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Original Article

Community-based Analysis of the Factorial Structures of the Recent Increase in Low Birthweight Infants.

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Abstract

This study was conducted to determine whether the regional factors were related to the increase in the percentage of low birthweight (LBW: <2,500g) infants in Kumamoto Pref., and to establish a tentative structure model for predicting low birthweight infants. Analyses for frequency of LBW infants between 1974 and 1997, and a multiple regression model and covariance structure model were conducted using data from the vital statistics between 1992 and 1997 and regional indicators concerned with LBW infants from official registered statistical data between 1992 and 1997. The 72 regional factors were clustered into four groups linked with agricultural areas such as Urban, Flat, Hilly and Mountainous areas. The recent increase in the incidence of LBW infants resulted from the increase in moderate-LBW (MLBW: 2,000-2,500 g) infants of full term-LBW infants. There was a steady annual increase in the Urban agricultural area LBW infants since 1992. The two structure analyses revealed that the Urban area had a marked effect on the increase in LBW infants, whereas, farm villages in Hilly or Moutainous areas had less effect on the increase in LBW infants. These findings suggest that the regional factors relating to the mothers' life-style or regional environments play a key role in the etiology and prevention of LBW, and will be a useful in the analyses using official registered material.

Key words: low birthweight infant, community-based factors, urban rural differences, structure model, agricultural area

Introduction

The low birth weight (LBW:< 2,500g) infants rates (per hundred live births) in Japan has been increasing annually [1] from 5.5% in 1985 to 7.5% in 1995. However, the perinatal mortality rate, the neonatal mortality rate and the infant mortality rate have decreased annually since 1985 [1], although they have shown signs of having bottomed out.

We analyzed the relationship between perinatal mortality rate and LBW infants over 27 years (1968 - 1994), in Kumamoto pref. and the entire nation of Japan [2]. As a result, the relationship in Kumamoto Pref. was classified in three terms (the first term: 1968-1976, the second term in: 1977-1988, the third term: 1989-1994), which were concerned with medical treatment, living standards and social and economical factors at each term. In the third term, the moderate-LBW infants (MLBW: 2,000-2,500g) contributed to the increase in LBW infants more than very-LBW infants (VLBW:< 1,500g) and extremely-LBW infants (ELBW:< 1,000g). This suggested that an increase in LBW infants had developed due to an increase in MLBW infants. This tendency has been reported in other studies [3,4]. These studies also indicated that the recent increase in LBW infants was not related to risks from obstetrical factors such as infant's sex, parity, maternal age or period of gestation. Among the majority of the risk factors, maternal cigarette smoking and alcohol intake, gestational age and plural births have been thought to be influential on the LBW [5-8]. However, although the prevalence of these risk factors is high in developed countries [5-10], it is very low in Japan at present. For example, maternal smoking accounted for 5-10% of all births [11], maternal alcohol intake is uncommon [12], plural delivery is 1.1% of all births [1], and full-term delivery accounts for 60% of all LBW births [1-4]. Therefore, the common risk factors for the LBW infants were not considered to affect the percentage of increase in the LBW infants in Japan. It has been

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suggested that there might be a strong association between the increase in LBW and regional factors relating to mothers' life-styles or the regional environment. From this viewpoint it is essential to clarify the etiology and prevention of LBW to analyze regional factors relating to the lives of both mother and child.

The regional differences among the districts in Kumamoto prefecture [13, 14] or in Japan as a whole [15] in the LBW infant births have already been reported. However, there have only been a few studies on aspects of regional or social characteristics. The purpose of the present study was to determine whether regional factors were related to the increase in LBW infants, and to establish a tentative model by introducing social, economical, geographic and medical factors influencing LBW infants from the official registered statistical data.

Material and Methods

Sources

For analysis, the birth data of vital statistics between 1974 and 1997 was obtained from the records of the Ministry of Health and Welfare, Japan. The information on perinatal deaths was obtained from "Annals of Health Statistics of Kumamoto Prefecture" (Department of Health of Kumamoto Pref.) [16] and "Maternal and Child Health Statistics of Japan" (Ministry of Health and Welfare Japan) [17]. The information collected focused on Japanese with an address in Kumamoto Prefecture. Unknown birthweights were excluded for analysis.

The regional index relating to LBW infants between 1992 and 1997 was based on the classification of factors for eating habits [18] and disease [19]. The selected factors were the following: natural environment, health and medical care, welfare and social security, obstetrical care, mother and child health and the regions policy, population, economy, industry, living and education standards. This information was obtained from the "Index 100, living of Kumamoto Pref." [20], "Kumamoto Pref. statistics yearbook" [21], "The Regional health undertaking report in 1997 fiscal year" [22], "Kumamoto Pref. regional statistical information" [23] and "The Public welfare white paper CD-ROM" [24]. All official registered data was collected from government publications, which were compiled by each public government office and government-affiliated institution.

Analysis

1. The regional features of Kumamoto Prefecture

The regional area examined in this study was Kumamoto prefecture on the West Coast of Kyushu Island in Japan. The regional divisions according to administrative classification such as municipal area [25], secondary health service area according to Medical Service Law, living area [26] and agricultural area [27] were used as the features of the regions. Using 96 kinds of regional items, Pearson's correlation and scatter plots were drawn to explore the relationship between the LBW infants and each item. Since missing data of 10 or more per item was excepted, 72 items were analyzed using a Cluster analysis (Ward's method) using the NAP ver. 4.0 program for Macintosh (Aoki S. 1994). The mean values of each item were calculated based on the total population of each classification group.

2. Incidence of LBW infants' births

According to the definition of LBW infants of ICD-10, the annual changes in the LBW infant rates were analyzed between 1974 and 1997 in Kumamoto Prefecture. Each finding was input into the computer according to 94 municipalities (cities, towns and villages). Neither the secondary health service area nor the living area showed marked regional differences in the LBW infant rate. Therefore, the focus of analysis was on the municipal area and the agricultural area. For the municipal area, city parts were 15 cities including 4 towns-and-villages located adjacently to the same region as Kumamoto City and 11 other cities, and the remainder were suburban districts (79 town-and-villages). The agricultural area was classified into four groups: Urban area (Urban), Flat farming area (Flat), Hilly farming area (Hilly) and Mountainous farming area (Mountainous) [27].

The frequency distribution and normal plots and cross tabulations for the rate of births were used to identify and validate the outliners using the StatView-J 5.0 software program (SAS institute, Inc. 1998). For comparison of frequency, statistical significance was determined at the 0.05 level using the chi-square test.

A total of 108,695 births over six years between 1992 and 1997 were used for a logistic analysis. As a dependent variable, each LBW birth had a value of one and each non-LBW birth had a value of zero. Eight items were adopted as independent variables, which were categorized as follows: "Agricultural area (Urban, Flat, Hilly, Mountainous)", and the obstetrical items were as follows; "Sex (Male, Female)", "Age of mother (19 years and under, 20-34 years, 35 years and over)", "Plurality (Single, Plural)", "Period of gestation (Full-Term, Pre-Term)", and "Past history of stillbirth (past fetal death, none)". The "Year" and "Gestational age" were processed as quantitative variables.

After including this information to estimate the effects of the agricultural area and obstetrical factors on the LBW infant, an analysis was conducted using the SAS program mentioned above. This program calculated the values for the odds ratio (OR) and their 95% confidence intervals for each factor. The statistical significance was determined at the 0.05 level by the Wald chi-squared test.

3. Association between regional features and the incidence of LBW infants

1) The multiple regression analysis

Six items were chosen as independent variables from the above mentioned regional items. The items were selected with values of over $\pm$ 0.2 of Pearsons correlation. The MLBW infants were calculated as dependent variables. Regression diagnosis for model checking was applied to check the constant variation in residuals and the linear relationship using the StatView-J 5.0 software program as mentioned above.

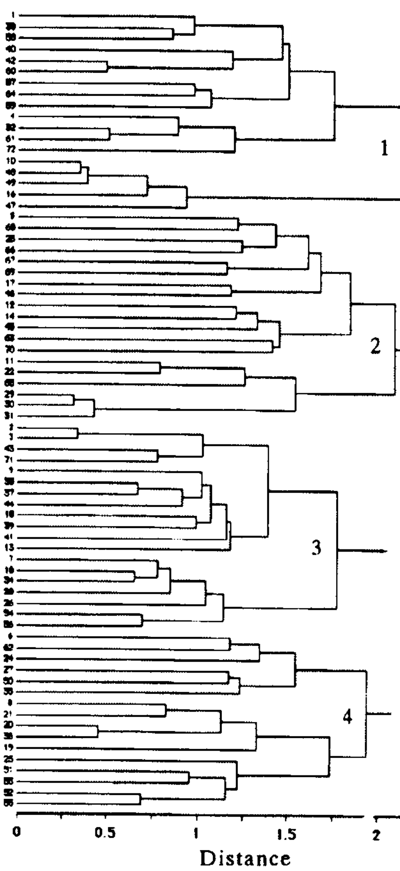
2) The Covariance structure analysis

This analysis [28] provided the means for evaluating the strength of association between the regional items and the LBW infants. To begin, a measurement model was specified in which latent variables were constructed to measure "Regional environment" and "LBW". The selected six items from each cluster for this analysis served as the observed variables of latent variable of "Regional environment". Similarly, the under 2.0 kg LBW infants and the MLBW infants served as the observed variables of latent variable of "LBW". The residual of each observed variable and latent variables were defined as error and disturbance, signified by E and D, respectively. The factor loadings linked the observed variables to latent variables. In the structural equation model, "Regional environment" is regressed on "LBW". The analyses were conducted using the Amos 4 software program (SPSS Japan Inc. 1999) and this model fit was assessed by analysis of moment structures (Amos) summary statistics[29].

Results

1. The regional features of Kumamoto Prefecture

The 72 regional items were divided into 4 clusters as a dendrogram as shown in Figure 1 with the items organized according to cluster. Enclosed items with a semi-closed square and an open square denote the variables of multiple regression analysis and covariance structure analysis, respectively. In Table 1, the mean values of the regional items for covariance structure analysis were calculated according to the agricultural area. These values selected from each cluster were linked with agricultural area, that is, clusters 1, 2 and 3 reflected Hilly and Mountainous, Flat, and Urban, respectively. Other items among each cluster also showed similar tendencies. However, the items among cluster 4 did not show such a clear tendency.



Cluster 1

NO.	Related factors of LBW infants, in 1992-97
1	Percentage of forest land
38	Construction costs per person
58	Welfare commissioners per 100,000 persons
40	Fire per 100,000 persons
42	Diffusion of child-care facilities
60	Number of capacity in child-care facilities
57	Number of public health nurses per 100,000 persons
64	Rate of healthy examination consultations
59	Yearly days of assistance from home helpers per 100 persons.
4	Rate of owned houses
32	Ratio of primary industrial workers
61	Number of adult day care centers per 100,000 persons
72	Rate of joining clubs by elderly persons
10	Average age
48	Ratio of ageing population
49	Dependency ratio of aged population 65 years old and over
16	Death rate per 1000 population
47	Rate of senior solitary households

Cluster 2

NO.	Related factors of LBW infants, in 1992-97
5	Ratio of Full-time farmer households
68	Ratio of visit guidance for pregnant women
23	Commuting and going to school time
66	Ratio of individual health guidance of pregnant women
67	Ratio of attending a lectureby mothers and parents
69	Ratio of attending a nourishment guidance by pregnant women
17	Perinatal mortality rate per 1000 live births
46	Ratio of educational expenses
12	Marriage rate per 1000 population
14	Crude birth rate per 1000 population
45	Rate of going to high school in Kumamoto Prefecture
63	Percentage of blood donations
70	Ratio of attending an open school for women
11	One-family number of men per 1000 population
22	Numbers of cars per 1000 families
65	Ratio of pregnant women precision inspection
29	Percentage of employees (15 years old and over/population)
30	Ratio of employees (15 years old and over)
31	Ratio of women workers

NO.: Number of variables

Cluster 3

NO.	Related factors of LBW infants, in 1992-97
2	Ratio of life region area
3	Population density
43	Number of elementary school children per school
71	Ratio of arable land areas
9	Rate of population increase
35	Villager income per person
37	Financial power index
44	Number of junior high school students per school
15	Ratio of adult population
39	Traffic accidentper 100,000 persons
41	Number of pollution complaints
13	Divorce rate per 1000 population
7	Nuclear family rate
18	Residential quarter average price
34	Ratio of tertiary industrial workers
28	Rate of users of flush toilet
26	Garbage gross weight
54	Number of doctors per 100,000 persons
56	Number of pharmacists per 100,000 persons

Cluster 4

NO.	Related factors of LBW infants, in 1992-97
6	Rate of road pavement
62	Rate of public assistance
24	Ratio of hygiene expense
27	Rate of processing garbage to make compost at high speed
50	National health insurance consultation fees per person
33	Ratio of secondary industrial workers
8	Ratio of attending an open school for women
21	Numbers of eating and drinking shops
20	Retail price per 1000 persons
36	Number of offices per 1000 persons
19	Diffusion of water service
25	Number of telephone spreads
51	Number of general clinics per 100,000 persons
53	Number of general clinic sickbeds per 100,000 persons
52	Number of dental offices per 100,000 persons
55	Number of dentists per 100,000 persons

☐ Observed variables of covariance structure analysis
☐ Independent variables of multiple regression analysis

Figure 1 The dendrogram and the regional items by cluster analysis.
Numbers were added to the 72 regional items, which were classified into four clusters using Ward's method as shown in the dendrogram, and which are indicated according to the clusters from 1 to 4 in the tables. Items enclosed with a semi-closed square (☐) denote the variables of Multiple Regression Analysis as shown in Table 3 and the items enclosed with an open square(☐) denote the variables of Covariance Structure Analysis as shown in Figure 5.

Table 1 Comparison average among agricultural areas for covariance structure analysis

Observed variables	Year of research	Urban	Flat	Hilly	Mountainous
Percentage of forest land [a]	('85)	19.3	31.1	71.2	90.2
Construction costs per person (thousand yen) [b]	('92)	96.2	104.4	153.4	210.8
Ratio of women workers [c]	('90)	45.8	50.3	50.2	50.4
Commuting and going to school time (min.) [d]	('90)	22.4	24.5	20.8	25.4
Divorce rates (per thousand persons) [e]	('92)	1.6	1.1	1.1	0.7
Rate of users of flush toilets [f]	('93)	81.6	49.5	36.5	23.8

values are shown as means
Data for variables of 94 cities and villages were analyzed
a) Percentage of forest land: (Forest area/total area) × 100
b) Contractual cost per person: Contractual cost/expenditure (thousand yen)
c) Ratio of woman workers: woman workers/women (15 years old and above)
d) Commuting and going to school time (min.): Time/persons (15 years old and above)
e) Divorce rates (per thousand persons): (divorces/population) × 100
f) Rate of users of flush toilets: (users of flush toilets/population) × 100

2. Annual changes in the birthweight of all live births and LBW infants

1) Annual changes in the birthweight distribution of all live births

The birthweight distribution plot was classified into groups with 100-g increments between 1974 and 1997 in Kumamoto Prefecture. There appeared to be a shift to the heavy weight side between 1974 and 1976. Since 1977, however, the birthweight shifted to the lightweight side. Figure 2 shows birthweights as probability plots. The probability plots compared the extreme ends of different distributions in 1974 and 1997. In 1997, the shift was greater at the lower end and the heavier end plots, compared with the plot in 1974.

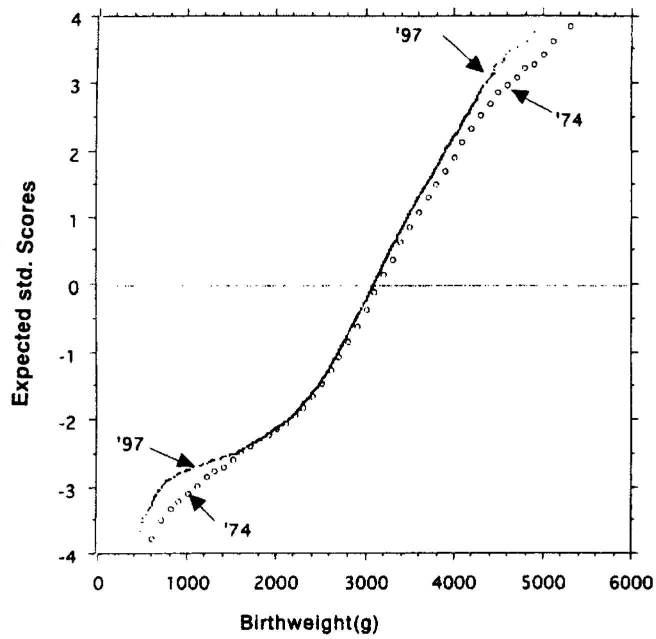


Figure 2 The normal probability plots of live births, in 1974 and 1997. The plot of 1997 is shown as a fine dotted curve, for 1974 an open circle curve.

2) Live births classified by regional area, agricultural area and birthweight

The total number of LBW infants for the nine years between 1987 and 1995 were divided into the city parts and the suburban districts (data not shown). Although, the MLBW infants rate in the city parts was significantly higher than the suburban rate (chi-square test, p=0.01), no significant difference was found between these parts in the VLBW infants and the ELBW infants. Overall, the rate of the LBW infants in the city was significantly higher than in the suburban areas (chi-square test, p=0.01). As shown in Table 2 the total LBW infants were calculated according to the agricultural area. The rates of LBW infants and MLBW infants in Urban areas were the highest among other agricultural areas, but this tendency was not significantly different. Similarly, among 4 agricultural areas there was no significant difference between the VLBW infants and the ELBW infants.

3) The incidence of LBW infants according to gestational week

In Figure 3, the LBW infants' rates are shown according to the gestational week. During pregnancy from 22 to 33 weeks, most infants were born as LBW as shown in closed circles at each week of gestation (Fig.3). However, the percentages of the LBW at 37 and 38 weeks accounted for 18% and 17.9%, respectively. Term births (37-41 weeks) in LBW infants accounted for 57% of all LBW infants. Thus, the percentage of full-term LBW births was higher than that of LBW preterm births.

4) Annual changes in the incidence of LBW infants according to agricultural area, and duration of gestation

Figure 4 shows the LBW infants rates according to the agricultural area, year and the duration of gestation between 1992 and 1997. The rates for full-term LBW infants (Full-term: 37 to 41 weeks) were higher than those for preterm LBW infants (Pre-term: under 37 weeks) in all agricultural areas. Overall, whereas the rates of Urban areas in full-term delivery indicated an increased tendency each year, those of Hilly areas were low compared with other areas. Among the pre-term delivery cases,

Table 2 Percentage of live births by birthweight, agricultural area, in Kumamoto Prefecture between 1987-1995

Live births by birthweight	Kumamoto Prefecture (1985-1995)	Urban		Flat		Hilly		Mountainous		Chi-square test
	Live Births	%	Live Births	%	Live Births	%	Live Births	%	Live Births	
Toal	173,167	100	82,418	100	44,523	100	41,982	100	4,244	
over 4.5kg	208	0.10	85	0.16	71	0.11	48	0.09	4	
4.0 to 4.5kg	3,272	1.77	1,456	2.03	904	1.99	837	1.77	75	
3.5 to 4.0kg	27,944	15.34	12,641	16.97	7,556	16.77	7,039	16.68	708	
3.0 to 3.5kg	78,925	45.70	37,666	45.26	20,149	45.69	19,181	45.45	1,929	
2.5 to 3.0kg	51,615	30.47	25,112	29.18	12,990	29.15	12,237	30.07	1,276	
2.0 to 2.5kg	8,542	5.09	4,191	4.79	2,132	4.79	2,012	4.88	207	
1.5 to 2.0kg	1,627	0.93	770	0.99	439	0.92	388	0.71	30	
1.0 to 1.5kg	656	0.38	310	0.41	184	0.36	152	0.24	10	
under 1.0kg Extremely low birth weight	378	0.23	187	0.22	98	0.21	88	0.12	5	N.S.
under 1.5kg Very low birth weight (Listed again)	1,033	0.60	497	0.63	282	0.57	239	0.35	15	N.S.
under 2.5kg Low birth weight (Listed again)	11,200	6.62	5,458	6.40	2,851	6.29	2,639	5.94	252	p=0.07

N.S.: not significant

Significance among agiricultural areas based on chi-square test

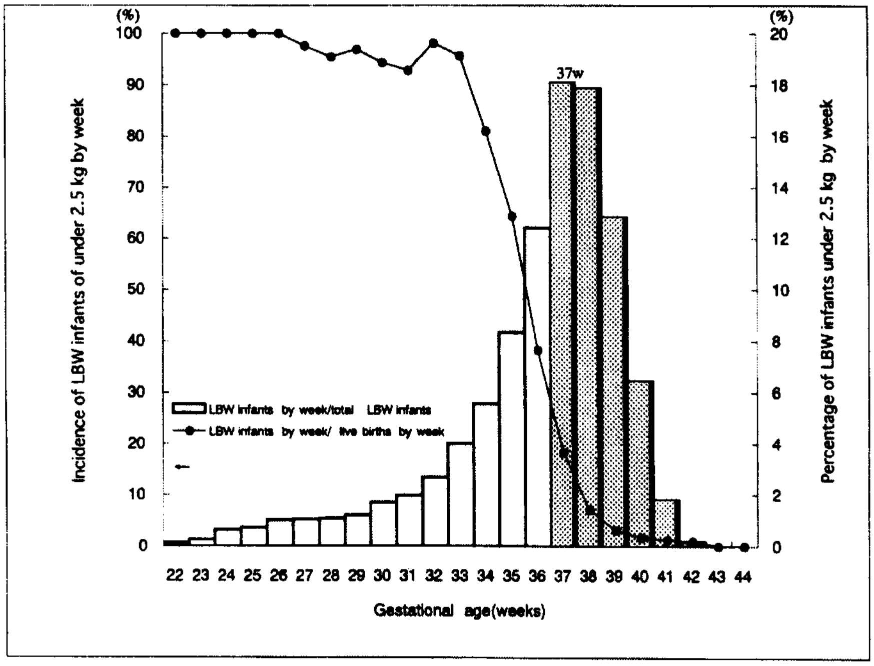


Figure 3 The percentage distribution of LBW infants according to gestational age between 1992-97. Closed circles (-●-) with a fine solid line denote the rate of LBW infants according to gestational age for all live births and the frequency of LBW infants according to gestational age for all LBW infants. The frequency for 37 weeks gestation and over is shown as a semi-closed square (▩).

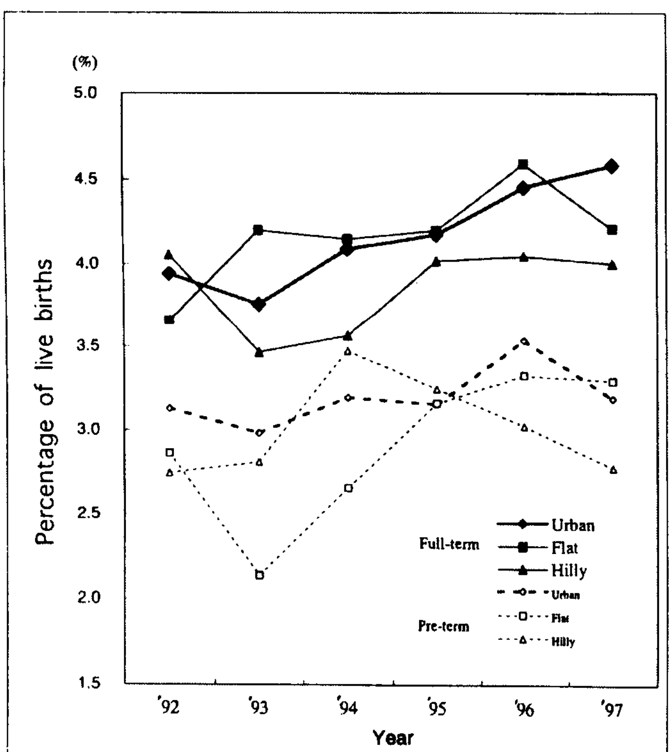


Figure 4 The rate of LBW infants according to period of gestation and agricultural area, in 1992-97. The marks with a fine solid line denote the rate of term-LBW infants and those with a dotted line denote the rate of preterm LBW infants. The rates of Mountainous area and post-term infants (42 weeks and over) were not shown for small numbers of births.

the LBW infants' rates of Urban and Flat areas showed a few increases and those of Hilly areas had decreased since 1995.

5) Effects of obstetrical items and agricultural area on LBW infants

The rates of LBW infants according to agricultural area between 1992 and 1997 are shown as follows: the rate in Urban, Flat, Hilly, and Mountainous areas were 7.37%, 7.09%, 6.87% and 6.39%, respectively, and these differences were significant (chi-square test, p =0.03, data not shown). In Table 3, when the odds ratio of agricultural area was calculated and compared with Urban area, the risk of LBW infants was significantly lower in Hilly areas (OR=0.92, p<0.01). As Compared with the LBW infants rate in 1992, the risk of LBW infants become annually higher (OR=1.03, p<0.001). The risks related to the infant's sex, the age of the mother and plurality of births were consistent with the findings of other studies[4-6].

3. Association between regional features and the incidence of LBW infants

In Table 4, the multiple regression analysis showed a standardized partial regression coefficient and correlation coefficient per regional items for MLBW infants. Among all 6 items, the 4 items of "Ratio of full-time farmer households", "Commuting and going to school time", "Marriage rate" and "Ratio of adult population" showed positive correlations with the MLBW infants. The correlation of "Ratio of full-time farmer households" was highest among the items investigated and a significant predictor of MLBW infants (β =0.259, p<0.01). Those items were selected from clusters 2 and 3 shown in Figure 1. Only 2 items; "Yearly days of assistance from home helpers" and "Ratio of pregnant women precision inspection" showed a negative correlation with the MLBW infants. The former item was a significant correlation (β = -0.243, p<0.05), which was

Table 3 Results of logistic analysis for low birthweight infants

Variables	OR	95% limits lower-upper	Warld Chi-square test
Agricutual area (the reference is Urban)			
Flat	0.95	0.90-1.01	
Hilly	0.92	0.87-0.98	**
Mountainous	0.85	0.72-1.02	
Sex (compared to Male)			
Female	1.15	1.10-1.21	***
Age of mothers (the reference is 20-35 years)			
19 years old and under	1.26	1.06-1.50	**
35 years old and over	1.37	1.26-1.48	***
Plurality (the refernce is Single)			
Plurality (2.3.4 deliveries)	22.37	20.35-24.5	***
Weeks of gestation (from 22 weeks)			
Every weeks	0.30	0.39-0.40	***
Period of gestation (the references is Full-term)			
Pre-term	35.30	33.1-37.6	***
Post-term	0.21	0.12-0.36	***
Fetal deaths (there is no historical reference)			
Past history of fetal death	2.20	1.83-2.66	***
Year (from 1992)			
Every year	1.03	1.01-1.04	***

Data for 108,717 live births between 1992 and 1997, in Kumamoto Pref. were analyzed N.S.: not significant
**: $p<0.01$, ***: $p<0.001$
OR: odds ratio, 95% limits Lower-Upper: 95% confidence interval

Table 4 Results of multiple regression analysis for the low birthweight infants of 2.0 to 2.5kg

Variables	Year of research	Standardized particalregression coefficient (β)	Correlation coefficient (r)
Yearly days of assistance from home helpers	('93)	-.243*	-.396
Ratio of full-time farmer households	('85)	.259**	.297
Communting and going to school time (min.)	('90)	.098	.223
Marriage rate (per 1,000 population)	('92)	.169	.211
Ratio of pregnant woman precision inspection	('97)	-.155	-.225
Ratio of adult population	('90)	.050	.224
R		.527	

*: $p<0.05$ **: $p<0.01$
R: multiple correlation coefficient
Data for variables of 94 city-town-villages were analyzed

selected from cluster 1. The multiple correlation coefficient was 0.527. However, in the case of LBW and VLBW as dependent variables, the findings did not fit well.

In addition, we tried to analyze the covariance structure analysis. In Table 2, the means of the six observed variables for "Regional environment" were calculated according to the agricultural area. The means of "Percentage of forest land" and "Construction costs" showed the highest tendency rates in Hilly and Mountainous areas. These variables were selected from cluster 1. The "Commuting and going to school time" and "Ratio of women workers" selected from cluster 2 showed the highest tendency rates in Flat areas. The "Divorce rate" and "Rates of users of flush toilets", selected from cluster 3, showed the highest tendency rates in Urban areas. The values of other regional items according to the cluster analysis also showed similar tendencies (data not shown). Thus, the items in each cluster linked with the features of the agricultural area, that is, the items selected from cluster 1, 2 and 3 were the features in Hilly and Mountainous areas, Flat areas and Urban areas, respectively. Figure 5 shows the findings of fitting the model for covariance structure analysis. The latent variable of "Regional environment" consisted of the variables shown in Table 1. There was a significant negative association of 3 items, which were "Percentage of forest land", "Construction costs per person" and "Ratio of women workers". Although the significant positive associations of "Commuting and going to school time" and "Rates of users of flush toilets" were found, there was no significance for "Divorce rate". Factor loadings for "Percentage of forest land" and "Construction costs per person", which were selected from cluster 1 (Hilly and Mountainous areas), were appreciably high: -0.73 and -0.70, respectively. While factor loadings for "Divorce rate" and "Rates of users of flush toilets" which were selected from cluster 3 (Urban areas) were also appreciably high: 0.51 and 0.73, respectively. The factor loadings for items selected from cluster 2 (Flat area) were very low. The standardized regression coefficient linking "Regional environment" was 0.25. The factor loading for the MLBW infants (0.88) was higher than under 2.0 kg infants (0.10). The magnitudes of fit statistics are shown in Amos summary statistics in Figure 5. The GFI (Goodness of fit index) and AGFI (Adjusted goodness of fit index) indicated that model provided a good fit to the covariance matrix. Other fit indices showed suitable values.

Discussion

This study indicated that the regional differences according to the agricultural area existed for those factors that affected the increase in the LBW infant rate in Kumamoto Prefecture. The four groups of agricultural areas were closely linked with the four clusters of regional items. This suggested that the classification of the agricultural area and the selected regional items were effective to indicate regional features.

Considering the increase in term delivery infants or MLBW infants in Japan, the present research focused on environmental factors to improve intrauterine growth and to prevent LBW

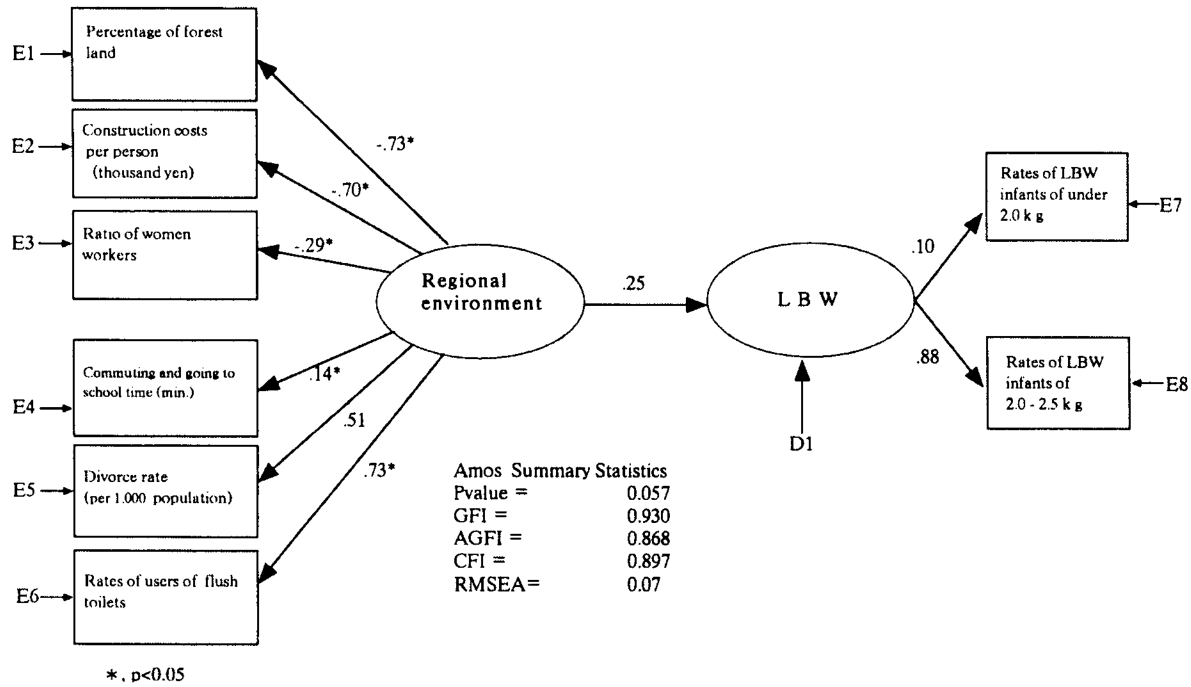


Figure 5 **The covariance structure model with parameter estimates and Amos 4 summary statistics. The error variables are shown from E1 to E8 and the disturbance variable was shown as D1. The items enclosed with an open square (□) denote the observed variables and the enclosed items with a circle denote the latent variables. The values indicate the factor loadings for observed variables and the standardized regression coefficient. Significant estimates are indicated with an asterisk (*p<0.05). The results of the model fit statistics are attached to the figure. Fit indices are as follows: GFI (Goodness of fit index), AGFI (Adjusted goodness of fit index), CFI (Comparative fit index), RMSEA (Root mean square error of approximation).**

infants, because the obstetrical factors and narcotic addiction factors (maternal smoking, alcohol intake) were likely to have little impact on the entire population even if they are associated with huge risks of prematurity or intrauterine growth, as mentioned in the "Introduction". The findings in this study showed that the increase in incidence of LBW between 1974 and 1997 resulted from the increase in MLBW infants. This finding was consistent with other studies[3, 4, 13]. Although the increase in the MLBW infants was small in Hilly areas, the increase in Urban areas was significant since 1992. Thus, the regional differences in the incidence of the LBW infants was confirmed clearly by the agricultural areas, that is, the LBW rate was from the highest to the lowest in the order of Urban, Flat, Hilly and Mountainous. Regional differences in the rate of VLBW and ELBW were not confirmed. This suggested an influence of the regional environment on the increase of the MLBW infants.

Low birthweight can be caused by many factors, which can influence the duration of gestation and the rate of intrauterine growth. This indicates that the causes of LBW are multifactorial[5]. In highly developed countries, pre-term infants have recently received increased attention[5, 10]. The cause is unknown despite the increase in pre-term births[30]. The present findings showed that there has been a small increase in the preterm LBW infants, although the rate of full-term LBW infants was higher than that of pre-term LBW infants, and has been increasing rapidly in Urban areas since 1992. For full-term LBW infants, most underlying causes (e.g. maternal smoking, weight at conception and gestational weight gain) have been identified. However, the regional differences of these factors have not been sufficiently clarified.

As mentioned above, the present findings resulted from two structure analyses which showed interactions between the regional environment and MLBW infants which have caused the increase in LBW infants. Most of the six regional factors in each analysis were considered to have an indirect influence on the birthweight. Thus, the factor itself may not affect birthweight, but instead reflects the increased frequency of other more direct factors that are present among the group of women "at risk". The regional factors which are selected from four clusters linked with features of the agricultural area, that is, clusters 1, 2 and 3 reflected Hilly areas, Flat areas and Urban areas, respectively. In addition, the items selected from cluster 1 showed a negative correlation with the MLBW infants (Regional environment as covariance structure analysis). The items selected from cluster 3 showed a positive correlation. In cluster 2, negative and positive correlations were shown. These findings suggest that the Flat area reflected the features of both the Hilly and Mountainous areas and Urban areas because the Flat areas were located midway between these two areas. Thus, the Urban areas had a marked effect on the increase in LBW infants, whereas farm villages in Hilly or Mountainous areas had less effect on the increase in LBW infants.

The standardized regression coefficient (0.25) in covariance structure analysis was similar to the multiple correlation coefficient (0.527: 0.278 as coefficient of determination for MLBW infants). The factor loading was higher in MLBW infant (0.88) than under 2.0 kg infants (0.10). This suggested that the influence of regional environment on the LBW infants was relatively large and especially so on the MLBW infants. The factor loading for under 2.0 kg was very small, and the multiple regression model did not fit well when the rate of VLBW infants was analyzed as a dependent variable. This may be because no difference in the incidence according to regional or agricultural area among VLBW and ELBW infants was found. The survival of these ELBW or VLBW infants depends to a greater degree on the advances in neonatal medicine[31,32].

Recently, an epidemiological study indicated that passive smoking[33,34], weight management[35], nourishment intake[36,37], a double load of housework and work[38], and the stresses during pregnancy[39], resulted in an increase in LBW infants. These factors are considered to have a direct influence on birthweight and will be attributed to variations in the life-style of the pregnant women. In the future, it will be necessary to analyze whether the prevalence of those risk factors is remarkable in Urban areas or in farm village areas. The farm villages have problems such as depopulation and those associated with remote rural areas, however, the farm villages appear to have favorable effects on pregnant women. This may be suggested as the healthy region which coexists with the function of farm village and urban areas[40].

From a public health standpoint, the present findings confirmed the regional risk factors for LBW infants by statistical analysis, and suggested that a comprehensive model should be useful in the prevention of LBW infants among pregnant women. In addition, the usefulness of analysis using the official registered material was confirmed through the process of this research, and effective materials related to LBW were shown.

Conclusion

This study attempted to determine whether regional factors were related to the increase in LBW infants using the official registered material. The following findings were obtained.

1. The classification of agricultural areas and selected regional items were effective to indicate regional features in Kumamoto Prefecture.

2. Characteristic changes were noted in the live birth weight distribution between 1974 and 1997 in Kumamoto Pref. In 1997, the distribution shifted to lightweight births, and the extreme end of its distribution was confirmed at the lower end by a probability plot. The number of MLBW infants of all LBW infants has especially increased and the number of full-term LBW infants has increased since 1992 more significantly in Urban areas.

3. Agricultural areas clearly confirmed the differences in the incidence of LBW infants. The urban areas had a marked effect on the increase in LBW infants, whereas the farm village areas had less effect on the increase in LBW infants. The regional environment had especially a great effect on the MLBW infants.

4. The usefulness of analyses using the official registered material was confirmed through the process of this research, and a comprehensive analytic model could be shown.

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