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Preliminary Study on Restoration of the Immunization System of the Democratic Peoples' Republic of Korea after Reunification

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Background

According to the 'Immunization Summary' published by the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), the number of infants who died within one year of life in 2013 was 8,000 in North Korea (Democratic Peoples' Republic of Korea, DPRK) and 1,000 in South Korea (Republic of Korea, ROK) [1]. The number of infant deaths per 1,000 in DPRK is 22, the number of infant deaths under the age of 5 is 27, while ROK is 3 and 4, respectively.

About 64% of the world's leading causes of deaths in infants and young children under age 5 included infectious diseases such as diarrhoea, malaria, measles and meningitis [2]. Thus, immunization against infectious diseases is the most cost-effective public health intervention, along with hygiene and anti-bacterial therapy, to protect thousands of infants and young children from epidemic deaths each year [3,4]. DPRK has adopted socialist healthcare system since 1945 and has pursued the following state-led policies, namely: (1) free-of-charge medical treatment, (2) preventive medicine, (3) physician's quota allocation, and (4) combination of Korean traditional medicine and western medicine. However, in the 1990s, the DPRK government suffered from the disintegration of the Soviet Union, the death of president Kim Il-Sung in 1994, and the severe economic and food crisis that began in 1995. During this period, the above-mentioned 'four healthcare policies' have completely lost function, and most of the antibiotics and preventive vaccines depended on relief goods from foreign governments, international organizations and medical charities [5].

The collapse of DPRK's healthcare system threatened the health status of young and infants more seriously [6]. As the direct causes of DPRK's high rate of infant mortality is infectious diseases as well as malnutrition, it is urgent to secure vaccines and supply chain management for the large-scale vaccination needed for rapid re-unification on the Korean peninsula in the future [7]. Therefore, to restore the immunization system for young and infants in DPRK to the same level as that of ROK, basic studies were needed in advance to understand the incidence of infectious diseases, vaccination, and vaccine supply and demand status in DPRK.

Methods

It is a common opinion among experts that the accuracy and reliability of the healthcare data published by some international organizations as well as by the DPRK government are low and insufficient. In general, the group that best understands the realities of DPRK society is those who were born and escaped while living in DPRK. There are more than 32,000 people who settled in ROK as of 2017. In order to obtain relatively accurate information on DPRK's healthcare reality, we first gathered data from UNICEF and WHO. Among the people who escaped from DPRK, medical personnel, teachers of the nursery schools or kindergartens, and ordinary people who raised their children were selected and in-depth interviews were conducted to correct errors in the data, repeatedly. In addition, the statistics of the vaccination, the annual report on the prevention and control of infectious diseases, and the data on the public disclosures of the ROK government, were collected and compared with the information of the DPRK and the international organizations [8].

Results

Birth and mortality rates

The number of newborns, young and infant survivors, the rate of infant-mortality, and the mortality rate under-5 years in DPRK were higher than the data released by UNICEF and WHO, but the young and infant survival rate was smaller. Particularly, errors to infant mortality and under-5 mortality were very significant. Pre-1990 infant mortality rate was 20%, well over 60% in the mid-1990s, and 70~80% in the late-1990s (Table 1).

Immunization Status of DPRK and ROK

The estimated 2012 DTP3 coverage rate for infants under 12 months of age worldwide was 83% (range: 72~97%), with 110.6 million inoculated. BCG, Polio3 and MCV1 were 89%, 84% and 84%, respectively. In 2012, 131 (68%) countries achieved a DTP3 immunization rate of over 90%, and 59 (30%) countries achieved an inoculation rate of over 80% in all regions. In 34 (18%) countries, DTP3 vaccination rates were 80~89%, 70-79% in 13 (7%) and less than 70% in 16 (8%) countries. Hepatitis B vaccine was introduced in 181 (93%) countries as an essential vaccine for infants and young children, with 79% (72~91%) of hepatitis third vaccination rates (including countries that did not receive vaccines). The third vaccination rate of Haemophilus influenzae type b (Hib) vaccine introduced in 184 (91%) countries by the end of 2012 was 45% (11~91%). Rotavirus vaccine was introduced in 41 (21%) countries and Pneumococcal Conjugate Vaccine (PCV) in 88 (45%) countries. The rate of complete inoculation of rotavirus was 11% globally but 69% in the North America [9].

According to UNICEF, the vaccination rate for DPRK is over 94%. According to the WHO's immunization data, the proportion of BCG immunization in the country as of 2014 was 98%. Diphtheria, pertussis and tetanus immunization, which are essential for infants, were 94% and 93%, respectively. Hepatitis B and polio vaccination rates were 99%. However, according to the testimony of the refugees, DPRK's medical practitioners survey and record the area in charge almost every day to write health statistics, but if the errors are not carefully corrected when the data is firstly written without duplicate review, the published statistics are also less reliable [10].

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Indicator	DPRK		ROK	
	UN data¶	Actual data	UN data¶	Actual data+
Births*	3,58,000	△	4,72,000	4,36,455
Surviving infants§	3,50,000	▽	4,71,000	4,35,888
Infant mortality rate† (per 1,000 live births)	22	△	3	3
Under-five mortality rate‡(per 1,000 live births)	27	△	4	-

DPRK (Democratic Peoples' Republic of Korea, North Korea); ROK (Republic of Korea, South Korea).
*The number of children born each year.
§The number of children who have survived beyond their first year of life.
†The probability of dying between birth and exactly one year of age. The rate is expressed as the number of infant deaths per 1,000 live births.
‡The probability of dying between birth and exactly five years of age. The rate is expressed as the number of deaths of children under age five per 1,000 live births.
¶Data source: Immunization Summary, A statistical reference containing data through 2014 (The 2014 Edition). UNICEF and WHO.
+Data source: Live birth (August). Vital Statistics. Statistics of ROK government.
△,▽: Signs that indicate greater or less than the data presented in the left column.

Table 1: Births and mortality rates of DPRK and ROK [10].

	DPRK												ROK	
	1980		1990		1995		2000		2007		2013			
Vaccine	UN data§	Actual data	UN data§	Actual data	UN data§	Actual data	UN data§	Actual data	UN data§	Actual data	UN data§	Actual data	UN data§	Actual data*
BCG	50	-	99	▽	82	▽	78	▽	96	▽	98	▽	99	99.8
DTP1	74	-	98	▽	84	▽	61	▽	93	▽	94	▽	99	99.9
DTP3	50	-	98	▽	64	▽	56	▽	92	▽	93	▽	99	99.6
HepBB	-	-	-	▽	-	▽	0	▽	96	▽	99	▽	0	99.9
HepB3	-	-	0	▽	0	▽	0	▽	92	▽	93	▽	99	99.4
Hib3	-	-	0	▽	0	▽	0	▽	0	▽	0	▽	0	89.3
Rota	-	-	-	▽	-	▽	-	▽	0	▽	0	▽	0	34.2
PcV3	-	-	-	▽	-	▽	-	▽	-	▽	0	▽	0	77.8
Pol3	50	-	99	▽	88	▽	93	▽	99	▽	99	▽	99	99.4
MCV1	29	-	98	▽	67	▽	78	▽	99	▽	99	▽	99	99.6
MCV2	-	-	-	▽	-	▽	0	▽	0	▽	99	▽	95	-
PAB	0	-	90	▽	90	▽	81	▽	91	▽	93	▽	-	-

DPRK (Democratic Peoples' Republic of Korea, North Korea); ROK (Republic of Korea, South Korea); BCG (Bacillus Calmette-Guérin, vaccine against tuberculosis); DTP1 (first dose of diphtheria and tetanus toxoid with pertussis vaccine); DTP3 (third dose of diphtheria and tetanus toxoid with pertussis vaccine); HepBB (birth dose of hepatitis B vaccine); HepB3 (third dose of hepatitis B vaccine); Hib3 (third dose of Haemophilus influenzae type b type B vaccine); Rota (last dose of rotavirus vaccine); PcV3 (third dose of Pneumococcal conjugate vaccine); Pol3 (third dose of polio vaccine); MCV1 (first dose of measles-containing vaccine); MCV2 (second dose of measles-containing vaccine); PAB (protection at birth against tetanus).
*Source: 2013 Korea National Immunization Survey, Korea Centers for Disease Control & Prevention, ROK.
§Source: Immunization Summary, a statistical reference containing data through 2014 (The 2014 Edition), UNICEF and WHO.
△,▽: Signs that indicate greater or less than the data presented in the left column.

Table 2: The United Nations data and testament of interviewees on immunization coverage rate of DPRK (%, interviewee's estimates, as of July 2015) [10].

Since 1995, the free-supply of almost all medicines by the government has been discontinued. In 1997, some of the UN-sponsored vaccines were distributed, but this was only a benefit for the Communist Party executives and intelligentsia classes. During the period from 1990 to 2005, nationwide immunizations became impossible, and the state-sponsored immunizations for children were not restored to date (Table 2).

The decline of the immunization program over the years has been confirmed in the Multiple Indicator Cluster Survey (MICS), which was conducted concurrently with the 1998 Nutrition Survey. According to the survey, the vaccination rate is very low. Among children aged 12~23 months, 63.9% were vaccinated against BCG, DPT and measles vaccination rate was less than 40%, and polio vaccination rate was 76.5%. Tetanus showed that only 4.6% of pregnant women and mothers with children under two years of age were injected twice with tetanus toxin. In 2000, BCG 85%, DPT 84%, polio 90.6%, measles 91.5%, and the vaccination against tetanus to maternal was 85.6% overall. In 2001, 70% of measles and 50% of tetanus toxins were detected, and polio is now more than 95% [11].

DPRK government has been trying to take responsibility for 7 types of infectious diseases, including tuberculosis, hepatitis B, diphtheria-tetanus-pertussis, measles-mumps-rubella, chickenpox, Japanese encephalitis and typhoid. The government has not been able to pay attention to the prevention of polio, Hib, and even rotavirus infections [12]. So, the prevalence of these pathogens is sure to be very serious. Moreover, vaccination against HPV, shingles and meningococci may only be possible in a vicinity of the capital city, Pyongyang (Table 3).

On the other hand, in ROK, the government is paying the total cost of vaccination for major 14 infectious diseases to all children under the age of 12 [13], and both the inoculation schedules and the overall preventive practices are excellent (Table 3 and Table 4). The urgent necessary vaccines for DPRK are tuberculosis, hepatitis B, diphtheria-tetanus-pertussis, polio and typhoid [14,15]. However, all the 14 kinds of vaccines included in the standard vaccination schedule of ROK should be provided as quickly as possible for DPRK's children and infants [16]. Also, vaccination against hepatitis A and influenza infections, which are rampant every year, is also needed [17].

Quantity of vaccine needed and estimated cost

Rapid restoration of the immunization system for young children and infants in DPRK is very important. To do a forecasting, we set the

Classification	Disease	Vaccine	Immunization	Coverage rate (%)
National coverage	Tuberculosis	BCG (intradermal)	o	87.5
	Hepatitis B	HepB	o	37.5
	Diphtheria, tetanus, pertussis	DTaP, Td/Tdap	o	75
	Polio	IPV	o	12.5
	Haemophilus influenzae type b	PRP-T/HbOC	o	12.5
	Pneumococcal	PCV (conjugate) PPSV (polysaccharide)	×	0
	Measles, mumps, rubella	MMR	o	62.5
	Varicella	Var	o	75
	Hepatitis A	HepA	×	0
	Japanese encephalitis	JE (killed), JE (live attenuated)	o	75
	Influenza	Flu (killed), Flu (live attenuated)	o	12.5
Private coverage	Tuberculosis	BCG (transcutaneous)	×	0
	Rotavirus	RV1 RV5	×	0
	Human papillomavirus	HPV4/HPV2	×	0
	Herpes zoster	Zoster	×	0
	Meningococcal	MCV	×	0
	Typhoid	ViCPS	o	37.5
DPRK (Democratic Peoples' Republic of Korea, North Korea).				

Table 3: Immunization coverage in DPRK (Survey results as of July 2015) [10].

Disease	Vaccine	Standard dosing number*	Cost per dose	
			(KRW)	(USD)
Tuberculosis	BCG (intradermal)	1	16,950	15.41
Hepatitis B	Hep B	3	2,230	2.03
Diphtheria, tetanus, pertussis	DTaP	3	4,510	4.1
	Td	-	12,600	11.45
	Tdap	-	19,290	17.54
Polio	IPV	3	8,420	7.65
Diphtheria, tetanus, pertussis, polio	DTaP-IPV	3	20,210	18.37
Measles, mumps, rubella	MMR	1	10,650	9.68
Varicella	Var	1	12,570	11.43
Japanese encephalitis	JE (killed, mouse brain-derived)	3	4,840	4.4
	JE (live attenuated)	2	11,210	10.19
Haemophilus influenzae type b	Hib	3	5,630	5.12
Pneumococcus	PCV (conjugate) 13	3	59,740	54.31
	PCV (conjugate) 10	3	51,600	46.91
	PPSV (polysaccharide)	-	14,310	13.01
Hepatitis A	Hep A	2	14,360	13.05
ROK (Republic of Korea, South Korea); *Standard doses based on 2015 Korea Immunization Schedule; KRW (Korean Won,₩); USD (U.S. Dollar, $ 1.00=KRW 1,100).				

Table 4: Immunization commission fee by regulations on commission of vaccination in ROK (As of July 2015) [10].

demand for vaccine by assuming that the target to be achieved first is the same as the National Childhood Immunization Program in ROK in 2015 (Table 5) [19,20]. In addition, the following conditions were applied: all the booster doses are accepted, DTaP, JE (killed, attenuated), PCV 13 are chosen and inoculated to prevent diphtheria, tetanus, pertussis, Japanese encephalitis, pneumococcal infections. By the official statistics of the year 2015, the number of newborn infants in ROK was 436,455. And in DPRK is estimated to be 358,000. Based on these figures, the quantity of vaccine needed for inoculation was estimated. When applying the prices of ROK in 2015, the cost of vaccination will be $ 106 million and $ 129 million for DPRK and ROK, respectively (Table 5). Considering the poor supply of electricity and road transport systems in DPRK, the cost of transporting and refrigerating the vaccine was excluded because it is difficult to estimate.

Discussion and Conclusion

In DPRK, young children and infants are suffering from infectious diseases, and the national immunization system is not implemented normally. Although some vaccines are provided by humanitarian assistance projects of international organizations, distribution and supply are limited, and many young children are still unable to obtain immunity against infectious diseases [21]. In the current situation that the major cause of deaths in young children under 5 years is malnutrition and infectious diseases, various humanitarian approach and support measures are needed for early recovery of vaccination system. A simple prediction suggests that an additional $ 106 million a year is needed to restore the DPRK's immunization system after the reunification of the Korean peninsula.

Disease	Vaccine	DPRK§		ROK*	
		Total dose	Cost (USD)	Total dose	Cost (USD)
Tuberculosis	BCG (intradermal)	3,58,000	55,16,455	4,36,455	67,25,345
Hepatitis B	Hep B	10,74,000	21,77,291	13,09,365	26,54,440
Diphtheria, tetanus, pertussis	DTaP	10,74,000	44,03,400	13,09,365	53,68,397
Polio	IPV	10,74,000	82,20,982	13,09,365	1,00,22,594
Measles, mumps, rubella	MMR	3,58,000	34,66,091	4,36,455	42,25,678
Varicella	Var	3,58,000	40,90,964	4,36,455	49,87,490
Japanese encephalitis	JE (killed)	10,74,000	47,25,600	13,09,365	57,61,206
Haemophilus influenzae type b	Hib	10,74,000	54,96,927	13,09,365	67,01,568
Pneumococcus	PCV (conjugate) 13	10,74,000	5,83,27,964	13,09,365	7,11,10,423
Hepatitis A	Hep A	7,16,000	93,47,055	8,72,910	1,13,95,443
Total sum		82,34,000	10,57,72,727	1,00,38,465	12,89,52,614

DPRK (Democratic Peoples' Republic of Korea, North Korea); ROK (Republic of Korea, South Korea).
§ multiplied by DPRK's births as 358,000 [1]; *multiplied by ROK's births as 436,455 [18]; USD (U.S. Dollar, $).

Table 5: Estimates of paediatric immunization doses and costs per year for DPRK and ROK (As of July 2015) [10].

According to ROK government data, the number of DPRK defectors living in ROK exceeded 30,000 in mid-2016 [22]. Of the defectors who settled in ROK, 110 were doctors, 158 were nurses, and 9 were pharmacists [23]. The healthcare situation of DPRK's children and infants revealed through their testimony was much worse than that already known by UNICEF or WHO figures. Unfortunately, vaccine medicines have been introduced into DPRK through international relief organizations, including UNICEF. However, only a small amount is supplied to ordinary people because of the strong control of the DPRK government, and the amount used for strengthening immunity of DPRK's children was extremely small. On the other hand, Inter-Korean Cooperation Fund (IKCF) has been established by ROK and is being supported every year. Cumulative amount executed in the last 5 years (2012~2016) is 943 million dollars. Among them, humanitarian aid projects amounted to US $ 3.92 million, only 0.5% of the total. In other words, if the current Korean Unification Fund or the IKCF are used and the DPRK government accepts the import of medicines or gratuitous supplies, it is possible to supply the entire amount of vaccine for childhood vaccination that DPRK needs immediately [24]. In June 2017, the DPRK government requested a $ 6 million humanitarian grant from the ROK government to conduct a population surveys. However, due to recent political issues, DPRK is receiving international economic sanctions; it is a troubled and unfortunate situation.

Finally, the results of this study addressed the actual situation of vaccination against DPRK's children. However, some of the defectors were selected indirectly in a short period of time by selecting a small number of experts, the amount of information collected was low, and the subjectivity was not fully eliminated.

Conflict of Interest

The authors declare that they have no conflict of interest.

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