Anhang 2

Comparison of the time-integrated thyroid activities for different age-gender groups estimated in the first and second levels of thyroid dose estimation.

Statistical properties of their distributions.

COMPARISON OF THE TIME-INTEGRATED THYROID ACTIVITIES FOR DIFFERENT AGE-GENDER GROUPS ESTIMATED IN THE FIRST AND SECOND LEVELS OF THYROID DOSE ESTIMATION. STATISTICAL PROPERTIES OF THEIR DISTRIBUTIONS.

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1. The overall system of thyroid dose reconstruction for the entire population of Ukrainian children aged 0 to 18 at the time of the accident can be presented according to a three-level system of thyroid dose estimation:

- at the first level, instrumentally-individualized doses to the thyroid are calculated for all persons with direct thyroid measurements; a distinction is made between two categories: (1) the individuals whose residence histories and dietary habits were obtained by means of personal interviews; and (2) the individuals for whom residence history and dietary habits were assumed on the basis of information for the population in the same area of residence at the time of the accident;
- at the second level of the system of dose estimation, age-gender group-average doses to the thyroid are estimated for the population that resided at the time of the accident in the settlements where direct thyroid measurements were carried out; and
- at the third level of the system of dose estimation, age-gender group-average doses to the thyroid are estimated for the population that resided at the time of the accident in the settlements where no direct thyroid measurements were carried out.

The degree of precision of the thyroid dose estimates decreases from the first to the third level in the system of dose estimation. Doses of the first and second levels, which are mainly based on the results of direct thyroid measurements can be used in the dose-responds -analysis.

2. The instrumentally-individualized time-integrated thyroid activities, $A_{k,a,s,j}$, for the individual *k* of age *a*, gender *s* measured in settlement *j*, were estimated on the basis of the results of the direct thyroid measurements in the framework of the first level of thyroid dosimetry.

The values of the time-integrated activities $\tilde{A}_{a,s,j}$ of the second level is calculated as: $\tilde{A}_{a,s,j} = \tilde{A}_{a_{ref},s,j} \cdot f_{a,s}$, where $\tilde{A}_{a_{ref},s,j}$ is the settlement-specific time-integrated thyroidal ^{131}I activity for the gender *s* and reference age-interval a_{ref} in the settlement *j*, $f_{a,s}$ is the relative age-gender functions of time-integrated activity for different age-gender groups.

The comparison of two sets of results which are the instrumentally-individualized time-integrated thyroid activities of the first level, $A_{k,a,s,j}$, and time-integrated activities of the second level, $\tilde{A}_{a,s,j}$, estimated for the same settlement are compared in Fig. 1. Examples are given for some rural settlements with different numbers of thyroid measurements, for some urban settlements, and for the large cities of Kyiv, Chernihiv, and Zhytomyr. Given results demonstrate good coincidence the first and second levels' estimation.

3. An analysis of the distributions of the measured thyroid activities, $(\tilde{Q}_{k,a,s,j})_t$, taken in the

same day *t*, among the *k* subjects of the same age-gender *"a-s"* group of the settlement *j* is shown in Fig. 2. An analysis of the instrumentally-individualized time-integrated thyroid activities, $A_{k,a,s,j}$ for different age-gender groups in the same settlement are shown in Fig. 3. The types of distribution were tested according to Lilliefors test. The results given in Figures 2 and 3 showed that in most settlements these distributions are lognormal.

4. Because epidemiologists often use the arithmetic means of the distributions of the dose in their analyses, the arithmetic and the geometric means were compared for the samples of measured thyroid activities, $(\widetilde{Q}_{k,a,s,j})_t$, made on the same day *t* for children of the same age and gender in the same settlement *j*. Average values of ratios between arithmetic and geometric means, $mean[\frac{ArM(\widetilde{Q}_{k,a,s,j})_t}{GM(\widetilde{Q}_{k,a,s,j})_t}]$, for different ages and the overall average are shown in Table 1. The ratios of the arithmetic mean and of the geometric mean are greater than one in all samples, with values in the narrow range from 1.35 to 1.53.

5. Ratios between arithmetic and geometric means for instrumentally-individualized time-integrated thyroid activities $A_{k,a,s,j}$ were also calculated for people of the same gender, age, and same settlement *j*. Values of these ratios averaged over all settlements $N_{a,s}$ where direct thyroid measurements were made are shown in Table 2 and calculated in according to eq.(1)::

$$mean[\frac{ArM(A_{a,s,j})}{GM(A_{a,s,j})}] = \frac{1}{N_{a,s}}(\sum_{j=1}^{Na,s}\frac{ArM(A_{k,a,s,j})}{GM(A_{k,a,s,j})}) \quad (1)$$

The values of $mean[\frac{ArM(A_{a,s,j})}{GM(A_{a,s,j})}]$ are in a narrow range from 1.28 to 1.61 for boys and girls of all age groups.

6. A comparison of the results obtained for assessments in the first and second levels of thyroid dose estimation is presented in Table 3. The ratios between the arithmetic (and geometric) means of the instrumentally-individualized integral thyroid activities $A_{k,a,s,j}$ and the values of time-integrated activities $\widetilde{A}_{a,s,j}$ for the same age-gender group "a-s' in the settlement *j*, are shown in Table 3 for all age-gender groups. These ratios are averaged over all $N_{a,s}$ settlements where direct thyroid measurements were made in the age and gender group considered and calculated in according to eqs. (2) and (3):

$$mean[\frac{ArM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}] = \frac{1}{N_{a,s}}[\sum_{j=1}^{Na,s}\frac{ArM(A_{k,a,s,j})}{\widetilde{A}_{a,s,j}}] \quad (2)$$

$$mean[\frac{GM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}] = \frac{1}{N_{a,s}}[\sum_{j=1}^{Na,s}\frac{GM(A_{k,a,s,j})}{\widetilde{A}_{a,s,j}}] \quad (3)$$

It is seen in Table 3 that for all age-gender groups the geometric means of the instrumentally-individualized time-integrated thyroid activities $A_{k,a,s,j}$ are very close to the calculated values of $\widetilde{A}_{a,s,j}$, while the arithmetic means are substantially greater.

Therefore, on average, the group-averaged assessments of the thyroid doses of the second level $\widetilde{D}_{a,s,j}$, obtained for any age-gender *a*-*s* group from any settlement *j*, are very close to the geometric means of the instrumentally-individualized doses obtained for the same age gender group from the same settlement. Assuming that the distributions of the estimated thyroid doses of the second level are lognormal, the arithmetic means and standard deviations of those distributions can easily be derived from the geometric means and estimated geometric standard deviations.

Table 1

Average age specific ratios of the arithmetic to geometric means of the measured thyroid activities $(\tilde{Q}_{k,a,s,j})_t$ averaged over the sets of measurements taken in 1986 in the same settlement *j*, on the same day *t* and for the same age and gender group (only sets with more than 10 measurements have been considered); the rations were computed separately for boys and girls of each age group, and then were combined

Age	*Number of sets of measurements*	*Number of measurements*	$mean[\frac{ArM(\tilde{Q}_{k,a,s,j})_t}{GM(\tilde{Q}_{k,a,s,j})_t}]$
1	35	742	1.53
2	47	1,066	1.52
3	61	1,343	1.48
4	59	1,282	1.45
5	61	1,254	1.46
6	70	1,611	1.39
7	85	1,702	1.37
8	138	3,533	1.39
9	131	3,692	1.39
10	149	4,116	1.35
11	154	4,539	1.36
12	149	4,499	1.36
13	168	4,726	1.38
14	163	4,570	1.37
15	125	2,655	1.39
16	68	1,269	1.43
17	54	905	1.35
18	4	43	1.39
1-18	1721	43,547	1.39

Table 2

Ratios of the arithmetic to geometric means of instrumentally individualized time-integrated activities for the age and gender groups in the settlement *j* averaged over the settlements with direct thyroid measurements: $mean\left[\frac{ArM(A_{a,s,j})}{GM(A_{a,s,j})}\right]$; *M* is males, *F* is females.

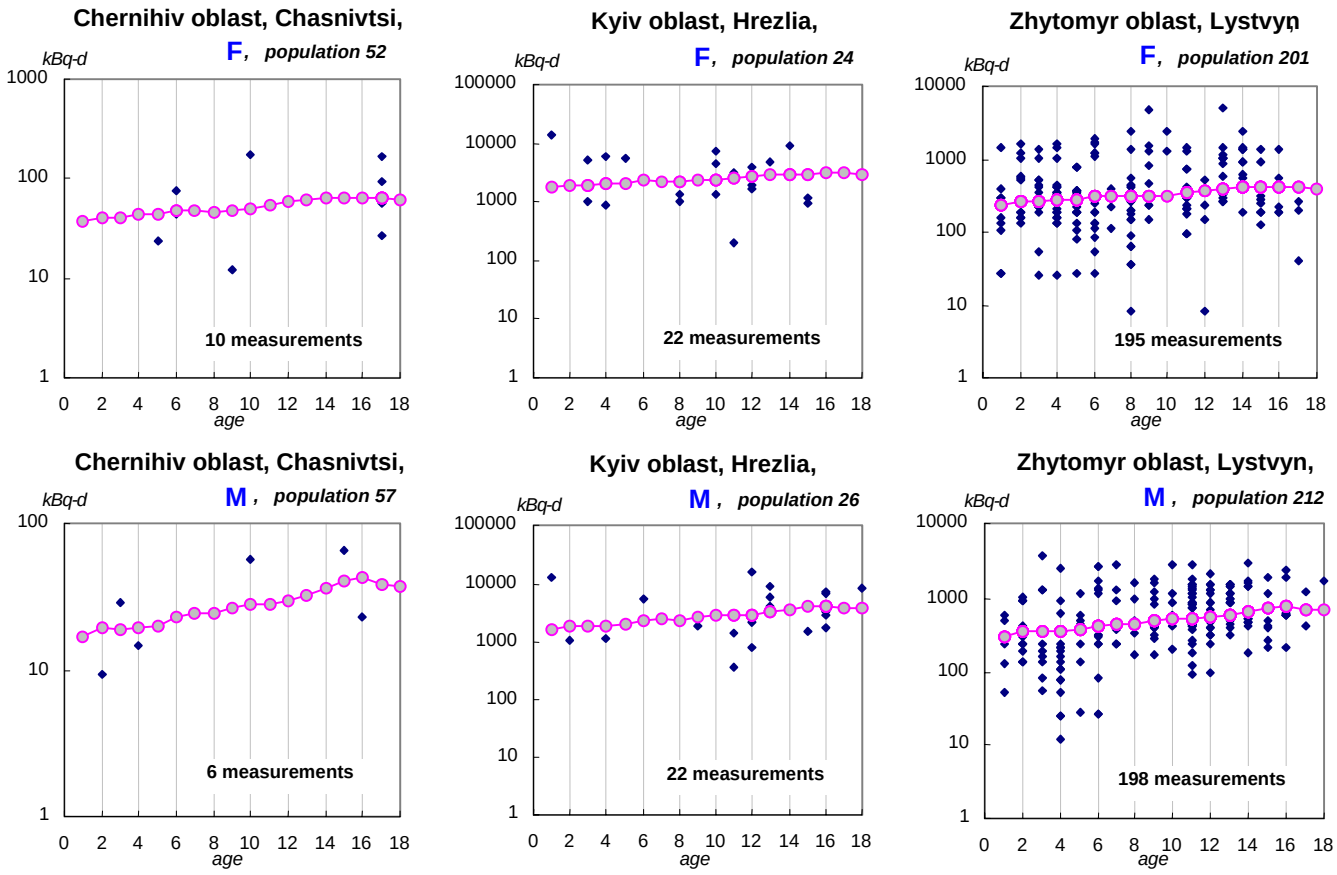
Age group	*Number of settlements*		*Number of instrumentally individualized activities*		$mean\left[\frac{ArM(A_{a,s,j})}{GM(A_{a,s,j})}\right]$	
	M	*F*	*M*	*F*	*M*	*F*
1	68	71	844	848	1.61	1.60
2	78	76	1,033	1,033	1.50	1.44
3	84	86	1,140	1,231	1.47	1.38
4	69	85	1,091	1,151	1.46	1.34
5	74	70	1,116	1,011	1.36	1.36
6	76	73	1,254	1,245	1.42	1.36
7	87	91	1,370	1,412	1.31	1.31
8	126	142	2,453	2,425	1.30	1.34
9	133	128	2,579	2,481	1.32	1.32
10	141	142	2,811	2,712	1.29	1.32
11	152	157	2,990	3,051	1.30	1.28
12	155	146	3,036	3,013	1.33	1.28
13	172	160	3,200	3,086	1.36	1.29
14	168	171	3,242	3,065	1.40	1.30
15	144	147	2,041	2,163	1.36	1.34
16	79	85	1,048	1,180	1.40	1.33
17	55	69	748	847	1.30	1.36
18	15	16	119	138	1.34	1.55
1-18			32,115	32,092		

Table 3

Comparison of the thyroid dose estimations of the first and second levels made for the same settlement:

$mean\left[\frac{ArM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}\right]$ and $mean\left[\frac{GM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}\right]$ are the ratios of arithmetic (geometric) means of instrumentally individualized time-integrated activities. The means are averaged over all settlements with direct measurements; *M* is males, *F* is females.

Age group	*M*		*F*	
	$mean\left[\frac{ArM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}\right]$	$mean\left[\frac{GM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}\right]$	$mean\left[\frac{ArM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}\right]$	$mean\left[\frac{GM(A_{a,s,j})}{\widetilde{A}_{a,s,j}}\right]$
1	1.75	1.13	1.86	1.18
2	1.74	1.14	1.60	1.11
3	1.54	1.08	1.45	1.04
4	1.53	1.09	1.41	1.05
5	1.45	1.06	1.50	1.13
6	1.47	1.04	1.32	0.98
7	1.33	1.02	1.35	1.02
8	1.34	1.04	1.36	1.03
9	1.34	1.03	1.37	1.05
10	1.39	1.08	1.38	1.05
11	1.36	1.05	1.31	1.02
12	1.38	1.04	1.31	1.03
13	1.41	1.04	1.39	1.07
14	1.50	1.07	1.37	1.05
15	1.41	1.04	1.44	1.07
16	1.66	1.16	1.44	1.07
17	1.49	1.14	1.46	1.08
18	1.77	1.28	1.64	1.11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age
Kyiv oblast, Hrezlia,
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kBq-d
22 measurements
age
Zhytomyr oblast, Lystvyn
F, population 201
kBq-d
195 measurements
age
Chernihiv oblast, Chasnivtsi,
M, population 57
kBq-d
6 measurements
age
Kyiv oblast, Hrezlia,
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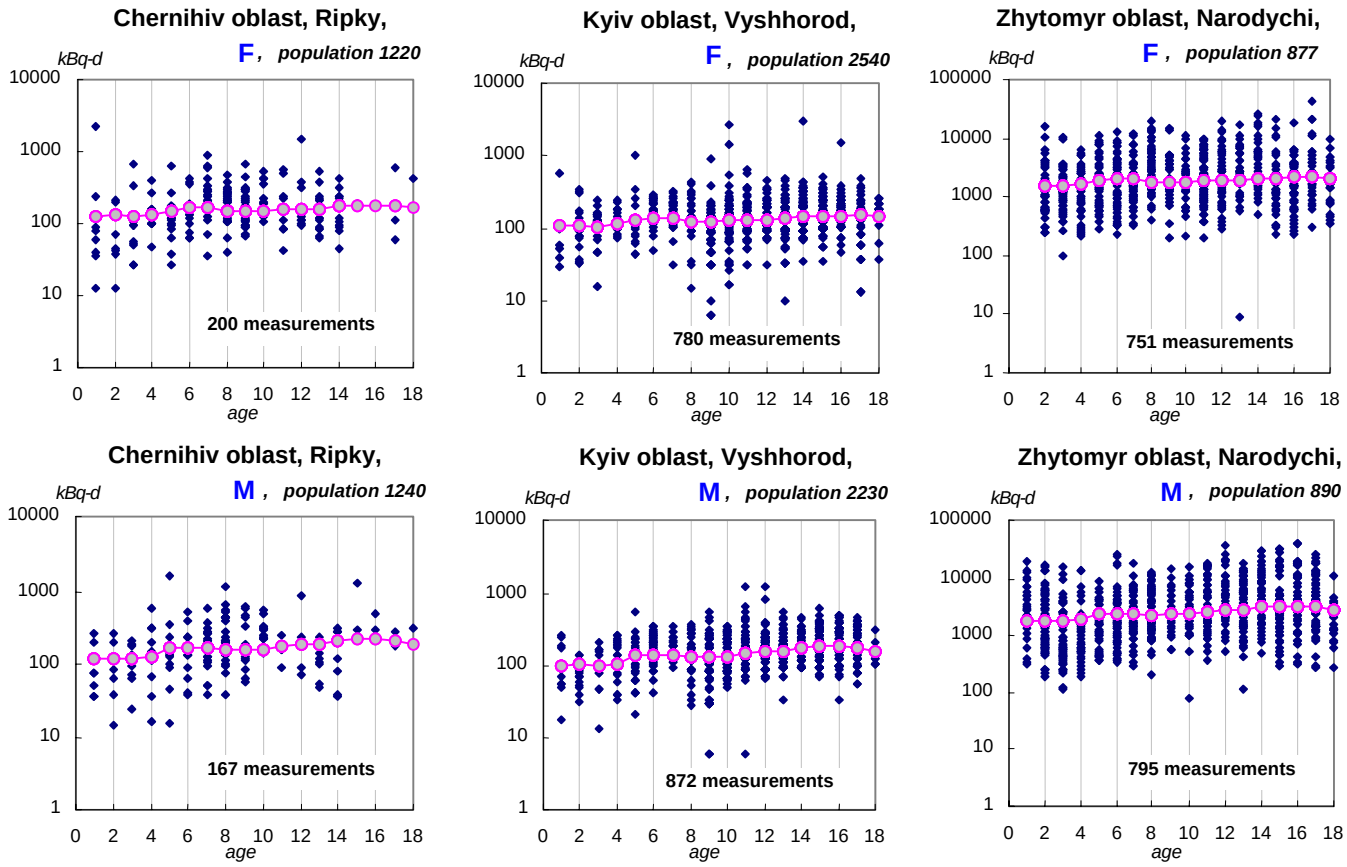
198 measurements
age

a)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age
Zhytomyr oblast, Narodychi,
F, population 877
kBq-d
751 measurements
age
Chernihiv oblast, Ripky,
M, population 1240
kBq-d
167 measurements
age
Kyiv oblast, Vyshhorod,
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Zhytomyr oblast, Narodychi,
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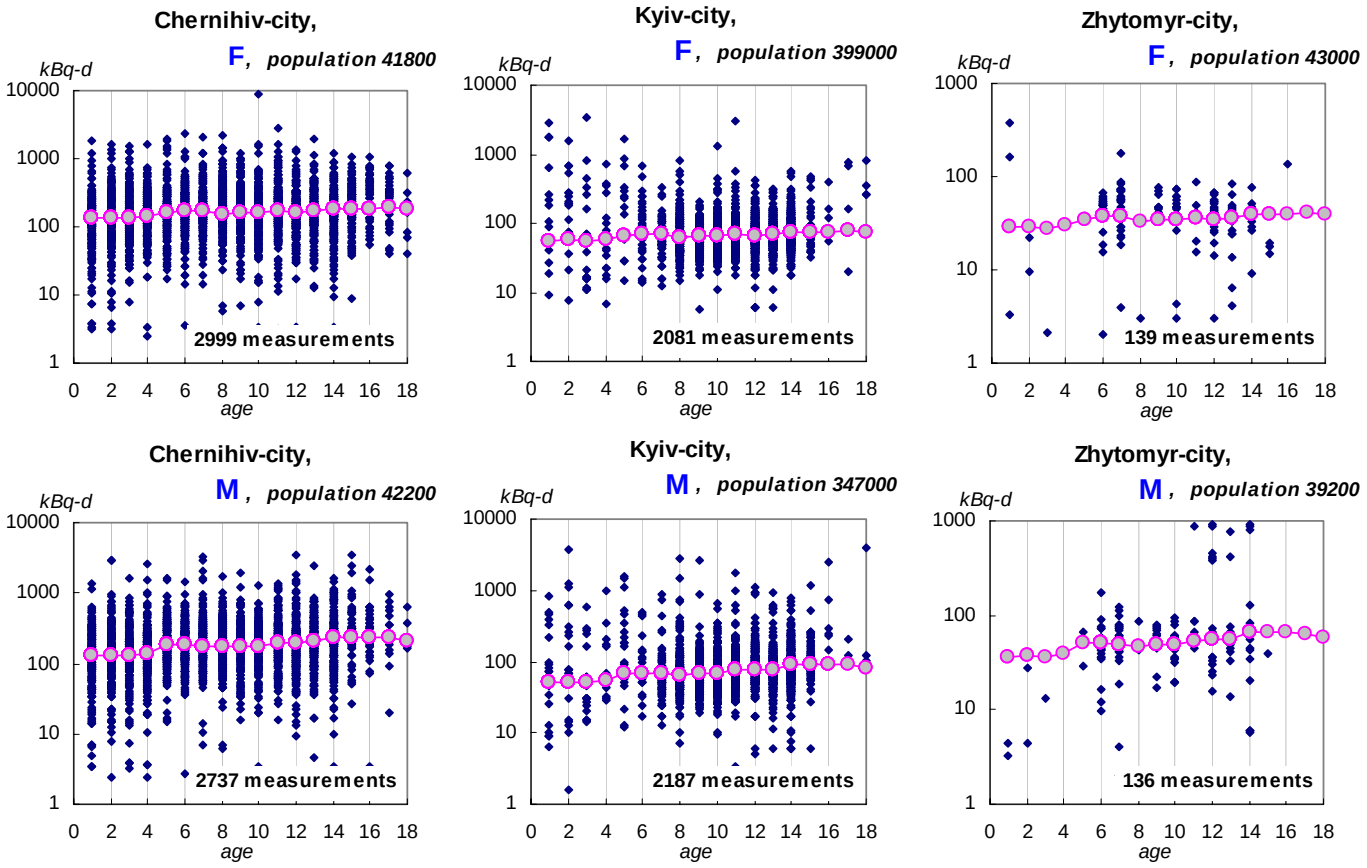
795 measurements
age

b)



(c)

Fig. 1Examples of time-integrated thyroid activities $A_{k,a,s,j}$ estimated based on the results of direct thyroid measurements (dark points) and of time-integrated activities $\tilde{A}_{a,s,j}$ estimated using the relative age-gender functions of time-integrated activity, $f_{a,s}$ for different age-gender groups of the same settlements (closed circles). *M is male, F is female; a) rural settlements; b) small towns; c) Chernihiv, Zhytomyr, and Kyiv cities.*

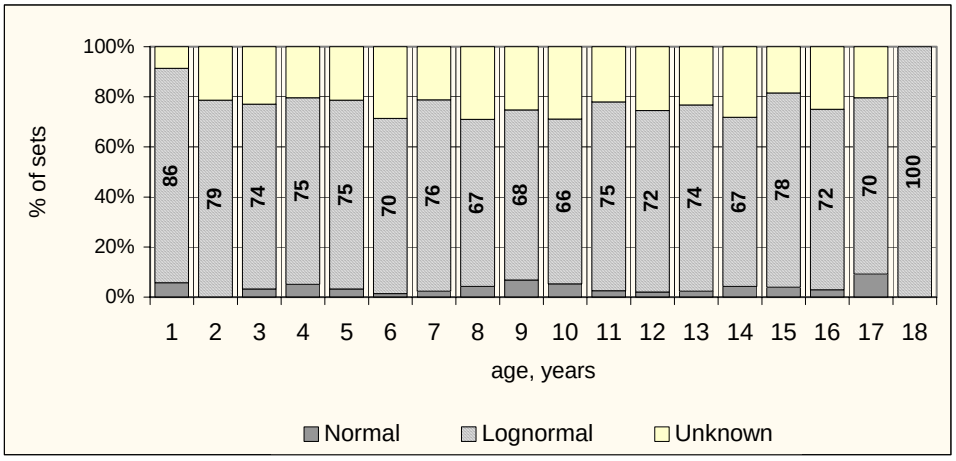
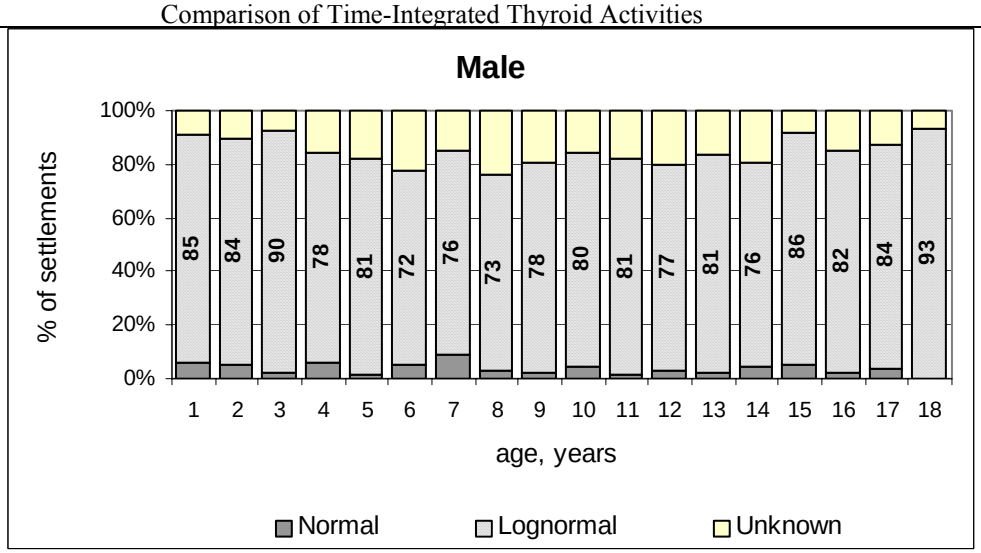
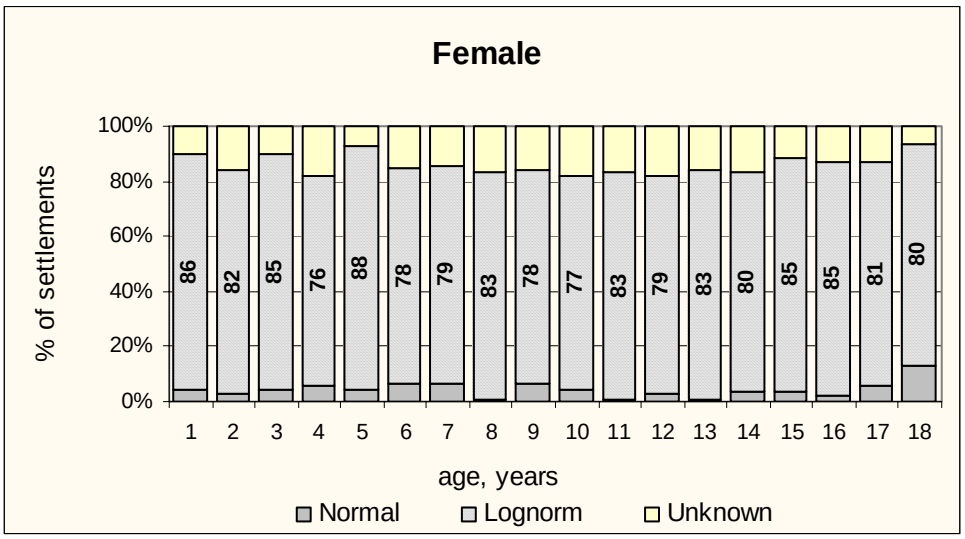


Fig. 2. Percentages of different types of distribution among the 1,721 sets of 43,547 thyroid activities $(\tilde{Q}_{k,a,s,j})_t$ measured for different age groups *"a-s"*. Each set includes at least ten thyroid activities ($k \geq 10$) measured on the same day t for children of the same age and gender in the same settlement j. Details are given in Table A4.1

Normal and *Lognormal* are the normal and lognormal distributions, respectively. *Unknown* refers to a distribution that is neither normal nor lognormal according to Lilliieforts test



(a)



(b)

Fig. 3 Percentages of different types of distribution among the sets of instrumentally-individualized time-integrated activities for different age-groups of male and female. Each set includes at least ten instrumentally-individualized time-integrated activities $A_{k,a,s,j}$ ($k \geq 10$) for children of the same age and gender *"a-s"* in the same settlement *j*

Normal and *Lognormal* are the normal and lognormal distributions, respectively. *Unknown* is the distribution that is neither normal not lognormal according to Lilliieforts test

(a) Males: 1,876 groups, 32,115 instrumentally-individualized time-integrated activities
(b) Females: 1,915 groups, 32,092 instrumentally-individualized time-integrated activities