Table 2 shows a comparison of morbidity rates per 100,000 people for general classes of diseases, both for the population of Russia as a whole and for emergency workers. It is clear from Table 2 that morbidity rates among emergency workers in a series of cases repeatedly exceeded the analogous ones for the population of Russia. Undeniably, the levels, completeness and quality of prophylactic medical examination of emergency workers differ greatly from the usual Russian practice. In fact, the peculiarity of prophylactic medical examination of emergency workers is that for their examinations the most currently available methods of disease diagnosis are applied, and the work is carried out by trained and competent specialists. Thus, according to the data of the Medical Radiological Research Centre (MRRC) of RAMS the diagnosis of primary registered diseases by specialists at this institution is several times higher than by local physicians. In this situation it is very difficult to choose an adequate control group for comparison.

It is known that the social and psychological factors connected with the Chernobyl accident are of great importance as causes of pathology and morbidity among emergency workers. In combination with radiation effects, this can be defined as the "Chernobyl syndrome". Attempts to determine the significance of the role of radiation in this complex syndrome are very important. Therefore, morbidity and disability rates were estimated
Table 2
Prevalence of disease in the total population of Russia and in emergency workers in 1993 (per 100 000) and ratio of morbidity rates

<table>
<thead>
<tr>
<th>Classes of diseases - Classes de maladies</th>
<th>Population of Russia - Population russe (rate per 100,000)</th>
<th>Emergency workers - Personnel de secours (rate per 100,000)</th>
<th>Ratio of morbidity rates - Ratio des taux de morbidité</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neoplasms - Néoplasmes</td>
<td>788</td>
<td>747</td>
<td>0.9</td>
</tr>
<tr>
<td>Malignant neoplasms - Néoplasmes malins</td>
<td>140</td>
<td>233</td>
<td>1.6</td>
</tr>
<tr>
<td>Diseases of the endocrine system - Maladies du système endocrinien</td>
<td>327</td>
<td>6,036</td>
<td>18.4</td>
</tr>
<tr>
<td>Diseases of the blood and blood-forming organs - Maladies du sang et des organes sanguinoformateurs</td>
<td>94</td>
<td>339</td>
<td>3.6</td>
</tr>
<tr>
<td>Mental disorders - Maladies mentales</td>
<td>599</td>
<td>7,473</td>
<td>9.6</td>
</tr>
<tr>
<td>Diseases of the circulatory system - Maladies du système circulatoire</td>
<td>1,472</td>
<td>6,306</td>
<td>4.3</td>
</tr>
<tr>
<td>Diseases of the digestive system - Maladies du système digestif</td>
<td>2,635</td>
<td>9,739</td>
<td>3.7</td>
</tr>
<tr>
<td>All classes of diseases - Toutes classes de maladies</td>
<td>50,785</td>
<td>75,606</td>
<td>1.5</td>
</tr>
</tbody>
</table>

a For malignant neoplasms the standardized index for age distribution of emergency workers as of 1993 is given. - Pour les néoplasmes malins, on donne l’indice standardisé de la structure par âge du personnel de secours en 1993.

for the following groups – 0-5 cGy, 5-20 cGy, and over-20 cGy – based on dosimetric data for emergency workers included in the RNMDR. In this case, the contingents of emergency workers exposed in the range of 0-5 cGy were used as an interval control group. As is seen from Table 3, the morbidity rates for a series of diseases in the 5-20 cGy and over-20 cGy dose groups are significantly higher than those in the 0-5 cGy dose group. The over-20 cGy dose group consisted almost entirely (99.1%) of the 1986-1987 emergency workers. In the 5-20 cGy dose group, the emergency workers of 1986-1987 represent 91.2%. In the lowest-dose group (0-5 cGy) the emergency workers of 1986-

Table 3
Diseases among emergency workers in different dose groups in 1993: comparison of morbidity rates per 100,000 persons, Russia, 1995

<table>
<thead>
<tr>
<th>Classes of diseases - Classes de maladies</th>
<th>Dose groups - Groupes de dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5 cGy</td>
</tr>
<tr>
<td>Neoplasms - Néoplasmes</td>
<td>690</td>
</tr>
<tr>
<td>Malignant neoplasms - Néoplasmes malins</td>
<td>217</td>
</tr>
<tr>
<td>Diseases of the endocrine system - Maladies du système endocrinien</td>
<td>5,270</td>
</tr>
<tr>
<td>Diseases of the blood and blood-forming organs - Maladies du sang et des organes sanguinoformateurs</td>
<td>213</td>
</tr>
<tr>
<td>Mental disorders - Maladies mentales</td>
<td>5,178</td>
</tr>
<tr>
<td>Diseases of the circulatory system - Maladies du système circulatoire</td>
<td>5,287</td>
</tr>
<tr>
<td>Diseases of the digestive system - Maladies du système digestif</td>
<td>9,106</td>
</tr>
<tr>
<td>All classes of diseases - Toutes classes de maladies</td>
<td>69,831</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rates differ significantly (p < 0.001) from corresponding ones in the 0-5 cGy group. - La différence entre les taux est significative (p < 0.001) par rapport à ceux du groupe de dose 0-5 cGy.

<sup>b</sup> Rates differ significantly (p < 0.001) from corresponding ones in the 5-20 cGy dose group. - La différence entre les taux est significative (p < 0.001) par rapport à ceux du groupe de dose 5-20 cGy.
Ten years have elapsed since the Chernobyl accident. The gravest technologically generated accident throughout human history has attracted considerable attention from the whole world community. At the same time, the problem of estimating the total damage to life and health of people exposed to radiation remains very complicated (4, 5). The negative effects of Chernobyl include a spectrum of factors which may reinforce each other. In particular, to date there are no theoretical models or practical recommendations on estimating the contribution of the social, psychological or emotional factors that surround diseases due to radiation accidents. On the other hand, for maximum effective rehabilitation of the affected population, the impartial determination of the contribution by both radiation and non-radiation components is necessary. Therefore, the continuation of long-standing investigations within the framework of the National Radiation and Epidemiological Registry along with obtaining new scientific data in the field of radiation epidemiology is of great practical importance in limiting the health consequences of the accident.

Résumé

L'accident de Tchernobyl et les risques de rayonnements: évolution des taux épidémiologiques (taux de morbidité, d'incapacité et de décès) en fonction des données figurant dans le registre national

Dix années se sont écoulées depuis l'accident de Tchernobyl. L'accident technologique le plus grave de l'histoire de l'humanité a attiré l'attention de toute la communauté mondiale au plus haut point. Pourtant, les problèmes relatifs à l'estimation de l'ensemble des dégâts occasionnés à la vie et à la santé des personnes exposées aux rayonnements demeurent très compliqués (4, 5). Les conséquences désastreuses de Tchernobyl comprennent une variété de facteurs qui risquent de se renforcer mutuellement. En particulier, il n'existe à ce jour ni modèle théorique ni recommandations pratiques sur l'estimation de la contribution des facteurs sociaux, psychologiques ou affectifs aux maladies dues à des accidents radiologiques. D'autre part, en vue d'une réadaptation des malades la plus efficace possible, il importe de déterminer de manière objective à la fois la contribution des rayonnements proprement dits...
et celle des éléments autres que les rayonnements. La poursuite d'enquêtes de longue durée dans le cadre du registre radiologique et épidémiologique national et l'obtention de nouvelles données scientifiques dans le domaine de l'épidémiologie des rayonnements revêtent par conséquent une grande importance sur le plan pratique pour limiter les conséquences sanitaires de l'accident.

References/Références