

Immunization Statuses of Children in Childcare Centers and Sociodemographic Factors Associated with Delayed DTaP4 Immunization

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I. INTRODUCTION

Childhood immunizations are among the most cost-effective health care interventions. Protection from vaccine-preventable disease depends on maintaining high levels of immunization coverage. Thus, assessing the quality of childhood-immunization delivery is crucial in maximizing the individual's and population's protection against vaccine-preventable diseases.

The Korea Centers for Disease Control and Prevention (KCDC) recommends seven basic vaccines (bacille calmette-gu rin (BCG), hepatitis B (HepB), diphtheria, tetanus toxoids and acellular pertussis (DTaP), polio, measles-mumps-rubella (MMR), Japanese encephalitis, and varicella) during childhood and three vaccines for specific-risk populations, including influenza, typhoid fever, and hemorrhagic fever with renal syndrome. Table 1 shows the immunization schedule recommended by the KCDC. The immunization rate for children can be assessed

with an up-to-date immunization measure, which is the proportion of children vaccinated at a certain age (Salmon et al., 2006). Using this method, the Korea Institute for Health and Social Affairs in 2000 reported the following immunization rates: 99.6% for BCG, 98.7%, 98.0%, 95.3%, 75.8% for a series of DTaP, 98.3%, 94.8%, 80.4% for a series of HepB and 90.2% for MMR (cited in Kim, H. Y., 2001). However, since the up-to-date vaccination determines only the coverage at specific ages, it does not allow measurement of delay in age-appropriate vaccinations. Age-appropriate vaccination can be assessed by determining the age at vaccination for a certain vaccine dose (Salmon et al., 2006). Thus, some children may be considered up-to-date even if one or more vaccine doses were administered later than recommended. Studies using the age-appropriate vaccination method reported much lower children's immunization rates (Choi, 2006; Jin & Lee, 2007). Choi (2006) reported the age-appropriate immuni-

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zation rates of children ($n=308,524$) whose data were extracted from the immunization registry of 246 public health centers: the rates were 52.4% for BCG, 13.0%, 71.1%, 14.8% for a series of HepB, 86.5%, 81.0%, 72.3%, 56.5% for a series of DTaP. Polio vaccination 1, 2, and 3 were 86.7%, 81.2%, and 72.9%, respectively and the MMR and varicella were 83.6% and 49.2%. In both studies, DTaP4 was administered relatively at lower rates as 80.4% and 56.5% compared to other DTaPs.

Jin and Lee (2007) investigated with children beginning school using a parent's questionnaire that was validated by the immunization registry of public health centers. The study resulted in the age-appropriate immunization rate of 80.3% for BCG and 86.7%, 77.5%, 57.6%, 68.8% for a series of DTaP. The rates of immunization for a series of HepB were 89.5%, 89.1%, and 86.7%, for HepB1, 2, and 3. Polio 1, 2, 3 was also reported to be 86.8%, 77.8%, 57.8%, respectively, and MMR was 67.7%. Although a rate of over 60-80% of individual age-appropriate vaccination was reported in the study (Jin & Lee, 2007), Kim's study (2006) reported only 50.3% of children received all 4 doses of DTaP, 3 doses of polio, and 1 dose of MMR at the recommended age. To achieve maximum protection against vaccine-preventable diseases, children should receive all immunizations within the recommended age intervals. Delay in the acquisition of immunity through late immunization can be a problem, especially for potentially severe infections in young infants, such as pertussis.

In U.S. only 77.2% of U.S. children aged 19 to 35 months had received their basic immunization series of 4 doses of DTaP vaccine, 3 doses of poliovirus vaccine, 1 dose

of MMR vaccine (CDC, 2002). A national study published in 2002 found that only 9% of U.S. children received all vaccinations by the recommended age, and 55% of children lacked the recommended vaccinations during the first 2 years of life (Luman, McCauley, Stokley, Chu, & Pickering, 2002). Another study reported in 2005 that approximately 34% of children studied were under-vaccinated for less than 1 month while 37% of children were under-vaccinated for more than 6 months during their first 24 months of life (Luman et al., 2005). The failure of age-appropriate immunization during childhood was largely due to a missed opportunity of the fourth dose. In Korea, the DTaP4 is recommended as an additional vaccine be completed by 18 months of age and often shows lower rate of age-appropriate vaccination compared to other DTaPs and vaccines (Choi, 2006; Jin & Lee, 2007). Thus, assessment of delay in age-appropriate vaccination provides more information about timeliness of vaccinations than up-to-date vaccination coverage.

Many studies have examined factors that contribute to whether children were immunized in compliance with the recommended schedules (Kim, Firmpong, Rivers, & Kronenfeld, 2007; Rosenthal et al., 2004; Jeong, 2004). Children in households with 2 or more other children, children with lower maternal education levels, and children of unmarried mothers were at increased likelihood of experiencing immunization delays (Luman et al., 2005). However, children of less educated mothers and in lower household income were more likely to have completed a series of vaccines (Kim et al., 2007). Compared to first born children, third children were more likely to be delayed in receiving DPT4, measles and HepB3 (Dayan et

al., 2006). Utilizing a private clinic, keeping the immunization card, and living in close proximity to clinics were factors for receiving a vaccine of DTaP3 on time (Jin & Lee, 2007; Jeong, 2004). Children receiving their vaccinations from private providers (clinic or hospital) had lower coverage levels than children receiving their vaccinations from other providers (Rosenthal et al., 2004). The vaccination coverage was lower for children whose parents reported problems accessing the health care system because of lack of transportation compared with those who did not report such problems. Thus, the purposes of this study were to assess the immunization status of children present in childcare centers in Korea and to compare sociodemographic factors of children with age-appropriate DTaP4 immunization with those of children with delayed DTaP4 immunization.

II. METHOD

1. Research Design

This study used an explorative, descriptive mail survey design.

2. Sample and Data Collection Procedure

Data for this study came from a large mail survey study of health programs for children in childcare centers, which was conducted between May, 2007 and October, 2007. The original study used a questionnaire to assess overall health needs of children present to the childcare centers. Childcare centers for the study were randomly selected from the registrar of childcare centers in the Women's Policy of Health and Welfare. Of a total of

25,942 registered childcare centers in 16 provinces in Korea, 1,296 centers (5%) were selected using a stratified sampling method. There were 75 public centers, 634 private centers, and 578 home centers included in the study. The mothers of children were asked to complete the questionnaire and return it to the principal investigator. The questionnaire was mailed to the childcare providers in the centers. The childcare providers were then instructed to choose conveniently two of the mothers to complete the questionnaire. Out of 2,592 mothers from 1,296 centers, a total of 431 returned their completed questionnaires (response rate of 16.6%). However, for this study, only children between 1 and 3 years old were purposely selected, and, thus, the final sample of the study included 248 children.

3. Survey Questionnaire:

The survey questionnaire of original study was developed particularly for the study to assess overall health needs of children present to the childcare centers including immunization status. The content validity of the original questionnaire was verified by a pediatric physician and two nursing faculties specializing in pediatrics. However, no reliability test of the questionnaire was performed.

Out of data reported by participated mothers, only following data was selected for this study: the child's immunization status (immunized or not and age at which the child was immunized), reasons for missed opportunities to immunize, if any and sociodemographic information including sex, age of child, the birth order, mother's age, her education level, and household income.

<Table 1> Recommended age for immunization by Korea centers for disease control and prevention

Vaccination dose	Recommended age	Acceptable interval
BCG	<1 month	
Hepatitis B		
1	<1 month	4 weeks
2	2 month	4 weeks
3	6 month	4 weeks
DTaP		
1	2 month	4 weeks
2	4 month	4 weeks
3	6 month	4 weeks
4 *	15~18 month	16 weeks
5 *	4~6 years	2 years
Poliovirus		
1	2 month	4 weeks
2	4 month	4 weeks
3	6 month	4 weeks
4	4~6 years	2 years
MMR		
1	12~15 month	16 weeks
2 *	4~6 years	2 years
Japanese encephalitis		
1	24~24 month	1 year
2	12~24 month	1 year
3	36 months	1 year
4 *	6 years	1 year
5 *	12 years	1 year
Varicella	12~15 month	16 weeks

*: additional vaccination; DTaP:diphtheria, tetanus toxoids, acellular pertussis; MMR: Measles, Mumps, Rubella

4. Data Management and Analysis

It was considered to be missing data when respondents who did not report specific dates for the immunization or who reported that they did not know the child's immunization history. Characteristics of children and mothers were described using a descriptive statistics. Percentages of children who had age-appropriate immunization for a specified series of vaccinations (hepB, DTaP, polio, MMR, and varicella) were calculated using a descriptive statistics. Children (>2years) selected were divided into two groups according to whether they had had an age-appropriate immunization for DTaP4. It is recommended that the DTaP4

as an additional vaccine completed by 18 months of age. Thus, delayed immunization for DTaP4 in this study was defined as the status when the DTaP4 was not administered by 18 months of age. The groups were compared using t-test to identify differences in their sociodemographic factors including age of child, birth order, mother's age, mother's education level, and household income.

III. RESULTS

Of the 248 children, 17.3% were 1 year old 39.1% were 2 years old; and 43.5% were 3 years old. Half of the children were boys. 56.9% children were born first and 29.8%

〈Table 2〉 Characteristics of children and mothers

Variable		n	(percentage)
Age	1 year	43	(17.3%)
	2 year	97	(39.1%)
	3 year	108	(43.5%)
Sex	Boy	123	(49 %)
	Girl	125	(51 %)
Center type	Public	29	(11.7%)
	Private	116	(46.8%)
	Home	103	(41.5%)
Birth order	1st	141	(56.9%)
	2nd	74	(29.8%)
	3rd	26	(10.5%)
	4th	1	(0.4%)
	5th	1	(0.4%)
Mother's age (year)	< 29	45	(18.5%)
	30-39	185	(76.2%)
	39 <	13	(5.3%)
Mother's education	<High school	69	(27.9%)
	>College	176	(72.1%)
Household income (won)	<3,000,000	141	(62.1%)
	3,000,000<	86	(37.9%)

were second . About 11.7% of centers were public, 46.8% private, and 41.5% home centers. Most mothers' ages (76.2%) were between 30 and 39, and most mothers' (72.1%) education levels were higher than a college degree. Table 2 shows characteristics of children and their mothers.

1. Immunization rates and Age-appropriate Immunizations

As shown in 〈Table 3〉, the overall immunization coverage for HepB, DTaP, polio, and varicella among children present in childcare centers was above 95% except for

〈Table 3〉 Immunization rate and age-appropriate immunization

Vaccination dose	Immunization rate n (percentage)	Age-appropriate immunization n (percentage)
Hepatitis B		
1 (n=171)	169 (98.8%)	99 (58.6%)
2 (n=158)	156 (98.7%)	89 (56.3%)
3 (n=156)	155 (99.3%)	93 (59.6%)
DTaP		
1 (n=167)	165 (98.8%)	114 (68.3%)
2 (n=161)	161 (100%)	101 (62.7%)
3 (n=157)	156 (99.3%)	89 (56.7%)
4 (n=117) *	102 (87.1%)	53 (45.3%)
Poliovirus		
1 (n=111)	109 (98.2%)	76 (68.5%)
2 (n=104)	103 (99.0%)	72 (69.2%)
3 (n= 99)	98 (98.9%)	59 (60.0%)
MMR		
1 (n=150)	140 (99.3%)	90 (60.0%)
Varicella		
(n=155)	154 (99.3%)	106 (68.4%)

note: n was calculated after missing data deleted: * indicates additional immunization

DTaP4 (87.1%). The percentage of age-appropriate immunizations of vaccines studied ranged from 45.3% to 69.0%. The first dose of DTaP and polio was about 68%, which is higher than for the following series. Delay between the recommended age at vaccination and actual vaccine administration appears to increase with the number of doses in the series.

2. Sociodemographic Factors Associated with Delayed Immunization of DTPa4

Among sociodemographic factors, only age was a statistically significant difference between children with age-appropriate DTPa4 immunization and children with delayed DTPa4 immunization ($p < .005$) (Table 4). Younger children are more likely to receive the DTaP at recommended age than older children. Although it was not statistically significant, age-appropriately immunized children were more likely to be earlier in birth order their mother's education levels were likely to be lower, and their family household incomes were less than for delayed immunized children.

IV. DISCUSSION

This cross-sectional national survey study explored the immunization status of children taken care of in childcare centers in Korea.

Overall immunization coverage in this study was much higher than the reports from literature published in Korea (Choi, 2006; Jin & Lee, 2007). In general, immunization rates of children in Korea are relatively higher than those in the U.S. and Austria (Hull & McIntyre, 2006; Luman et al., 2002). The reason for this needs to be explored however, rates of age-appropriate immunization of Korean children (40%-60%) were not very different from those in U.S. reports. This finding further suggests investigating the factors that delay childhood immunization and interventions to raise age-appropriate immunization rates.

The results of the study identified that only the age of child is associated with age-appropriate immunization. The fact that younger children are more likely to receive age-appropriate immunization may indicate that those children are more likely to be earlier in birth order. Actually, the mean of birth orders of children immunized with DTaP4 on time in the study is smaller than those of children with delayed immunization of DTaP4. This result is consistent with a study (Dayan et al., 2006) showing that third children compared with first-born children were more likely to be delayed for DTaP4. Other factors, such as mother's education and age, household income, and birth order did not significantly affect whether a child receives an

<Table 4> Sociodemographic factors associated with delayed immunization for DTPa4

Variable	Age-appropriate Immunization (n=53)	Delayed Immunization (n=33)	t	p
Age	2.52	2.70	10.255	.002*
Birth order	1.32	1.50	1.897	.172
Mother's age (year)	32.30	32.48	.205	.652
Mother's education	3.09	3.16	1.030	.313
Household income (won)	316.97	351.03	.392	.533

immunization at the recommended age. This may be explained by the fact that most mothers' ages, education levels, and incomes were not very different from each other, as shown in (Table 2).

In the U.S., childhood immunization rates are 1 of the 10 leading health indicators to assess the health of the nation. Healthy People 2010 objectives call for administration of the recommended vaccines to 90% or more of children by 2 years of age and set a national age-appropriate vaccination target of 80% for children aged 19-35 months (Dayan et al., 2006). The National Immunization Survey (NIS) in the U.S., the primary means of measuring national coverage, uses random-digit dialing methods to survey households with age-eligible children; this is followed by a mail survey to the children's vaccination providers to validate vaccination histories (Salmon et al., 2006). In Korea, in 2002, the National Immunization Registry (NIR) Program was introduced by the KCDC in response to the need for a more systematic and practical means of identifying immunization histories during childhood (Lee et al., 2003). Currently, this program is implemented by all public health centers (Ko, 2007). However, this program has been in the process being implemented in local private practice settings, although more than 80% of these clinics have a computerization infrastructure (Lee et al., 2003). This can be a barrier to effectively managing a national immunization registry since more than half of all children receive their vaccinations in private clinics. It is important to use immunization data from more reliable and accurate systems, such as the NIR program, to represent national data and to manage immunization statuses of children

efficiently. The study findings from population-based cross-sectional studies to determine the percentage of children within a certain geographic area may have limitations in terms of sample selection bias. Children from rural areas are more likely to receive their immunizations in public health centers, and children from inner-city areas are more likely to receive their immunizations at private clinics or hospitals (Lee, 2004; Jin & Lee, 2007).

In recent years, increasing numbers of children receive their daily care in childcare centers in Korea. Over the last few decades, the number of children in childcare centers has increased. This trend is likely to continue in the future. Bringing numerous children together into a childcare facility may be associated with increased transmission of infection among child attendees. Although incidence of vaccine-preventable disease is low, places such as childcare centers have the highest risk of transmission if disease is introduced. Age-appropriate immunization as well as understanding the epidemiology of the infections would allow childcare facilities to reduce infectious disease and provide a healthier and safer environment for their attendees (Brady, 2005). Child health care providers, such as childcare providers serving in childcare centers and pediatricians and pediatric nurses in public health centers and local clinics, should work together to ensure that all children receive all childhood immunizations on time. Childcare providers in childcare centers can play a role in assessing immunization statuses of their children to ensure age-appropriate immunization.

There are limitations to the study. First, information obtained from maternal report was

based on the mother's recall and not validated by the health care providers who administrated the children's vaccinations. In addition, there was a significant amount of missing data in immunization dates that might affect the study results. The age of the child was asked in years rather than in months or according to birth date. This could provide confusion for the mothers when counting their children's ages and, thus, result in inaccurate ages being used in the data analysis. Second, although the childcare centers were selected randomly using a stratified sampling method, the childcare providers were asked to select the mothers to complete the questionnaire, and a potential selection bias could exist. Third, the relatively small sample size with a survey return rate of 16.6% cannot be considered a nationally representative data.

V. CONCLUSIONS

Immunizations are one of the simplest and most effective approaches to protecting the health of children from preventable infectious diseases. Although high immunization coverage of children in childcare centers was reported, the rates of age-appropriate immunization were much lower than the rate of immunization. To fully protect children from vaccine-preventable diseases, all vaccines should be completed at the age recommended. A strategy to increase age-appropriate immunization during childhood needs to be developed. Childcare providers or health care providers employed in childcare centers can play a pivotal role in monitoring the appropriate immunization statuses of children in their care to ensure that they all receive all childhood immunizations on time.

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ABSTRACT

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Purpose: Immunization is one of the simplest and most effective approaches for protecting the health of children from preventable infectious disease. This study assessed the immunization statuses of children presenting to childcare centers in Korea and compared the sociodemographic factors of children with age-appropriate immunization for DTaP4 with those with delayed immunization for DTaP4. **Method:** A national mail survey was used to collect data on the children's immunization history and sociodemographic information. A total of 248 mothers returned completed questionnaires for their children. **Results:** The overall immunization coverage for HepB, a series of DTaP and polio and varicella was above 95%. However, the percentage of age-appropriate immunizations of vaccines ranged from 45.3% to 69.0% depending on the vaccines. Only the age of the child was a significant factor for delayed immunization for DTaP4. **Conclusion:** To fully protect children from vaccine-preventable disease, childcare providers can play a role in monitoring the immunization statuses of children in their care centers to ensure that they all receive all childhood immunizations on time.

Key words : Immunization, Child day care center, Child