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ORIGINAL PAPERS

SELECTED ASPECTS OF THE POPULATION HEALTH STATUS IN ECOLOGICAL HAZARD AREAS IN COMPARISON WITH ECOLOGICALLY "CLEAN" AREA. II. ASSESSMENT OF SPATIAL DISTRIBUTION OF MORTALITY

TADEUSZ DUTKIEWICZ, CZESŁAW ANDRYSZEK, JERZY KOŃCZALIK and DARIUSZ RACHAŃSKI

Department of Environmental Health Hazards
The Nofer Institute of Occupational Medicine
Lodz, Poland

Key words: Distribution of territorial mortality from all diseases and diseases of the cardiovascular system.

Abstract: On the basis of age adjusted rates of mortality from all diseases and from diseases of the circulatory system in female and male populations living in ecological hazard areas and in ecologically "clean" area, the distributions of the rate values were assessed. In the regions under consideration, urban and rural regions were distinguished. The goodness of fit of the empirical distribution to the normal one was assessed using the following statistical parameters: arithmetic mean, mode, median, standard deviation, coefficient of variation, coefficient of asymmetry, difference between the third and the first quartiles, as well as the Chi^2 and λ–Kolmogorow-Smirnow tests, maximum difference between cumulative distribution functions and standard deviation of differences between empirical and theoretical frequencies.

A differentiation in the mean values of age adjusted rates of mortality from both groups of diseases in ecological hazard areas and in "clean" area was indicated particularly in urban female and male populations.

INTRODUCTION

It is generally considered that the mortality rate is an essential measure of population health status (10) which reflects morbidity from diseases which are primary causes of death. The mortality pattern indicates that over 75% of deaths are caused by the three main groups of diseases, the so called civilization-related diseases

Address reprint requests to prof. T. Dutkiewicz, Department of Environmental Health Hazards, The Nofer Institute of Occupational Medicine, P.O. Box 199, 90-950 Lodz, Poland.

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(diseases of the circulatory system, neoplasms and injury, and poisoning) mostly associated with environmental factors. It can therefore be assumed that the spatial variability of mortality should depend on the differential effects of harmful factors in the natural environment.

In Poland from the mid-sixties until the eighties a continuous upward tendency in mortality rates had been observed. As stressed by Okólski (13) and also by Kędelski (9, 10), an unfavourable (positive) trend applied to Poland. Hungary and to the former Soviet Union.

In the majority of Western countries a downward tendency in mortality rates was noted during that period. In Governmental Demographic Commission Reports (4) as well as in the publications of Andryszek and co. (1, 2, 3) it is stressed that the highest mortality rates, particularly in males are observed in the highly urbanised and industrialised regions of the country where people are usually exposed to ecological hazards.

Vierlose (16) specifies five voivodships (administrative regions) of the highest male mortality rates, namely: Katowice, Wałbrzych, Elbląg, Łódź and Jelenia Góra. He also stresses that a higher male mortality is accompanied with higher female mortality rates.

Higher mortality in ecological hazard areas (EHAs) was also confirmed by other authors (3) who indicated in their studies on the causes of excess mortality in males of a working age, that the voivodships of highest mortality from diseases of the circulatory system (DCS) are concentrated in the western regions of the country. Another group of authors (6), when analysing the mortality dynamic from DCS during the years 1975–1985, indicated that the increase in mortality from these diseases was much higher in males than in females and that the highest rate was observed in the male 50–59 age group. Following the differentiation from an average life-span as a synthetic index of health status, in individual voivodships, Andryszek (1) revealed that the lowest values of this index were found in Katowice, Wałbrzych, Łódź, Jelenia Góra and Szczecin voivodships, that is in regions of ecological hazard.

OBJECTIVES OF THE STUDY AND COMMENTS ON THE METHODOLOGY

The main objective of this study was to asses mortality distributions from all diseases and mortality from diseases of the circulatory system in regions of ecological hazard in comparison with ecologically "clean" reference area.

A detailed analysis of the health effects in population living in an EHAs was presented in a separate paper (5). However, it is worth recalling here that an urban region or its district and a rural region were adopted as the basic units for the analysis and that data registered in the database applied to the year 1989. A direct method was used for the age adjustment of relevant mortality rates. The rate of mortality from diseases (the general mortality rate excluding external deaths – injuries and poisonings) was used in the analysis.

A BRIEF SUMMARY OF MORTALITY IN POLAND

General mortality after the World War II

Four periods can be distinguished in the mortality dynamic after the W.W.II. During the first year after the war (1946) – the mortality rate was equal to 10.2 per 1 000 total population. The starvation of the nation which took place in the aftermath of the war as well as extremely difficult living conditions increased the mortality rate to 12.4 per 1 000 total population in 1951. That was the highest rate observed during the whole post-war period. The trend in the period takes the following equation:

$$y = 0.362\ t + 693 \text{ (Fig. 1)}$$

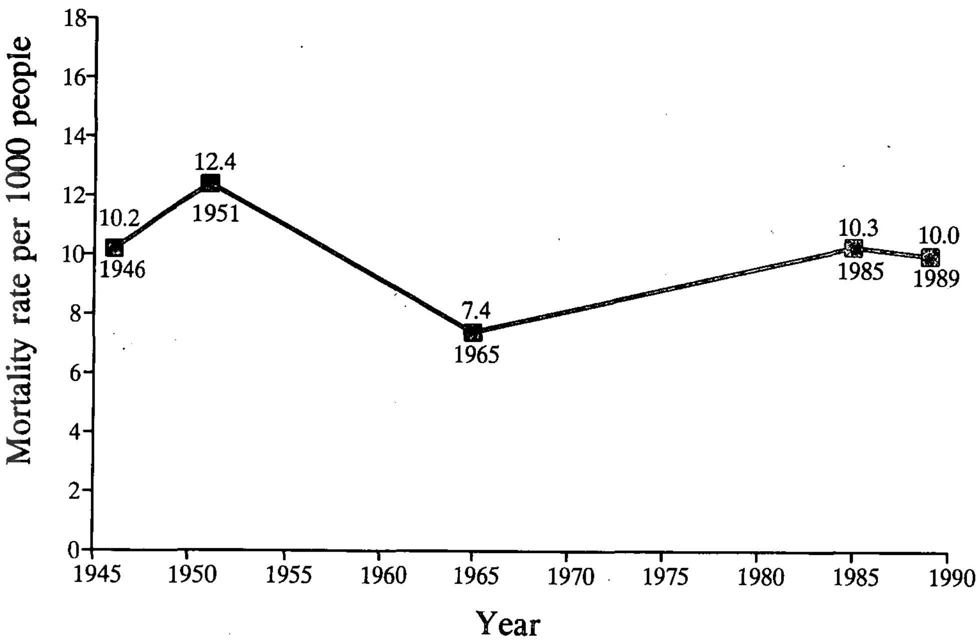

Fig. 1. General mortality in Poland after the World War II. Trends in time intervals.

During the next period until 1966 a downward tendency with the minimum level of 7.3, expressed by the following equation, was observed:

$$y = -0.322\ t + 638.8$$

The average dynamic of decrease was similar to the average increase observed during the years 1946–1951. From 1966 to 1985 a slow but systematic upward tendency was observed according to the equation given below:

$$y = 0.133\ t - 254.1.$$

During the second half of the eighties a stable mortality rate at the level of the post-war period was noted. On average 10 persons per each 1 000 of population died annually during these last years.

Mortality from diseases of the circulatory system (DCS) in Poland in comparison with other European countries (6)

In Poland diseases of the circulatory system cause 50% of all deaths. In recent years the rate has even exceeded this level. At the beginning of the seventies the mortality dynamic from DCS slightly exceeded the average European rate. While in the majority of European countries an impressive downward tendency has been observed since 1973, in Poland the opposite tendency has been noted (Fig. 2). In consequence, in 1987 mortality from DCS exceeded the average European mortality rate by 50.6% in males and by 44.3% in females. Hence, in the list of European countries, Poland takes fifth place after Bulgaria, Romania, the former USSR and Hungary in male mortality and the eighth in female mortality. Higher rates are found only in the former Yugoslavia, DDR and Czechoslovakia. As far as female mortality is concerned Poland is left behind Romania, Bulgaria, the former USSR, Hungary, the former DDR and Czechoslovakia.

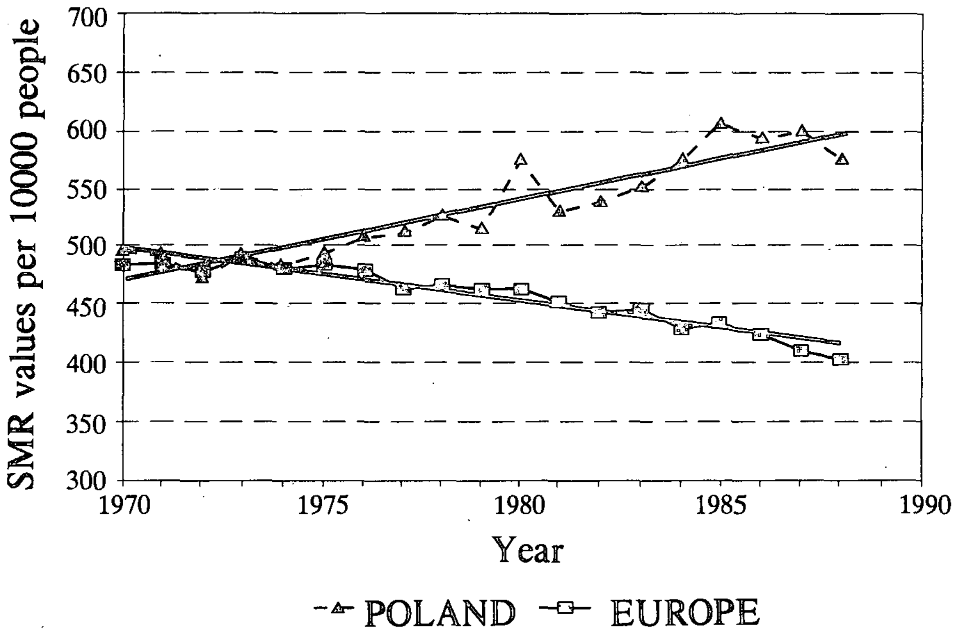

Fig. 2. Mortality dynamic from diseases of the circulatory system in Poland and in Europe.

THE RESULTS OF THE ANALYSIS OF THE SPATIAL MORTALITY DISTRIBUTION

As indicated in Table 1 and Fig. 3, the mortality distribution from all diseases in an EHAs is highly compatible with the normal distribution. Despite the fact that the Chi^2 statistics exceed critical values at the level of significance $\alpha = 0.01$ because of large number of units under study, the λ Kolmogorow-Smirnow test does not provide evidence for rejecting the hypothesis on the normal distribution. Parameters based on the differences in relative numbers also show high compatibility: a maximum difference of fraction at the level of 0.05 and a standard deviation of differences in relative numbers below 0.05. However, the distribution shows a high degree of

Table 1. Assessment of mortality rates distribution character from all diseases in EHAs and outside EHAs

Classes of mortality rates	EHAs		Outside EHAs	
	P_{emp}	P_{theor}	P_{emp}	P_{theor}
to 56.8	0.02	0.01	0.01	0.01
56.8–64.9	0.02	0.02	0.02	0.02
64.9–73.0	0.03	0.05	0.04	0.02
73.0–81.0	0.08	0.10	0.11	0.11
81.0–89.1	0.17	0.16	0.18	0.17
89.1–97.2	0.24	0.19	0.23	0.19
97.2–105.2	0.20	0.18	0.20	0.18
105.2–113.3	0.13	0.14	0.11	0.13
113.3–121.4	0.05	0.08	0.05	0.08
121.4–129.5	0.02	0.04	0.02	0.03
over 129.5	0.03	0.03	0.03	0.02
Number of observed units	409		2558	
$\varkappa^2$ – statistics of Chi^2 test	22.74		88.87	
P; P_{emp}; P_{theor} – probability empirical and theoretical probability	$P < 0.01$		$P < 0.01$	
D_{max} – maximum difference between cumulative distribution function	0.05		0.05	
KS; p – λ Kolmogorow-Smirnow test: probability	0.94 $p > 0.05$		2.33 $p > 0.05$	
S – standard deviation of differences between empirical and theoretical frequencies	0.02		0.02	
R^2 – coefficient of determination	0.86		0.93	

symmetry in urban and rural regions outside EHAs which is characterised by rather high values of kurtosis as compared with the normal distribution estimated on the basis of the empirical distribution parameters. Differences between comparable distributions are statistically significant mainly because of the very large number of analysed units, although the maximum difference of fractions and the deviation of fraction differences are at the same level.

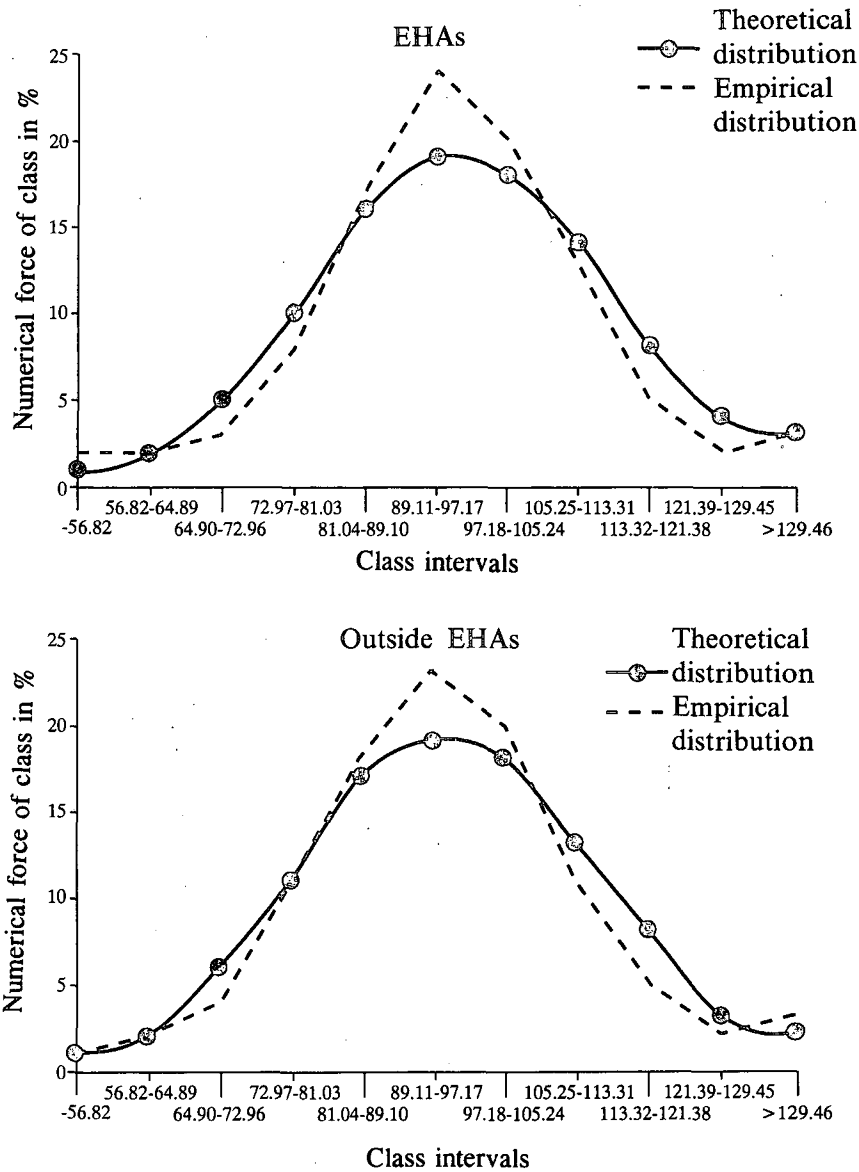

Fig. 3. Goodness of fit for mortality distribution from all diseases in and outside EHAs in Poland in 1989.

Mortality from diseases (Table 2 and Fig. 4) is higher in urban an rural regions of EHAs regions in comparison with the reference area (5). An average mortality in males living in urban regions of EHAs is higher by 12% than the average rate in reference area. Among females, the difference is even higher – by 18%. Particularly high differences are observed at the level of the first quartile. Among males the first quartile is higher by 14% in EHAs while among females it is much higher – 34.4%. In rural areas differences are very small.

Table 2. Statistical parameters for assessment of mortality distribution from all diseases in EHAs in comparision with analogical distribution in "clean" reference area

Statistical parameters	Males				Females			
	Urban regions		Rural regions		Urban regions		Rural regions	
	EHAs	clean	EHAs	clean	EHAs	clean	EHAs	clean
n – number of observed units	178	76	231	327	178	76	231	327
X – arithmetic mean	139.2	109.0	67.5	118.1	76.5	66.1	69.6	71.8
δ – standard deviation	35.6	22.4	53.1	26.2	15.1	19.0	16.8	13.4
V% – coefficient of variability	25.6	20.5	78.7	22.2	19.7	28.7	24.1	18.7
Me – median	126.5	122.5	121.1	114.3	76.9	68.6	70.9	70.7
Q_1-Q_3 – range between the third and first quartile	22.5	30.7	23.1	20.8	13.9	63.3	14.0	21.2
Mo – model	129.5	129.4	129.4	129.5	77.7	69.7	70.3	62.3
A_1 – coefficient of asymmetry	0.27	−0.91	−1.27	−0.44	−0.08	−0.19	−0.04	0.71

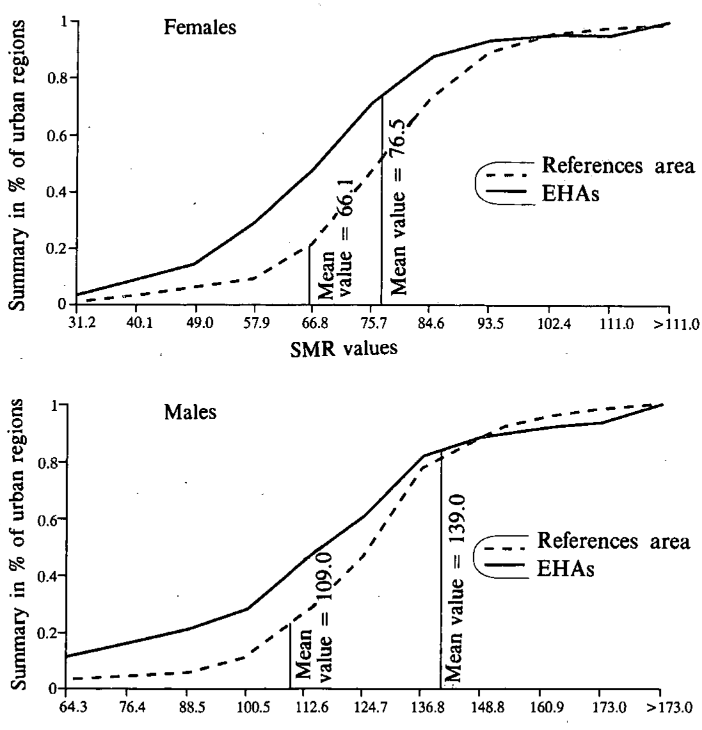

Fig. 4. Comparative probability of the distribution function values of mortality from all diseases, SMR in urban regions of EHAs and reference area in Poland in 1989.

Distribution of mortality from diseases of the circulatory system

As shown above, diseases of the circulatory system are the cause of over 55 per cent of all deaths in males. In females this figure reaches 58% (Table 3). The

Table 3. Mortality from DCS in EHAs as percentage of total mortality from all diseases

Statistical parameters	Males				Females			
	Urban regions		Rural regions		Urban regions		Rural regions	
	EHAs	clean	EHAs	clean	EHAs	clean	EHAs	clean
$\bar{X}$	54.5	54.2	52.3	51.2	57.9	53.8	54.2	58.1
Me	53.6	52.0	52.0	52.0	57.5	58.3	57.3	57.7
Q_1	64.0	65.3	45.2	45.1	54.1	57.9	42.5	42.4
Q_3	57.8	50.9	52.1	50.9	52.2	56.7	42.5	56.2
Mo	51.7	50.1	54.8	55.4	56.0	51.6	56.3	52.7

distribution of DCS mortality rates is favourably compatible with a normal distribution (Table 4). A higher level of goodness of fit was obtained in EHAs. The λ Kolmogorow-Smirnow test does not provide any evidence for rejecting the hypothesis on the goodnes of fit distribution at a maximum difference of the cumulative distribution function and a standard deviation of differences in empirical and technical distributions equal to 2%.

Table 4. Assessment of mortality rates distribution character from DCS in EHAs and outside EHAs

Classes of mortality rates	EHAs		Outside EHAs	
	P_{emp}	P_{theor}	P_{emp}	P_{thor}
to 19.8	0.01	0	0.01	0.01
19.8 – 26.4	0.02	0.01	0.02	0.02
26.9 – 33.0	0.03	0.04	0.05	0.05
33.0 – 39.6	0.07	0.09	0.11	0.11
39.6 – 46.2	0.15	0.16	0.17	0.16
46.2 – 52.8	0.21	0.21	0.21	0.20
52.8 – 59.4	0.14	0.20	0.20	0.18
59.4 – 66.0	0.06	0.15	0.12	0.14
66.0 – 72.6	0.04	0.08	0.06	0.08
72.6 – 79.2	0.01	0.03	0.03	0.03
over 79.2	0	0.01	0.03	0.02
Number of observed units	409		2 558	
χ^2	15.68		34.65	
P	$P < 0.01$		$P < 0.001$	
D_{max}	0.05		0.05	
KS; p	0.94 $p > 0.05$		2.33 $p > 0.05$	
S	0.02		0.02	
R^2	0.86		0.93	

The distribution of mortality from DCS in urban and rural areas outside EHA also indicates a high level of agreement with the normal distribution.

Among males an average mortality rate in EHAs urban regions is equal to 68 per 10 000 and is higher by 13% than in ecologically "clean" area (Table 5). In rural regions differences are smaller (by 6%). Among females an average rate in EHAs urban regions reaches 44.4 and this is higher by 14.4% than in relative risk (RR) of mortality urban regions.

Table 5. Statistical parameters for distribution assessment of mortality from DCS in EHAs in comparision with analogical distribution in "clean" reference area

Statistical parameters	Males				Females			
	Urban regions		Rural regions		Urban regions		Rural regions	
	EHAs	clean	EHAs	clean	EHAs	clean	EHAs	clean
n	177	76	231	327	176	76	231	327
$\bar{X}$	68.5	63.0	66.9	58.5	43.6	38.1	41.3	41.1
δ	16.7	22.8	25.2	16.3	11.7	14.3	12.7	12.4
V%	24.4	36.2	37.7	27.8	26.7	37.6	30.8	30.2
Me	67.1	62.9	61.8	59.1	44.2	39.0	41.7	40.3
$Q_1 - Q_3$	16.4	17.5	21.4	14.7	11.0	16.3	16.6	15.8
Mo	79.2	65.2	79.2	61.3	43.9	39.6	43.4	39.6
A_1	−0.64	−0.10	−0.48	−0.17	−0.03	−0.10	−0.16	0.12

The smallest differences of rates under study are found in males living in EHAs urban regions (V = 23.3%) and the highest among males living in urban regions of "clean" area (V = 40.6%). In this group the distribution of rates in question varied highly from normal values (high level of right asymmetry and relatively strong flatness).

CONCLUSIONS

Observations made over a long period of time, as well as the pattern of mortality rates in the Polish population, undoubtedly prove that the health status of the population considered in spatial units, depends, first of all, on a given demographic situation and secondly on the effect of natural environment factors. One should, however, be aware that it is very complicated and difficult to distinguish the health risk from evironment degradation or ecological hazards manifested mainly by the mortality from diseases because of the multiple character of the parameters analysed.

A less dynamic natural increase in the population resulting from, among others, the aggregated health status of the population due to a continuous degradation of the natural environment, calls for a thorough analysis of these negative factors.

The general mortality in the mid-eighties, after a long period of upward tendency (1966–1985), maintains the high level characteristic of the post-war period (about 10 deaths per 1 000). In Poland general mortality from DCS is still increasing contrary to other European countries.

The mortality from all diseases shows spatial variability. Its distribution is, however, close to a normal one. Mortality rates from all diseases are usually higher in EHAs urban regions than in the urban regions of ecologically "clean" area. Differences are rather small and the distributions compared are very much alike. In rural regions the differences between rates are much smaller and sometimes are not even observed.

A mean rate of mortality from DCS reaches about 55% in males and about 58% in females of general mortality from all diseases.

The spatial distribution of mortality from DCS is, to a agreat extent, in agreement with the normal distribution. A mean rate of mortality from these causes is considerably higher (by 13% in males and by 17% in females) in the urban regions of ecological hazard areas in comparison with the reference area. In rural regions the differences are unnoticeable.

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