原　著

Statistical Determination of Infanticide Rates by Prefecture in Japan
- Criminal Statistics of the Metropolitan Police Department from 2006 to 2015 -
日本における乳児の他殺による死亡率の都道府県別分析
－警視庁の犯罪統計 2006 年から 2015 年より－

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Abstract

Infanticide accounts for the largest proportion of homicide cases in Japan. However, few studies have attempted to determine regional differences, if any, in the numbers and rates of infanticide. Here we have estimated both numbers and rates of infanticide by prefecture, examined prefectural differences, and highlighted areas that require prioritized intervention.

The highest estimated infanticide rates for a prefecture were 8.6/100,000 births [95% confidence interval (CI): 2.37–18.64] and 7.5/100,000 births (95% CI: 3.14–13.65). However, infanticide had not been reported during the 10-year study period in six prefectures. Interestingly, prefectures with the highest and the lowest estimated infanticide rates were both non-urban areas, implying that regional differences may be important, and that identifying these regional differences may help develop more effective interventions to prevent infanticide.

抄　録

日本の他殺による死亡で最も多い年齢は、0 歳である。しかしながら、嬰児殺に対する地域差を明らかにしたものは現在のところ多くはみあたらない。そこで本研究は、嬰児殺数および死亡率を都道府県ごとに推定し、地域の差について検討を行い、重点的な予防介入を要する地域を明らかにすることを目的とした。

その結果は、最も高い死亡率（出生 10 万対）が 8.6 (95% CI: 2.37–18.64)、次いで 7.5(95% CI: 3.14–13.65) であった。また、10 年間において全く発生を認めなかったのは、6 都道府県であった。この地域は、共に都市部ではなかった。

この結果を基に、嬰児殺率の高い地域と低い地域の特性を踏まえた予防介入を考慮することが乳児の他殺による死亡の予防に役立つ可能性がある。

Keywords: Infanticide, Criminal statistics, Bayesian hierarchical model, Child abuse
キーワード：他殺、犯罪統計、階層ベイズモデル、児童虐待

1. Introduction

Children aged less than 1 year comprise the largest proportion of homicide cases in Japan[1)]. In 2015, the homicide rate among all age groups was 0.3 per 100,000; however, this rate in children aged less than 1 year was much higher, at 1.2 per 100,000[1)]. Moreover, studies have reported that children aged 0–12 months account for almost 46% of all deaths due to child abuse in Japan[2)]. These grim statistics indicate that additional measures are required to prevent infanticide in Japan. Further, it is essential to identify regions with high child fatality rates so that greater tailored support can be provided.

Reports also indicate that along with the unusually elevated levels of infanticide in Japan, the number of child abuse consultations handled by child consultation centers continues to increase [3)]. To better understand this phenomenon, studies have analyzed the response percentage to child abuse consultations by prefecture to identify areas that require prioritized intervention. These study results identified regional differences in child abuse consultations; as urban areas such as Osaka and Tokyo prefectures reported high rates, the need for greater support in these prefectures was recognized [4]. Nevertheless, it must be noted here that these results pertain to child abuse, and few studies have analyzed regional differences that influence infanticide alone. This scenario is attributable to the small number of infanticide cases when counted by prefecture, which in turn prevent statistical analyses and comparisons. However, recent advances in statistical methods, such as the Bayesian hierarchical model, can be used to overcome these limitations.

The Bayesian hierarchical model assumes a hierarchy in the probability distribution of parameters [5]. A major advantage of this method is that it provides a stable estimation of lower parameters independent of sample size [6]. Furthermore, the use of a random number generation algorithm lowers the risk of a local optimal solution, and a posterior distribution is used to calculate the estimated value. Thus, this method can be used to obtain results characterized by a high degree of uncertainty, such as interval estimation. Therefore, here, using the Bayesian hierarchical method based on the Poisson-gamma model [7], we have estimated the numbers and rates of infanticide by prefecture, analyzed regional differences, and identified areas that require prioritized preventative care.

2. Methods

2.1. Data acquisition and analysis

Cases of infanticide by prefecture in children aged less than 1 year were identified and extracted from criminal statistics records for the years 2006–2015 published by the Metropolitan Police Department [8].

2.2. Model and parameters

The total number of infanticide cases was used to establish stable tendency. First, the Poisson-gamma model was used to estimate the number of infanticides. Next, based on the Poisson-gamma model, the Bayesian hierarchical model was used to estimate the infanticide rate, which is a parameter of the number of infanticides. The percentages of two variables in the gamma distributions were assumed to be the beta distributions.

To find the denominator, demographic statistics published by the Ministry of Health, Labour, and Welfare were used, and the number of births by prefecture for the period 2006–2015 was calculated [9]. The total of the 10-year numbers for was used to calculate the numerator and denominator, respectively. Further, the statistics reported by the Metropolitan Police Department and the Ministry of Health, Labour, and Welfare were confirmed on April 2, 2016.

This study used freely available data and information identified as having academic value, which had been used previously and widely for research. Therefore, study approval was not required according to the guidelines established in Chapter 1, Article 3, of the General Provisions in Ethical Guidelines for Medical Research Targeting Humans [10].

2.3. Statistical analyses

The Poisson-gamma model that incorporates the Bayesian hierarchical model was used to estimate the number of infanticides (Equation 1).

$$di \sim Poisson\ (\lambda i)$$
$$\lambda i \sim Gamma\ (\alpha,\beta)$$

This estimation presumes that the number of infanticides (di) by prefecture (i) follow the Poisson distribution. The average parameter λi of the Poisson distribution was also assumed to be a gamma distribution with the hyperparameters of α and β. Default prior distributions of the hyperparameters were assumed to be exponential and gamma distributions, respectively [7] (Equation 2).

$$\alpha \sim Exponential\ (1)$$
$$\beta \sim Gamma\ (0.1,1)$$

We utilized a new configuration of the Bayesian hierarchical model that is based on the Poisson-gamma model to predict the infanticide rates (Equation 3).

$$d(i) \sim Poisson\ (Ni \cdot \theta i)$$
$$\theta i \sim Beta\ (\alpha,\beta)$$

In the formula described above, the infanticide rates di is generated as a Poisson distribution by averaging the multiplication values of Ni (number of births by prefecture) and θi (estimated mortality rates by prefecture). The β distribution is postulated for θi, and uniform distributions with the minimal value 0 and the maximum value 10,000 are presumed to be the hyperparameters α and β, respectively (Equation 4).

$$\alpha \sim Uniform\ (0,10000)$$
$$\beta \sim Uniform\ (0,10000)$$

The result of the above-described analysis represents the estimated infanticide rate per 100,000 births, by prefecture.

Parameters were estimated using Statistical Computing and Data Analysis with R (version 3.3.1) and "rstan" (version 2.10.1), a software package that uses the probabilistic programing language "STAN." The Hamiltonian Monte Carlo method was used for estimation. The total sample size was presumed to be 4,000 (iteration = 4,000, warmup = 2,000, thinning = 2, and chain = 4).

The Gelman–Rubin test was used for convergence diagnosis of the model [11], and proper convergence was concluded because the effective sample size among all samples was >10%, the Monte Carlo standard error was <10% of the standard deviations in the posterior distributions, and the statistic *R*, which describes the degree of mixing of Markov chains, was <1.1.

3. Results

Between 2006 and 2015, 178 cases of infanticide were reported in Japan. The highest number of infanticide cases in a prefecture was 20, and the second highest number was 18.

Overall, the average number of infanticide cases per prefecture over the 10-year study period was 3.79, with a variance of 16.21 (Table 1). Due to the relative infrequency

Table 1. Number of infanticide cases and estimated infanticide values and rates, by prefecture

Prefecture	Number of births	Number of cases	Estimated Values			Estimated Rates †		
			Maximum a Posteriori	Lower95CI	Upper95CI	Maximum a Posteriori	Lower95CI	Upper95CI
Hokkaido	395,072	9	7.2642	1.8605	12.3640	2.3343	1.0818	4.0674
Aomori	95,438	5	4.5216	0.6661	8.7032	5.3464	1.8562	10.8026
Iwate	96,206	1	1.8807	0.0231	4.5785	1.2162	0.0447	4.2539
Miyagi	189,279	5	4.5737	0.8221	8.6522	2.6549	0.8851	5.4865
Akita	67,587	1	1.9028	0.0388	4.8099	1.8242	0.0945	6.1639
Yamagata	85,905	1	1.9185	0.0322	4.7069	1.4018	0.0713	4.6045
Fukushima	156,102	2	2.6024	0.1082	5.8427	1.3711	0.2014	3.6871
Tokyo	1,073,511	18	13.3186	4.1471	20.2585	1.7113	1.0486	2.5649
Ibaraki	234,793	3	3.2201	0.2825	6.7381	1.4013	0.2890	3.3482
Tochigi	163,819	0	1.2454	0.0063	3.7709	0.1381	0.0000	0.9038
Gunma	157,316	3	3.2543	0.2443	6.7801	2.0783	0.5286	4.8924
Saitama	586,015	9	7.2679	1.9368	12.5043	1.5677	0.7298	2.6794
Chiba	500,727	5	4.6058	0.5732	8.7172	1.0411	0.3320	2.1288
Kanagawa	765,892	5	4.5546	0.7125	8.5918	0.6899	0.2405	1.3781
Niigata	177,156	4	3.9129	0.2712	7.7042	2.3753	0.6606	5.0460
Yamanashi	65,258	3	3.2350	0.2787	6.7412	4.9602	1.1150	11.6278
Nagano	171,455	0	1.2372	0.0024	3.5795	0.1214	0.0000	0.8664
Shizuoka	311,955	6	5.2245	0.6027	9.6192	1.9653	0.7701	3.7545
Toyama	81,564	0	1.2370	0.0038	3.5443	0.2693	0.0000	2.0433
Ishikawa	96,760	7	5.9030	1.1460	10.5834	7.4727	3.1416	13.6541
Fukui	67,867	2	2.5974	0.1111	5.6828	3.2629	0.4623	8.7256
Gifu	167,457	1	1.9032	0.0236	4.6309	0.7476	0.0433	2.5828
Aichi	685,430	4	3.9129	0.5027	7.6620	0.6070	0.1758	1.3069
Mie	150,041	2	2.5797	0.0585	5.7853	1.4648	0.2198	3.8225
Shiga	131,732	0	1.2288	0.0007	3.5736	0.1564	0.0000	1.1100
Kyoto	208,000	1	1.9070	0.0342	4.7466	0.5830	0.0283	2.0617
Osaka	741,834	20	14.5874	5.9513	21.9387	2.6788	1.6691	3.9441
Hyogo	469,542	5	4.5562	0.8392	8.4326	1.1118	0.3624	2.2408
Nara	105,782	4	3.9098	0.4113	7.6082	4.0241	1.0344	8.5910
Wakayama	74,764	2	2.5846	0.1291	5.7184	3.0823	0.4313	8.5888
Tottori	48,357	4	3.9285	0.4411	7.7705	8.5802	2.3675	18.6388
Shimane	56,578	2	2.5471	0.1491	5.5546	3.8399	0.5714	10.2854
Okayama	165,128	7	5.9007	1.2784	10.4721	4.2983	1.7103	7.9471
Hiroshima	250,400	8	6.5937	1.6470	11.2486	3.2669	1.4524	5.7393
Yamaguchi	111,110	3	3.2164	0.1329	6.6956	2.8951	0.6363	6.6950
Tokushima	58,375	0	1.2383	0.0058	3.3509	0.3462	0.0000	2.5971
Kagawa	82,723	0	1.2630	0.0003	3.5856	0.2550	0.0000	1.8837
Ehime	111,700	6	5.2879	0.9068	9.4384	5.5554	2.1183	10.7486
Kochi	54,296	2	2.5938	0.1588	5.7125	4.0391	0.5185	10.7341
Fukuoka	459,664	3	3.2486	0.2820	6.7609	0.7239	0.1728	1.7106
Saga	74,879	1	1.9183	0.0665	4.7513	1.6415	0.0889	5.4274
Nagasaki	117,959	3	3.2666	0.4188	6.6725	2.7583	0.6205	6.5056
Kumamoto	160,628	2	2.5549	0.1262	5.5975	1.3766	0.2014	3.7588
Oita	98,291	1	1.9143	0.0278	4.5916	1.2125	0.0605	4.1326
Miyazaki	99,709	3	3.1979	0.2964	6.5970	3.1804	0.8277	7.4780
Kagoshima	148,742	3	3.1803	0.2759	6.5402	2.1556	0.4779	5.1016
Okinawa	168,164	2	2.5727	0.0824	5.5790	1.3442	0.2321	3.4507

†The estimated infanticide rate per 100,000 births

of infanticides and the small number of samples per prefecture, subsequent analysis was conducted using the Bayesian hierarchical model.

The estimated number of infanticide cases, calculated using the Bayesian hierarchical model, is shown in Figure 1, and the estimated rates of infanticide in the Bayesian hierarchical model are shown in Figure 2. The calculated national mean was 3.8 infanticides per prefecture, with the Osaka prefecture predicted to have the highest estimate of 14.6 infanticides [95% confidence interval (CI): 5.95–21.94], followed by the Tokyo prefecture with 13.3 cases (95% CI: 4.15–20.26).

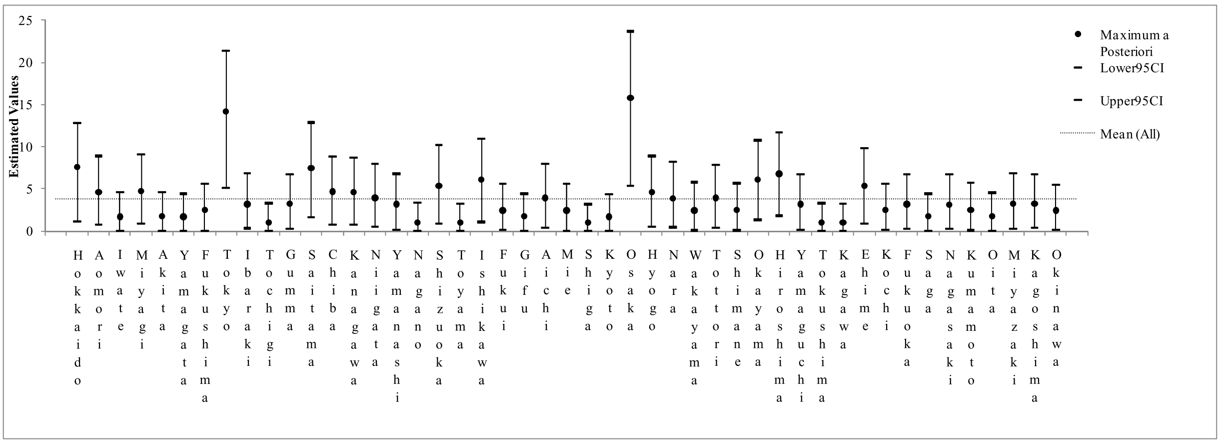

Figure 1. The calculated average value of a posterior distribution of estimated total infanticide cases by prefecture.
Black points indicate the average value of a posterior distribution [expected-a-posteriori (EAP)]. Error bars indicate the upper and lower limits of the 95% confidence interval. The dotted line indicates the average number of infanticides per prefecture in Japan.

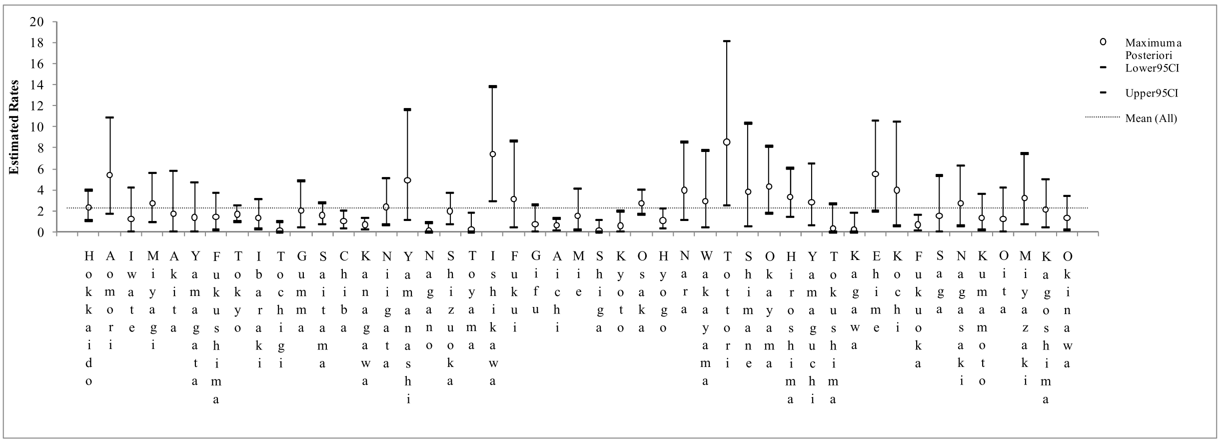

Figure 2. Posterior distribution of infanticide rates based on number of births by prefecture.
White circles indicate the posterior average value of an evaluated death rate [expected-a-posteriori (EAP)]. Error bars indicate the upper and lower limits of the 95% confidence interval. The dotted line indicates the average national mortality rate in Japan.

The estimated average national infanticide rate was 2.3/100,000 births. The Tottori prefecture had the highest evaluated mean national infanticide rate at 8.6 cases/100,000 births (95% CI: 2.37–18.64), followed by the Ishikawa prefecture at 7.5/100,000 births (95% CI: 3.14–13.65).

4. Discussion

This study used criminal records of the Metropolitan Police Department for the period 2006–2015 to ascertain the number of infanticides by prefecture in Japan. These data were used to analyze the number of infanticides in each of Japan’s 47 prefectures, and the Poisson-gamma model was used to estimate the infanticide rate in each prefecture. Our model predicted that two metropolitan prefectures would have the highest number of infanticide cases, which is in agreement with previous reports on child consultation center caseloads by prefecture [4].

However, the estimated infanticide rates were predicted to be the highest in the Chugoku and Hokuriku regions, and notably, these regions are relatively isolated from urban areas. Interestingly, our findings correspond with reports of infanticide from Finland, wherein infanticide rates have been reported to be higher in rural areas than in urban areas [12]. Conversely, our study also identified six prefectures with no cases of infanticide during the 10-year study period, and these prefectures are located in the Kanto, Chubu, Kinki, and Shikoku districts, all of which are also non-urban areas.

Thus, significantly, regions with both the highest and the lowest rates of infanticide have similar population densities, and these observations imply that allocating preventative resources based on population alone may not be effective.

Why prefectures with similar population densities have such starkly different outcomes is an interesting area of research. Meyer and Oberman [13] have stated that social, cultural, and environmental factors influence infanticide. While we have not investigated the specific external causes of regional differences, our analysis may allow future studies to link differences in social, cultural, or environmental factors with the risk of infanticide.

Friedman and Resnik [14] describe five major motives for infanticide: altruistic, accidental, acute mental illness, unwanted pregnancy, and spousal punishment. We now discuss our results in the context of these motives. Friedman et al [15] and Taguchi [16] have reported that unwanted pregnancies were the cause of several infanticide cases in Japan. Additionally, *The Verification Results of Deaths by Child Abuse, The 13th Edition,* [2] states that "unexpected and unplanned pregnancies" were reported in 54.5% of infanticides in Japan. Thus, when designing public safety measures to address these potential causes, the simplest intervention may involve programs that help avoid unwanted pregnancies.

Surprisingly, the prefecture with the highest infanticide rate also had the highest artificial abortion rate (10.0 per 100,000 women aged 15–49 years) among the 47 prefectures; this is much higher than the national average of 6.8/100,000 [17]. This high rate of artificial abortion points toward a large prevalence of unwanted pregnancies in this prefecture; therefore, preventing unwanted pregnancies can be a powerful method of preventing infanticide. According to UNICEF reports, the prevalence rate of contraceptives is only 54% in Japan, which is the lowest among the seven major countries included in the Organization for Economic Cooperation and Development [18]. Improving counseling for unwanted pregnancies is a major focus of the Ministry of Health, Labour, and Welfare's measures to prevent child abuse, along with strengthening cooperation in health and welfare, and fulfilling appropriate responses [2]. Based on the above, we predict that additional support measures that focus on preventing unwanted pregnancies may help reduce infanticide.

Next, the two prefectures with the highest infanticide rate also had lower rates of child abuse consultations. The numbers of child abuse consults among 100,000 infants aged 0–2 years at counseling centers were 134 and 284, which is lower than the national average of 693/100,000; this statistic was calculated as the number of child abuse consultations divided by the number of infants aged 0–2 years [19,20]. Similarly, child abuse consultations among 100,000 infants aged 0–2 years at municipality centers were 112 and 351, respectively, in these two prefectures, which are lower than the national average of 752/100,000 (calculated as above). A previous study that targeted children aged 0–19 years using the binomial-beta hierarchical Bayesian model also revealed that these two prefectures had lower rates of child abuse reporting [5]. These data imply that child abuse cases are not being identified and reported by the relevant organizations. According to a report from the Ministry of Health, Labour, and Welfare [2] on the contact status with relevant organizations, such as child abuse consultation centers, about 23.0% of total child abuse cases were affected by either no contact with the organizations (16.7%) or had unknown status (6.3%). Thus, it is important to improve counseling and consultations to prevent child abuse.

The relationship between mental illness and infanticide is questionable. Brockington [21] has described a relationship between mental illness and infanticide, and Krüger [22] states that 27% of mothers who committed infanticide (n = 11) suffered from mental illness. Additionally, Stanton [23] has reported on cases of mothers who had developed a mental illness, and Taguchi [16] reported a relationship between child-raising anxiety and infanticide in Japan. Nonetheless, Putkonen [24] and Tursz and Cook [25] have not observed a strong association between infanticide and maternal mental illness. Thus, the link between infanticide and acute mental illness remains questionable and warrants further research.

Marital status and age discrepancy between spouses are also reported risk factors of infanticide. Friedman et al [15] has reported that young, unmarried mothers are at a higher risk of committing infanticide. In contrast, Tursz and Cook [25] claim that 58.8% (n = 17) of infanticide cases were committed by a parent who is married or is living with their partner. Amon [26] has supported the latter statement and reported that more than 50% (n = 28) of people who committed infanticide were married, with an average age of 28 years. Taken together, these observations indicate that marital status and age of the perpetrators remain variable and that detailed investigations on how age and marital status influence infanticide risk are necessary for the better targeting of preventative measures and programs.

The above notwithstanding, our study has a few limitations. First, we sourced data on criminal cases of infanticide recognized by the Metro Police Department alone, which considers only murders and attempted murders of infants aged less than 1 year. Thus, accidental infanticides caused by child abuse may not be included in these data. Additionally, infanticide cases that were never detected/recorded by the police may exist. Thus, it is possible that we have underestimated the number of infanticide cases, which may affect our analysis.

In summary, this study identified differences in the number of infanticides by prefecture and used statistical analysis to obtain estimated infanticide rates. The highest estimates of infanticide rates were 8.6/100,000 births and 7.5/100,000 births. In contrast, infanticide did not occur in six prefectures during the study period. Further, prefectures with the highest and lowest infanticide rates were both non-urban areas, suggesting that regional differences may indeed be important influential factors. Therefore, identifying these regional differences may help develop tailored and effective interventions that prevent infanticide.

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