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2013 Modularization of Korea's Development Experience:

# Sustained National Deworming Campaign in South Korea 1969-1995

2014

MINISTRY OF HEALTH & WELFARE

KDI SCHOOL
KDI School of Public Policy and Management

2013 Modularization of Korea's Development Experience:

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# Sustained National Deworming Campaign in South Korea 1969-1995

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|---|---|
| Title | Sustained National Deworming Campaign in South Korea 1969-1995 |
| Supervised by | Ministry of Health and Welfare, Republic of Korea |
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| Research Management | KDI School of Public Policy and Management |
| Supported by | Ministry of Strategy and Finance (MOSF), Republic of Korea |

Government Publications Registration Number 11-1051000-000455-01

ISBN 979-11-5545-107-6 94320

ISBN 979-11-5545-095-6 [SET 18]

Knowledge
Sharing
Program

Government Publications
Registration Number
11-1051000-000455-01

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# Preface

The study of Korea's economic and social transformation offers a unique window of opportunity to better understand the factors that drive development. Within one generation, Korea had transformed itself from a poor agrarian society to a modern industrial nation, a feat never seen before. What makes Korea's experience unique is that its rapid economic development was relatively broad-based, meaning that the fruits of Korea's rapid growth were shared by many. The challenge of course is unlocking the secrets behind Korea's rapid and broad-based development, which can offer invaluable insights, lessons and knowledge that can be shared with the rest of the international community.

Recognizing this, the Korean Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI) launched the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience and to assist its developing country partners. The body of work presented in this volume is part of a greater initiative launched in 2007 to systematically research and document Korea's development experience and to deliver standardized content as case studies. The goal of this undertaking is to offer a deeper and wider understanding of Korea's development experience in hopes that Korea's past can offer lessons for developing countries in search of sustainable and broad-based development. In furtherance of the plan to modularize 100 cases by 2012, this year's effort builds on the 20 case studies completed in 2010, 40 cases in 2011, and 41 cases in 2012. Building on the past three year's endeavor that saw publication of 101 reports, here we present 18 new studies that explore various development-oriented themes such as industrialization, energy, human capital development, government administration, Information and Communication Technology (ICT), agricultural development, and land development and environment.

In presenting these new studies, I would like to express my gratitude to all those involved in this great undertaking. It was their hard work and commitment that made this possible. Foremost, I would like to thank the Ministry of Strategy and Finance for their encouragement and full support of this project. I especially would like to thank KSP Executive Committee, composed of related ministries/departments, and the various Korean research institutes, for their involvement and the invaluable role they played in bringing this project together. I would also like to thank all the former public officials and senior practitioners for lending their time and keen insights and expertise in preparation of the case studies.

Indeed, the successful completion of the case studies was made possible by the dedicated efforts of the researchers from the public sector and academia involved in conducting the studies, which I believe will go a long way in advancing knowledge on not only Korea's own development but also development in general. Lastly, I would like to express my gratitude to Professors Kye Woo Lee, Jinsoo Lee, Taejong Kim and Changyong Choi for their stewardship of this enterprise, and to the Development Research Team for their hard work and dedication in successfully managing and completing this project.

As always, the views and opinions expressed by the authors in the body of work presented here do not necessary represent those of the KDI School of Public Policy and Management.

**April 2014**

**Joon-Kyung Kim**

**President**

**KDI School of Public Policy and Management**

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# Summary


1. South Korea successfully implemented a sustained, nation-wide deworming campaign that was jump-started in 1969 with a three-year massive assistance program from the Overseas Technical Cooperation Agency (OTCA) of Japan, culminating in the 1997 WHO declaration that the country is essentially worm-free. This report presents objectives and achievements of this successful national deworming campaign; backgrounds and needs for the campaign; strategy and system employed; details of implementation; and assessment of impacts of the deworming campaign, from both epidemiological and economic perspectives.

2. Up until the 1960s before launching of the campaign, intestinal worm infection was endemic to all area of Korea, and most individuals in the population carried several different kinds of intestinal worms. Roundworms, whipworms, hookworms, and tapeworms were the most prevalent parasite species. In addition, many people suffered from clonorchiasis and infection by other types of worms. The Korean parasitologists and government officials were acutely aware of the health consequences of the intestinal worm infection, and of the likely negative impacts on educational and economic outcomes for those infected.

3. Leading parasitologists established the Korea Association for Parasite Eradication in 1964 with the goal of reducing the incidence of intestinal worm infection to zero within 10 years. In retrospect, their initial goal was overly ambitious, and it took the Association five years to lay down the necessary groundwork, and to sustain a sensible strategy for comprehensive school-based examinations and treatments for the next two and a half decades. The combined efforts by the Association and the government dramatically reduced the worm infection rates until it was decided that the comprehensive examination and treatment regimen might be safely ceased in 1995.

Population dynamics of intestinal worms imply the existence of a "break point". If a deworming campaign is prematurely ceased before the infection rate reaches the break point, the infection rate is bound to shoot back up to its former level of prevalence. If the infection rate is brought below the point, however, then the worm population should remain under check. That the national worm infection rates have remained at negligible levels for close to two decades since the halt of the massive intervention in 1995, suggests that the national deworming campaign indeed succeeded in overreaching this break point. Results from epidemiological assessments are indeed in line with this view.

4. This remarkable feat was achieved at modest costs to the public purse. Perhaps this had to do with the fact that the leading agency in charge of the national deworming campaign, KAPE, was a voluntary association of accomplished professionals dedicated to the mission of national deworming. The overhead at the Association was less than one third of the outlay, even including costs for construction of testing facilities. The Association was nimble and entrepreneurial. The Korean deworming campaign was the world's first mass deworming campaign to adopt the newly developed, much cheaper, Kato's stool examination method. The parasitologists at KAPE also worked closely with a local pharmaceutical company to develop and test effective treatments. This collaboration resulted in effective medications optimized for the mixture of worms usually found in the host in the country available for the deworming campaign at a fraction of the financial burden it might have cost otherwise. These innovations undoubtedly saved taxpayers' money, and helped sustain the national campaign for as long as it was needed.

5. To study long-term impacts of this sustained deworming campaign on educational attainment and productivity gains on the part of beneficiaries, we match individual workers from the 2000 Korean Census with the prevailing worm infection rate in the region where the worker attended middle school. The empirical strategy is inspired by the series of investigations by Hoyt Bleakley in his study of the long-term impacts of deworming in the American South. The results from our empirical analysis suggest substantial gains in years of schooling and other indicators of educational attainment, and also gains in earnings (and hence presumed gains in productivity).

6. Perhaps the three most important lessons that we may draw from this study of the Korean national deworming campaign are (a) that sustained, national deworming is a highly sensible public investment with the potential of huge returns, (b) that comprehensive school-based examination and treatment is a sound strategy, and (c) that to maximize the return for the public investment it is crucial that such a campaign be sustained long enough, until the campaign breaches the "break point".

7. Sustaining a huge, national operation over a long period that a national campaign may require, is not an easy task in any society. It is particularly more difficult and challenging to developing countries that are struggling with poor government finance, inadequate institutions, and lack of quality human capital in critical mass among other things. The fact that Korea was able to pull this off should be an encouragement to them. For those considering design and implementation of a similar comprehensive national deworming strategy, we offer the following practical observations based on the Korean experiences: (a) an integrated legal foundation is essential for coordination among multiple stakeholders including various government ministries and local government authorities, as well as to sustain the momentum, (b) an independent body, like the KAPE, formed by accomplished and dedicated practitioners, should bring vitality and necessary agility, saving costs and helping sustain the momentum, (c) it is important that the examination and treatment regime be accompanied by rigorous, scientific efforts to monitor the progress of the campaign, so that the results might be deployed for on-going assessment and public awareness campaigns, and (d) efforts should be made to maximize leverage from opportunities to collaborate with donors and technical cooperation, in the form of policy consultation and manpower training, may prove to be as important, if not more, as in-kind aid or financing.

## Acknowledgements

We gratefully acknowledge the help the authors of this report received in the course of the study from the Ministry of Health and Welfare, the Korea Association for Health Promotion (formerly the Korea Association for Parasite Eradication), especially Mr. Chung Ha Yoon currently the head of the Gangnam branch office of the KAHP, the Korea Foundation for International Healthcare, Prof. Han-Jong Rim of Korea University, KOICA, JICA, and Good Neighbors. Taejong Kim feels indebted to KOICA and Good Neighbors for the permission to study an on-going deworming program in Mwanza, Tanzania, and thankful to Prof. Keeseon Eom of Chungbuk National University (former President of the Korean Society for Parasitology) and his parasitology colleagues volunteering for the Mwanza program for the valuable chance to observe and learn from a field operation in deworming. Taejong Kim is also thankful to Prof. Jungho Kim of Ajou University, his research partner in a concurrent study investigating long-term impacts of the Korean deworming campaign on education and economic outcomes for his permission to use part of the unpublished work in progress for this report, to Ms. Sunjin Kim and Ms. Eunkyung Min of KDI School for excellent research assistance, and to Ms. Min Young Seo in the Impact Evaluation Lab of KDI School for administrative and moral support. We owe a lot to Mr. Jeong kyun Im of KDI School for his patient support. Our research benefited from critical comments by Prof.

Hyeok Jeong of KDI School, and additional comments by Prof. Yoshito Takasaki, Prof. Yasuyuki Sawada and other participants at the 2013 Hayami Conference for Development Economics and also by participants in the Evaluation of Social Programs session of the 2014 AEA Meetings. Last but not least, we salute Dr. Joon-Kyung Kim, the President of KDI for championing this project as the founding managing director of the KDI School's Development Learning and Research Network, and Prof. Kye Woo Lee for disciplined stewardship of the Network and its research activities including this study as the successor to President Kim.

We are humbled and honored to dedicate this study to the present and past members of the Korea Association for Parasite Eradication in memory of their lasting contribution for promotion of public health in the country and their dedication for public service.

# Chapter 1

## Objectives and Achievements

# Objectives and Achievements

The story of the Korean deworming campaign largely overlaps with the history of the Korea Association for Parasite Eradication (KAPE), established in 1964. The KAPE was a voluntary association of Korean parasitologists and practitioners in the field, who got together with the aim of exterminating intestinal worms in the country. The Association was responsible for the design of the deworming strategy and for its implementation. The Association played an instrumental role in organizing the institutional foundation with advocacy activities that led to legislation of a basic law that enabled close strategic partnership between the government and the community of practitioners for parasite control in Korea. The success of the Korean deworming campaign would not have been possible without the committed efforts on the part of the KAPE to secure crucial aid from overseas to kick-start the campaign and government buy-in afterward.

The Association's goal at its inception in 1964 to achieve eradication of worm infection within 10 years in the country proved to be overambitious. As it turned out, it took some time to lay the necessary groundwork, the single most important milestone being the legislation of the Parasitic Disease Prevention Act in 1966, and secure adequate resources from various sources. The Korean deworming campaign really launched on a national scale in 1969. The Association, however, maintained its strategic commitment to the initial goal of complete eradication of intestinal worm infection through thick and thin.

The key thrust in the national deworming strategy adopted and implemented by the KAPE was school-based collective screenings and mass treatment of all children infected. The strategy covered all schools in the country, primary and secondary, and was sustained for more than two decades until 1995 when the national infection rate fell below 0.02%. In 1997, the World Health Organization declared the country essentially worm-free.

<Table 1-1> shows the changes in *A. lumbricoides* (roundworm) infection rates among students in the nation's elementary, middle, and high schools through the period of 1969 till 1995. The roundworm was the single most prevalent of intestinal worms, or soil-transmitted helminths in the country. The standard test for infection examines eggs of intestinal worms (both fertilized and unfertilized) from fecal samples. The infection rate is measured then by the so-called egg-positive rate, or the proportion of egg-positive persons. The figures in the table document dramatic decreases in the egg-positive rate throughout the period. The infection rates for the other parasites registered a similar, dramatic decline in the course of the national campaign, as presented in the third column of the table. For the roundworm, the egg-positive rate dropped from 55.4% in 1969 to below 1% in 1987. The egg-positive rate for all intestinal worms dropped from 77% in 1969 to less than 1% in 1989. The U-rate measures the proportion of individuals who tested positive of unfertilized eggs over all egg-positives. The gradual increase in the U-rate as shown in the last column demonstrates the degeneration in the capacity for regeneration in the worm population. [Figure 1-1] presents the same information in a visual form.

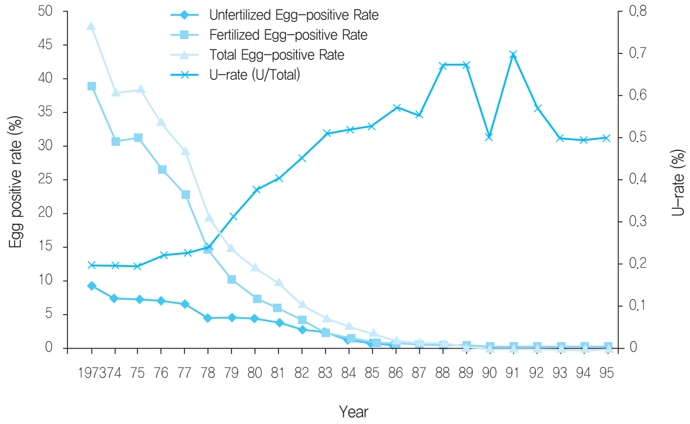
The KAPE took pains to carefully document the results of worm infection screenings of school children, carried out twice a year until 1987. After 1987, convinced that the worm infection was brought under sufficient control, the KAPE changed the screening regime to once every year. The annual efforts were supplemented by national sample surveys covering the entire population, not just the school children, once in every five years, starting from 1971.

**Table 1-1 | Changes in *A. lumbricoides* Infection Rates of Students (Elementary, Middle and High School): 1969-1995**

| Year | Number of Students Examined | Total Number of Students Positive for Eggs (%) | | Number of Egg-positive Persons (%) | | | | | | U-rate (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Unfertilized ** | | Fertilized ** | | Total | | |
| 1969* | 6,551,926 | 5,046,216 | (77.0) | - | | - | | 3,631,699 | (55.4) | |
| 1970* | 10,871,280 | 8,095,911 | (74.5) | - | | - | | 6,042,588 | (55.6) | |
| 1971* | 11,813,868 | 8,429,031 | (71.3) | - | | - | | 6,100,187 | (51.6) | |
| 1972* | 11,243,033 | 7,179,521 | (63.9) | - | | - | | 5,148,951 | (45.8) | |
| 1973* | 12,116,892 | 7,903,665 | (65.2) | 1,133,687 | (9.4) | 4,696,540 | (38.8) | 5,830,227 | (48.1) | 0.20 |
| 1974* | 11,901,236 | 6,350,121 | (53.4) | 895,301 | (7.5) | 3,650,208 | (30.7) | 4,545,509 | (38.2) | 0.20 |
| 1975* | 12,480,942 | 6,459,819 | (51.8) | 934,247 | (7.5) | 3,901,162 | (31.3) | 4,835,409 | (38.7) | 0.19 |
| 1976* | 13,423,636 | 6,104,644 | (45.5) | 978,360 | (7.3) | 3,540,956 | (26.4) | 4,519,433 | (33.7) | 0.22 |
| 1977* | 14,160,212 | 5,601,692 | (39.6) | 965,005 | (6.8) | 3,246,719 | (22.9) | 4,211,724 | (29.7) | 0.23 |
| 1978* | 15,030,061 | 4,200,218 | (27.9) | 684,927 | (4.6) | 2,229,938 | (14.8) | 2,914,865 | (19.4) | 0.24 |
| 1979* | 15,592,977 | 3,620,058 | (23.2) | 746,000 | (4.8) | 1,601,664 | (10.3) | 2,347,664 | (15.1) | 0.32 |
| 1980* | 15,495,361 | 3,050,527 | (19.7) | 720,355 | (4.6) | 1,162,655 | (7.5) | 1,882,895 | (12.2) | 0.38 |
| 1981* | 16,229,764 | 2,589,943 | (16.0) | 661,154 | (4.1) | 996,606 | (6.1) | 1,657,760 | (10.2) | 0.40 |
| 1982* | 16,216,136 | 1,947,871 | (12.0) | 1,042,498 | (3.1) | 620,413 | (3.8) | 1,122,911 | (6.9) | 0.45 |
| 1983* | 16,220,369 | 1,356,812 | (8.4) | 386,771 | (2.4) | 374,132 | (2.3) | 760,903 | (4.7) | 0.51 |
| 1984* | 16,091,005 | 889,495 | (5.5) | 257,276 | (1.6) | 217,198 | (1.5) | 492,474 | (3.1) | 0.52 |
| 1985* | 15,812,300 | 622,285 | (4.0) | 176,837 | (1.1) | 142,961 | (0.9) | 319,798 | (2.1) | 0.52 |
| 1986* | 14,861,006 | 403,015 | (2.7) | 112,517 | (0.8) | 87,408 | (0.6) | 199,925 | (1.4) | 0.57 |
| 1987* | 13,206,807 | 241,584 | (1.9) | 60,884 | (0.5) | 52,205 | (0.5) | 112,693 | (0.9) | 0.56 |
| 1988* | 12,703,799 | 148,261 | (1.2) | 39,920 | (0.4) | 30,289 | (0.3) | 112,184 | (0.6) | 0.67 |
| 1989 | 9,594,316 | 76,640 | (0.8) | 20,328 | (0.2) | 12,928 | (0.3) | 33,256 | (0.6) | 0.67 |
| 1990 | 9,146,913 | 50,579 | (0.6) | 12,150 | (0.1) | 9,638 | (0.1) | 21,788 | (0.2) | 0.50 |
| 1991 | 8,212,776 | 24,058 | (0.3) | 5,693 | (0.07) | 3,597 | (0.1) | 9,290 | (0.1) | 0.70 |
| 1992 | 4,294,499 | 8,310 | (0.2) | 1,653 | (0.04) | 1,239 | (0.03) | 2,892 | (0.07) | 0.57 |
| 1993 | 1,699,141 | 4,121 | (0.2) | 444 | (0.02) | 661 | (0.02) | 1,105 | (0.04) | 0.50 |
| 1994 | 1,531,706 | 3,576 | (0.2) | 334 | (0.02) | 334 | (0.02) | 668 | (0.04) | 0.50 |
| 1995 | 1,334,517 | 2,245 | (0.2) | 156 | (0.01) | 85 | (0.006) | 241 | (0.02) | 0.50 |
| Total | 307,836,478 | | | | | | | | | |

* Sum of both spring and fall examination results. ** Unfertilized: unfertilized eggs, Fertilized: fertilized eggs.
Source: Reproduced from Chai JY, 2011.

**Figure 1-1 |** Changes in *A. lumbricoides* Egg-prevalence and U-rates During 1973-1995




Source: Reproduced from Chai JY, 2011.

The main results from the national surveys are presented in <Table 1-2>. The results show that the worm infection rates dramatically decreased not just for roundworms, but also for hookworms and whipworms, the other intestinal worms with initially high rates of prevalence. The information in <Table 1-2> also demonstrates that worm prevalence was coming down not just for school children, subjected to the mass screening and mass treatment regime, but also for the adult population as well. The same information is also visually presented in [Figure 1-2]. The figure also shows the changes in per capita income for reference.

One particular challenge specific to the treatment and prevention of parasitic diseases is that there is no vaccine developed yet. Thus, patients once cured of infection at a point benefiting from chemotherapy remain vulnerable to risks of getting infected again. It is commonly observed in the field that population infection rates tend to shoot back up to its former level of prevalence once mass intervention stops.

Later in the report, we develop and present a simple dynamic model of worm infection rates in the vulnerable population, featuring this "stable steady state", and some other stylized facts in the epidemiology of intestinal worm infection. The model demonstrates that there are in fact two stable steady states, the other being the state of zero infection, and that there is bound to be a "break point". The break point is itself a steady state, but an unstable one. If the population infection rate is anywhere above this break point, the infection rate will over time shoot back up; if the infection rate is below the break point, the population infection will gradually converge to zero. The model thus leads to a natural and powerful policy implication: to maximize the benefit-cost ratio, or to maximize the "bang for the buck", mass intervention in chemotherapy for worm infection should be sustained until the population infection rate is brought under the break point.

The national deworming campaign in Korea, featuring comprehensive screenings of all school children and treatment of all those who tested positive, was brought to a halt in 1995. The reader may note that the intestinal worms in Korea were never literally exterminated even after 1995. It should be noted at the same time that the population infection rate didn't surge back after the cessation of the mass campaign in 1995, suggesting that the sustained national campaign succeeded in sufficiently suppressing the worm prevalence to below the break-point level.

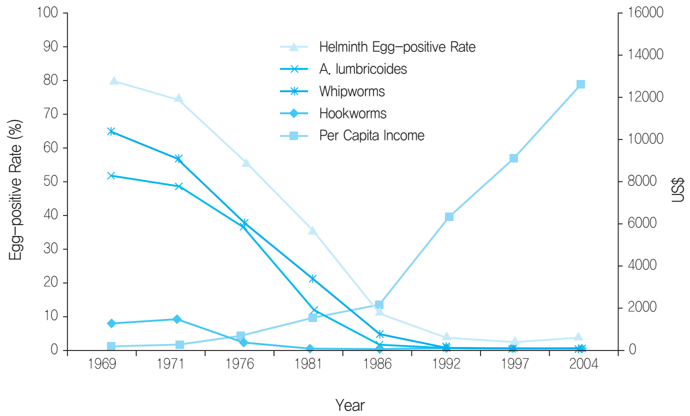
**Table 1-2 |** Comparison of *A. lumbricoides*, Whipworm, and Hookworm Prevalence through 1969 till 2004: Results from National Intestinal Parasite Infection Status Surveys *

| Year | Number of People Examined | Total Egg-positive Rate (%) | Cumul. Sum of Prevalence Rates (%) | Egg-positive Rate(%) | | | Per Capita Income (US$) |
|---|---|---|---|---|---|---|---|
| | | | | A. lumbricoides | Whipworm | Hookworm | |
| 1969 | 40,581 | 90.5 | 149.6 | 58.2 | 74.2 | 9.1 | 210 |
| 1971 | 24,887 | 84.3 | 147.1 | 54.9 | 65.4 | 10.7 | 286 |
| 1976 | 27,178 | 63.2 | 89.6 | 41.0 | 42.0 | 2.2 | 799 |
| 1981 | 35,018 | 41.1 | 54.5 | 13.0 | 23.4 | 0.5 | 1,749 |
| 1986 | 47,671 | 12.9 | 14.9 | 2.1 | 4.8 | 0.1 | 2,550 |
| 1992 | 46,912 | 3.8 | 3.9 | 0.3 | 0.2 | 0.01 | 7,183 |
| 1997 | 45,832 | 2.4 | 2.4 | 0.06 | 0.04 | 0.007 | 10,315 |
| 2004 | 20,546 | 4.3 | 4.4 | 0.03 | 0.02 | 0.0 | 14,162 |

Note: *Quoted from Hong et al. (2006).

Source: Hong et al. (2006).

**Figure 1-2 | Comparison of the Total Worm Egg-positive Rates for *A. lumbricoides*, Whipworms, and Hookworms Based on National Surveys on Intestinal Parasitic Infections: 1969-2004***




Source: Modified from Hong et al. (2006).

This report presents the story of this *sustained, national* deworming campaign in South Korea. The Korean experience is not unique: there are a small number of other episodes of similar, successfully implemented national deworming campaigns since the end of WW II, including those in Japan and Israel. To our best knowledge, however, there is no integrated account developed and available in the English language on these earlier episodes of similarly successful campaigns. The reader should recall that, in the late 1960s when the mass campaign was designed and launched, South Korea was still a struggling developing country, unsure whether the economic "takeoff" that began earlier in the decade was really that, or a false start. Thus, the Korean story demonstrates that a developing country with still weak public finance can successfully execute a sustained, national deworming campaign.

The story also illustrates how an effective partnership between the private sector and the public can bring to play the best of the two worlds. Needless to say, the government's committed support provided the essential foundation for the sustained, national campaign. At the same time, the KAPE's professionals, motivated by the shared passion to improve the state of public health, proved to be flexible and entrepreneurial at every critical turn, and adept at utilizing the results from rigorous scientific studies to muster and sustain public support, and to realize implementation in an economical manner.

The rest of the report proceeds as follows. The following Chapter 2 will discuss the background and needs for the national campaign, Chapter 3 introduces the strategy and the system adopted for the campaign, and Chapter 4 presents some noteworthy details in the implementation. Chapter 5 provides epidemiological assessment of various aspects of the deworming campaign, followed by assessment of the socioeconomic impacts and identification of success factors in Chapter 6. The materials in Chapters 2-4 heavily borrow from Chai (2011), one of the three co-authors of this report. Some of the materials in Chapter 5 are findings in the unpublished manuscript of Kim and Kim (2014). The report concludes with a discussion of implications for developing countries in the final Chapter 7.

# Chapter 2

## Backgrounds and Needs

# Backgrounds and Needs

In the past, Korea had been branded as 'the kingdom of parasites'. The intestinal parasite infection rate of Koreans measured by an American research team in 1948 in the immediate aftermath of the liberation of the country from the former Japanese colonial rule stood at 82.4% (Hunter et al., 1949), and the infection rate apparently persisted well into the 1960s as reported in <Table 2-1>. Investigations carried out by Korean researchers in the late 1960s tend to report slightly lower infection rates. It is not clear whether this difference reflects changes in sites, degrees of sophistication in test, or secular decline in the overall infection rate. A national sample survey was first carried out in 1969, registering the intestinal parasite infection rate of 58.2%. The study also reported large variations in infection rates across regions in the country with many places with higher infection rates of 70 to 80%. The status of intestinal helminths infection could be largely explained by the widespread use of night soil as fertilizer and the ubiquity of kimchi in the Korean diet, of which the main ingredients are cabbage and radish, often found to be contaminated by worm eggs.

It was against this background that public awareness of the seriousness of the public health challenge posed by intestinal worm infection arose in Korea in the 1960s, crystallizing into the formation of the Korea Association for Parasite Eradication in 1964. Among intestinal parasites, *Ascaris lumbricoides* (commonly known as roundworms) and hookworms are

Table 2-1 | Historical Reports on *Ascaris lumbricoides* Infection in Korea (1948-1969)

| Reporter (Year) | | Year of Investigation | Number of Examinees | Egg-positive Rate (%) | Region (Subjects) |
|---|---|---|---|---|---|
| Hunter *et al.* | (1949) | 1948 | 919 | 82.4 | National (residents) |
| Brook *et al.* | (1956) | 1951 | 1,726 | 81.3 | North Korean Soldiers (captives) |
| Crane *et al.* | (1965) | 1964 | - | 90.0 | Jeonju (hospital patients) |
| Kim | (1969) | 1964 | 408 | 71.8 | Gwangju (hospital patients) |
| Choi | (1967) | 1966 | 210 | 72.8 | Gwangju (students) |
| Kim *et al.* | (1968) | 1967 | 1,314 | 78.4 | Gyeonggido (residents) |
| Kim | (1969) | 1967 | 500 | 60.2 | Gwangju (hospital patients) |
| | | 1969 | 545 | 53.9 | Gwangju (hospital patients) |
| Seo *et al.* | (1969) | 1967-1969 | 40,581 | 58.2 | National (residents) |

Source: Reproduced from Chai JY, 2011.

known to bring much harm to the human body. Infection by these nematodes causes loss of nutrition, abdominal pain, diarrhea, anemia, and enteritis in mild cases. Roundworms are known to occasionally invade the liver, the biliary tract or the appendix, resulting in complications that may require emergency surgery. Hookworms cause mild anemia in infections with small numbers, but a heavy infection can bring severe anemia, enteritis, vomiting, diarrhea, loss of appetite, pica, earth eating, and other psychosomatic development disorders.

In the 1960s, Korean experts in parasitology resorted to various estimations of damages caused by worm infection in efforts to further raise public awareness of the significance of the problem, and rally necessary public support to address the challenge. One such estimate put the direct and indirect costs from widespread worm infection at over 1 billion US dollars (1,100 billion Korean Won) per year. About two thousand deaths a year were attributed to heavy infection by one particular type of worm, i.e., *A. lumbricoides*. They also estimated that the amount of blood taken by hookworms amounted to about 560 drums per day or about 11.6 billion ml per year, perhaps the most vivid figure in circulation around that time. The reduction in labor productivity was estimated to be worth annually 48 billion Korean Won.[1]

1. Deworming is now widely recognized as one of the most cost-effective policy interventions in the developing world. The Copenhagen Consensus in 2012 ranks deworming for children in 4th position among 16 most desirable investments in terms of bang for the buck. Miguel and Kremer (2004) reported that one additional year of schooling for a child could be bought at around $3.50 under a school-based deworming program such as the one they investigated in Kenya. Bleakley (2007) estimated that roughly 20 percent of the income gap between the northern and southern United States in 1900 can be attributed to hookworm infections prevalent in the South, and close to 50% of the closing of the income gap between the two regions to the worm eradication that took place during the first half of the 20th century.

# Chapter 3

## Strategy and System

# Strategy and System

The Korean government initiated mass parasitic control activities in late 1960s, spurred on by passionate efforts by the parasitologists assembled at the KAPE, including research, pilot deworming projects on a limited scale, and educational public campaigns to raise public awareness and inculcate more hygienic habits. These efforts culminated in the legislation of the Parasitic Disease Prevention Act (PDPA) by the National Assembly, the nation's legislature, in 1966. The Act mandated worm infection screening of all school children, primary to senior secondary, and administration of treatments to those who tested positive. The Act also recognized the central role of the KAPE in implementing the national strategy, and provided for government funding for the Association's deworming enterprise.

With government support, the KAPE expanded to a full national organization with the main office headquartered in Seoul, and 11 branch offices to cover all metropolitan cities and provinces of the country.

The Association decided roundworms to be the initial prime target for the national deworming campaign, and determined that the main strategy would be comprehensive screenings of all school children, covering all primary and secondary schools throughout the nation, to be administered twice a year (spring and autumn), and administered treatment pills to all children who tested positive of worm eggs in their fecal sample.

As a result of the consistent control programs accompanied by economic development, especially in rural communities, the prevalence of soil-transmitted helminths declined rapidly over the following two decades. The national egg positive rate of overall intestinal helminths decreased from 84.3% in 1971 to 41.1% in 1981, and further to 3.8% in 1992 (KAPE, 2004). The infection rate for all school children shows a similar pattern decreasing from 77.0% in 1969 to 0.8% in 1989. The students' egg-positive rate of roundworms (*Ascaris lumbricoides*) and whipworms (*Trichuris trichiura*), two major kinds of parasites in South Korea, recorded 55.4% and 36.9% in 1969, respectively, and both declined to 0.3% in 1989.

To a disinterested observer in the 1960s, however, all the later accomplishments of the Association would have seemed impossible and beyond one's wildest dreams. The Association did not initially have adequate budgetary support from the government, and steep challenges were all around. Due to lack of manpower, equipment and facilities, it was a hard slog in the 1960s to make any progress toward the ambitious goal of parasite extermination. The situation did not materially improve even after the passing of the Parasitic Disease Control Act in 1966. The Association initially sought financial support from civil society agencies such as the Korea Association of Voluntary Agencies (KAVA). The Association and KAVA decided to pursue the parasite eradication project with the goal of 'reducing the roundworm prevalence in the nation to zero in 10 years', and began with public awareness and hygiene campaigns and pilot projects of various sorts including deworming demonstration projects. KAVA provided funding for medicine and test kits needed in parasite examination and drug administration for 34,980 residents in 104 demonstration villages nationwide. The United States Information Service in Korea contributed 30 thousand posters for the public hygiene campaign.

The crucial break, however, came from Japan, that is, from the Overseas Technical Cooperation Agency (OTCA) of Japan. It should be noted that the OTCA is the precursor of the Japan International Cooperation Agency (JICA). The OTCA officially approved the plan to aid the burgeoning national deworming campaign in Korea in 1968. The OTCA naturally chose the KAPE as its partner for the collaboration. The project provided for one or two vans for each of the KAPE's provincial branch offices; microscopes and centrifuges for testing in all branch offices; medicine (piperazine) to be administered to school children; and crucially needed technical training to raise the level of proficiency of the KAPE's technicians in testing. The collaborative project that ran for three years from 1969 to 1971 proved to be pivotal for the real national launching of the deworming campaign in the country.[2]

We learned from the technical reports filed by the Japanese experts sent to Korea as a part of the collaboration that they were invariably impressed by the sincerity of the Korean experts working for the KAPE and the quality of institutionalized foundation for the deworming campaign in Korea.

2. It was the Colombo plan that helped launch the collaboration between the KAPE and the OTCA. The initial three-year project got extended to the second three-year phase. During the second phase, however, the scope of collaboration was not as extensive as during the first phase, and was more narrowly focused on literally technical assistance on issues involving intestinal worms other than roundworms.

The foreword by the OTCA President at the time of launching collaboration was as follows: The OTCA began a collaborative project with KAPE in 1969 as a part of technical cooperation in healthcare for Korea, our neighbor next door. The project was able to be accomplished its goals thanks to the cooperation of our partner, KAPE, with its unsurpassed passion for self-help, integrity in its organization, and consistency in its strategy and implementation, and thanks also to the sincerity of experts and relevant agencies in the country for serious collaboration and the social awareness of the significance of deworming. The successful implementation of the project has been extremely satisfactory for both countries, and set the standard for all technical cooperation projects to aspire to in the future. (Mr. Tazuki Keiichi, President of the OTCA, in the foreword to the final technical report on the project[3] with the original reproduced in [Figure 3-1].)

Even with the generous support from the OTCA, the KAPE had to struggle to find extra funds to cover the recurrent costs for personnel expenses and facility maintenance.[4] Up until 1969, the Association relied mostly on membership fees paid by the members, and receipt of nominal fees paid by tested individuals, for its financing. For instance, in 1969, membership fees amounted to about KRW 31 million, test fees to KRW 23 million, and government financial support less than KRW 3 million in the overall budget. The situation changed from 1970, when the government mandated local education district offices pay for the tests of the school children under their charge and increased funding support to help cover the overhead and auxiliary activities of the Association such as research. In 1982, the government allowed the Association to provide physical examination services for the general public and use the surplus from the new operation for the deworming program and related activities. With this change, the Association was renamed the Korean Association for Health Promotion (KAHP) as it is still currently known in the country.

3. OTCA report medical-74-21 (111) "The Final Report from the Experts Sent to Korea for Deworming".

4. In the early 1970s, the KAPE employed about 150 personnel to staff the headquarters and provincial branch offices. The majority of the staff was technicians trained for microscopic detection of worm eggs.

Figure 3-1 | The Foreword by the OTCA President in the 1974 Activity Report

## はしがき

当事業団は，一衣帯水の隣国韓国に対する医療面に於ける技術協力の一環として，韓国寄生虫撲滅協会に対して，昭和４３年度以降寄生虫撲滅の観点よりその協力を開始した。

本プロジェクトは，同協会の自主性・自助努力への比類なき熱意・組織の統一性やその運営方針の一貫性・国内協力機関及び専門家の真摯な協力態度寄生虫撲滅対策に対する社会的位置付け等により，所期の成果を着々と達成したためにその協力たるや日韓双方にとって極めて満足のゆくものとなってきており，今日，技術協力の典型的な成功例あるいは技術協力の鑑とさえ称されている程である。

そして，本年３月６年間に亘るその協力を成功裏に終了した次第である。本報告書は，協力終了時にあたり，昭和４６～４７両年度に派遣した専門家による現地の医療事情や，調査にあたった各専門家の所感を取りまとめたものである。

ここに，本報告者並びに種々御協力いただいた関係諸機関の方々に対し，この機会をかりて深甚なる謝意を表する次第である。

昭和４９年７月

海外技術協力事業団
理事長　田付景一

<Table 3-1> presents the summary of the breakdown in the outlay of the annual budget of the KAPE for its first twenty years. The original figures in the 1984 KAPE publication reviewing the history of the Association were in currency units of Korean ‘Hwan’ for 1964-1969, and Korean ‘Won’ (KRW) since 1970. The figures in the table were obtained by first converting ‘Hwan’ values for the initial years to ‘Won’ at the 10:1 ratio, and then converting the whole set of figures to US dollars based on the official exchange rate applicable to each year.

**Table 3-1 | Expenditures of Korea Association for Parasite Eradication 1964-1983**

(Unit: USD 1,000)

| Year | Pills and Kits | Public Education | Sanitation | Clean Vegetables | Testing Facility | Training | Research | Running Costs | Miscell. | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1965 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| 1966 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 5 |
| 1967 | 0 | 1 | 0 | 3 | 0 | 0 | 1 | 4 | 0 | 13 |
| 1968 | 11 | 1 | 0 | 1 | 0 | 0 | 0 | 6 | 0 | 23 |
| 1969 | 21 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 61 |
| 1970 | 392 | 21 | 0 | 2 | 0 | 3 | 7 | 129 | 0 | 596 |
| 1971 | 439 | 27 | 0 | 0 | 0 | 4 | 12 | 139 | 0 | 648 |
| 1972 | 429 | 28 | 0 | 0 | 0 | 2 | 5 | 145 | 0 | 633 |
| 1973 | 345 | 41 | 0 | 4 | 220 | 0 | 9 | 146 | 0 | 796 |
| 1974 | 474 | 52 | 0 | 0 | 184 | 0 | 8 | 165 | 0 | 922 |
| 1975 | 528 | 34 | 0 | 0 | 145 | 1 | 9 | 199 | 0 | 942 |
| 1976 | 552 | 34 | 0 | 0 | 0 | 1 | 11 | 264 | 0 | 872 |
| 1977 | 581 | 41 | 0 | 0 | 76 | 3 | 13 | 314 | 0 | 1028 |
| 1978 | 646 | 64 | 0 | 0 | 0 | 3 | 12 | 348 | 0 | 1074 |
| 1979 | 845 | 78 | 0 | 0 | 0 | 8 | 9 | 464 | 0 | 1404 |
| 1980 | 923 | 100 | 0 | 0 | 11 | 8 | 91 | 498 | 0 | 1631 |
| 1981 | 1180 | 152 | 0 | 0 | 59 | 10 | 39 | 535 | 0 | 1975 |
| 1982 | 1352 | 131 | 0 | 0 | 0 | 11 | 35 | 581 | 0 | 2110 |
| 1983 | 1494 | 134 | 0 | 0 | 0 | 13 | 15 | 624 | 0 | 2280 |
| Sum (64-83) | 10216 | 939 | 0 | 10 | 694 | 69 | 277 | 4575 | 0 | 17015 |
| Shares (%) | 60.0 | 5.5 | 0.0 | 0.1 | 4.1 | 0.4 | 1.6 | 26.9 | 0.0 | 100.0 |

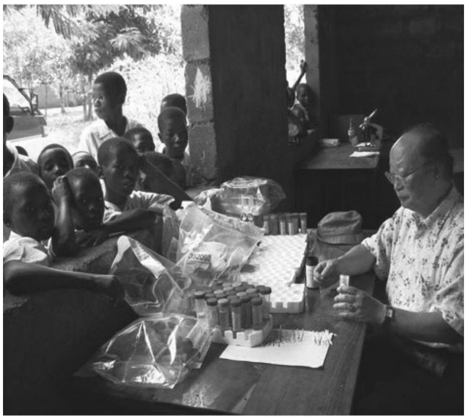
Source: KAHP (1984) *Twenty Years of the Korea Association for Parasite Eradication*.

The reader may note from the table that the budget of the Association shows a significant increase in 1970, marking the serious launch of the national campaign that year. Perhaps the single most important take-away from the table, however, is the relatively modest amounts in the annual outlay of the Association, never going beyond three million dollars per year. That the Association was able to cover with this small budget the entire student population of Korea from primary to secondary, more than eight million children at the time, with the regimen of comprehensive screenings and treatment of all who tested positive is remarkable.

The lean budget demonstrates how extraordinary of an organization the KAPE was. The bulk of the budget, close to two-thirds, went to cover the costs of the operations that were the main mission of the Association: spending for deworming pills and test kits (60.0%); public campaigns to promote hygiene and awareness of the deworming operations (5.5%); research (1.6%); and training of staff (0.4%). Only 4.1% of the budget was spent for testing facilities, essential for public health purposes, since stool samples for tests pose potential risks.

All this probably had a lot to do with the fact that the KAPE was a voluntary association of professionals dedicated to deworming for the purpose of promotion of public health in their country. The probity of members and their integrity in the business management of the Association has never come under doubt. The Association was flexible and entrepreneurial. The Korean national deworming campaign was the first mass deworming campaign that introduced the newly available Kato's method developed in Japan for stool tests, accounting in large part for the fact that the KAPE was able to test over eight million school children in the nation each year with such a lean budget. See [Box 3-1] below. The parasitologists also worked with a Korean pharmaceuticals firm, Shin Poong Pharmaceutical, to develop and test new deworming medicine optimized for the Korean mixture of intestinal worms. The new drugs that were developed and introduced enabled the sustained national deworming campaign to be funded at a fraction of the costs. It undoubtedly would have taken a much higher budget if medicine by multinational firms overseas were utilized. Shin Poong remains to this day a powerhouse in the Korean pharmaceutical industry, specializing in anti-worm drugs, including a line of malaria treatments.

**Box 3-1** | Dr. Han-Jong Rim



The Korea Association for Parasite Extermination, or KAPE, was blessed with several extraordinary leaders. Dr. Han-Jong Rim was one of them, an active member of the Association from the inception, an academic leader responsible for introducing several critical innovations in the Association's deworming operations, and later in his career he served from 1994 as the President of the Korea Association of Health Promotion (KAHP), the re-incarnation of the KAPE since 1982.

Dr. Han-Jong Rim began his career as a child parasitologist as a high school student, when he was awarded the highest honor of the Presidential Prize in the first national science exhibition held in independent Korea in 1949 with his study of parasites in the intestines of frogs. After obtaining his Ph.D. in medicine from Seoul National University College of Medicine in 1963, he went on to study at the University of Minnesota in the parasitology lab of Prof. Wallace as the first batch of young Korean medical scholars to benefit from a massive US International Cooperation Agency (ICA) capacity building project, popularly known as the Minnesota Project in Korea (Interested readers can refer to Kim and Kim (2012)). Later fellowships at the Dutch Royal Institute for Tropical Diseases and the German Hamburg Institute for Tropical Diseases gave him further opportunities to deepen his scholarship as a parasitologist, and network with leading experts of the world for international collaboration. At Seoul National University College of Medicine, he was one of the founding members of the Korean Society for Parasitology, and later became the founding father of the parasitology lab at Korea University.

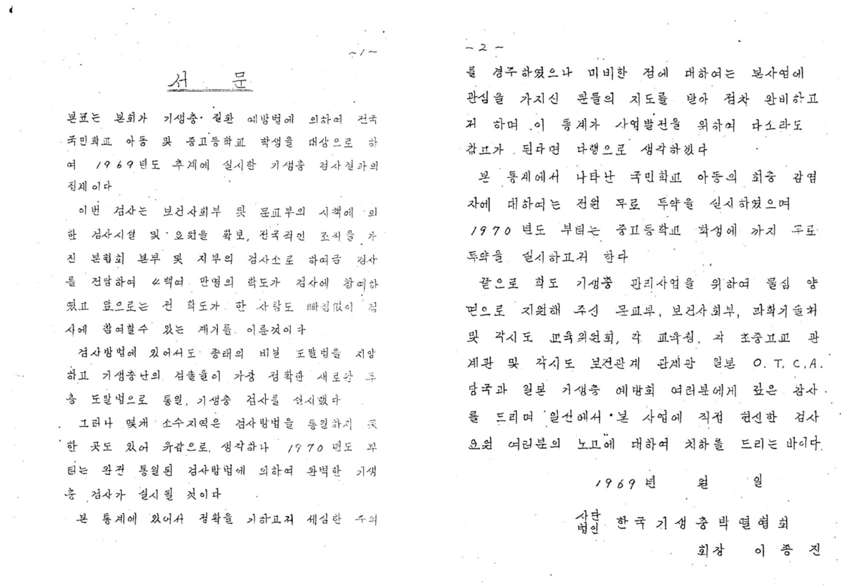
Dr. Rim's contribution to the deworming campaign in Korea include: discovery of new worm species (*Fibricola seoulensis*); development of new chemical treatments for worm infection; introduction of an innovative, cost-saving stool test routine (Kato method) into the mass screening regimen of the Korean national deworming campaign (world's first mass implementation of the newly developed testing routine from Japan); and demonstration of effectiveness of praziquantel against clonorchiasis. For the last accomplishment, Dr. Rim was awarded in 1987 the Academy of Korea Award, the nation's highest academic honor. Dr. Rim also pioneered Korea's overseas development cooperation for deworming with projects in China, Lao PDR, Tanzania, and North Korea in collaboration with younger generation of Korean parasitologists. When working on overseas projects, he was notorious for setting tough standards for younger parasitologists to follow, foregoing *per diem* compensations and lodging at cheap accommodations to save money for treatment of more children.

In the course of the deworming campaign, all school children were screened twice a year for worm infection until 1987, after which the screening regime relaxed to once a year, reflecting the dramatic decrease in the infection rates nation-wide up to this point. The KAPE meticulously kept administrative records from the school-based deworming regime, so we can find out the changes in school-by-school infection rates for each year since 1969.

[Figure 3-2] reproduces the foreword to the report on the results of the first national stool screenings by Dr. Jong Jin Lee, the former President of KAPE. We note that the foreword was printed from the original stencil pen copy, perhaps a sign of the budgetary limitations the KAPE had to cope with at the time. Succinct and graceful, the foreword lacks nothing that is necessary and appropriate in such a foreword, and represents an elegant specimen of scientific writing in Korean. The foreword notes that the results reported in the volume are based on the stool test of all primary school children administered in 1969 based on the Parasitic Disease Prevention Act; that the tests utilized the newly introduced Kato's method; that while efforts were made to have all test stations conform to uniform standards following the same methodology, routines varied in some regions; that all children who tested positive in the screening were given adequate medicine for treatment, free of charge; and that the school-based deworming campaign would expand to cover children in secondary schools as well in the following year (1970). The foreword concludes by gratefully recognizing support obtained from various government ministries and authorities (Ministry of Education, Ministry of Health and Social Affairs, Agency for Science and Technology, Provincial Education Committees as well as Provincial Education Offices, school officials and public health officials); help from the OTCA and the Japan Association for Parasite Control; and finally the dedicated service of the testing staff serving on the frontline.

Perhaps one extra take-away that bears some emphasis from the foreword is the extensive collaboration among government ministries (health and education) and local government authorities, not to mention international agencies. In terms of per capita income, Korea was of course still a struggling developing country in the 1970s. The seamless coordination of all these different institutions for an integrated, precise implementation of a vast operation can be regarded as rather remarkable. This aspect might deserve an independent, in-depth investigation from the science of delivery perspective.

**Figure 3-2 |** Foreword to the KAPE Report on the Results of the First National Stool Tests for all School Children in 1969 by Dr. Jong Jin Lee, the President of KAPE



~1~

서 문

본표는 본회가 기생충 질환 예방법에 의하여 전국 국민학교 아동 및 중고등학교 학생을 대상으로 하여 1969년도 추계에 실시한 기생충 검사결과의 집계이다

이번 검사는 보건사회부 및 문교부의 시책에 의한 검사시설 및 요원을 확보, 전국적인 조직을 가진 본협회 본부 및 지부의 검사소로 하여금 검사를 전담하여 4백여 만명의 학도가 검사에 참여하였고 앞으로는 전 학도가 한 사람도 빠짐없이 검사에 참여할수 있는 계기를 이룬것이다

검사방법에 있어서도 종래의 비닐 도말법을 지양하고 기생충난의 검출율이 가장 정확한 새로운 후층 도말법으로 통일, 기생충 검사를 실시했다

그러나 몇개 소수지역은 검사방법을 통일하지 못한 곳도 있어 유감으로 생각하나 1970년도 부터는 완전 통일된 검사방법에 의하여 완벽한 기생충 검사가 실시될 것이다

본 통계에 있어서 정확을 기하고저 세심한 주의

~2~

를 경주하였으나 미비한 점에 대하여는 본사업에 관심을 가지신 분들의 지도를 받아 점차 완비하고저 하며 이 통계가 사업발전을 위하여 다소라도 참고가 된다면 다행으로 생각하겠다

본 통계에서 나타난 국민학교 아동의 회충 감염자에 대하여는 전원 무료 투약을 실시하였으며 1970년도 부터는 중고등학교 학생에 까지 무료 투약을 실시하고저 한다

끝으로 학도 기생충 관리사업을 위하여 물심 양면으로 지원해 주신 문교부, 보건사회부, 과학기술처 및 각시도 교육위원회, 각 교육청, 각 초중고교 관계관 및 각시도 보건관계 관계관 일본 O.T.C.A. 당국과 일본 기생충 예방회 여러분에게 깊은 감사를 드리며 일선에서 본 사업에 직접 헌신한 검사요원 여러분의 노고에 대하여 치하를 드리는 바이다.

1969년 월 일

사단법인 한국기생충박멸협회

회장 이종진

The student stool examination results had their limitations, in that one could not gauge from them the changes in infection rates in the adult population as well as among the youth not in school. The KAPE thus decided to team up with the Ministry of Health and Social Affairs to conduct national intestinal worm infection surveys (National Intestinal Parasite Infection Status Surveys) once every five years. The first survey was carried out in 1971. Seven such surveys have been done till 2012, each time covering 0.1% sample of the entire population. Results were aggregated by parasite type, gender, age, place of residence, and level of household income. <Table 3-2> presents the outline of the eight surveys. Procured at very modest costs to public finance, the data available in the surveys provide a detailed look into the dynamics of overall worm infection rates in the course of a sustained national deworming campaign. Thanks to these surveys and the student stool examination results, the Korean deworming campaign is unique in the world as the best documented of deworming episodes implemented over a substantive geographical area and over a relatively long time period. Some summary results from the eight surveys were presented earlier in this report (<Table 1-2> and [Figure 1-2]). The trends in adult infection rates as ascertained through the surveys largely echoed the results from the student stool tests. These results demonstrated the appropriateness of the national strategy and the success in the implementation strategy, and no doubt played a significant role in mobilizing sustained public support for the on-going campaign.

Table 3-2 | Finances for the National Intestinal Parasite Infection Status Surveys (1971-2004)

| Year | Number of Subjects (persons) | Government Funding (thousand won) | Relevant Ministry, Agency |
|---|---|---|---|
| Total | 268,358 | 855,900 | |
| 1971 | 25,987 | 3,400 | Department of Chronic Diseases, Ministry of Health and Social Affairs and KAPE |
| 1976 | 30,220 | 5,000 | 〃 |
| 1981 | 40,119 | 109,000 | 〃 |
| 1986 | 47,671 | 163,900 | 〃 |
| 1992 | 51,556 | 190,000 | Department of Health Education, Ministry of Health and Social Affairs and KAHP (Korea Association of Health Promotion) |
| 1997 | 49,977 | 179,600 | Department of Health Policy, Ministry of Health and Welfare, KAHP |
| 2004 | 22,828 | 205,000 | Korea Center for Disease Control and Prevention; Korea National Institute of Health; and KAHP |
| 2012 | 24,423 | 250,000 | 〃 |

Source: Kim and Kim (2014).

# Chapter 4

## Details in the Implementation of the National Strategy

1. Comprehensive School-based Examination and Treatment
2. Educational Campaigns for the Students and the Public
3. Sanitation Improvement
4. Legal Foundation for the Government-KAPE Cooperation for Deworming

# Details in the Implementation of the National Strategy

As emphasized earlier, the main thrust in the national deworming strategy was comprehensive school-based examination and treatment. The main plank in the strategy was buttressed by some complementary interventions. Among these, hygiene education and an awareness campaign for the public were always a very important element.

During the 1960s, the KAPE also experimented with measures for improved sanitation and with enterprises to supply uncontaminated vegetables. In order to improve sanitation, the Association organized pilot projects with septic tanks and composting toilets. These were obviously based on sensible biological considerations. Adult nematode worms mate and lay eggs inside the human body, but the eggs do not hatch there: they need to be excreted and re-enter the body of the human host, through the skin, through inhalation, or through food intake. Since intestinal worms do not proliferate inside the host's body, and their lifespan is naturally limited, infected individuals should naturally be cured of infection over time as the adult worms inside their body die out, as long as they are protected from fresh rounds of infection by new worm eggs. Thus, improved sanitation and substitution of chemical fertilizers or compost for night soil could substantially enhance the impacts of chemical intervention.[5] As the information in <Table 3-1> showed earlier, however, in the Korean campaign designed and implemented by the KAPE, these additional potential

5. It is conceivable in theory therefore that improved sanitation in and of itself might succeed in worm control, even in the absence of medical treatment of infection or chemotherapy. It remains unclear how much the population infection rates might have come down in Korea in the 1970s and 1980s, but for the national deworming campaign focusing on school-based group test and group treatment, since the rapid rural development in the country since the early 1970s must have played a significant role in reducing worm prevalence. Later in the report, we present some evidence indicating the significant role of treatment intervention in the national campaign. One of the co-authors of this report is planning an additional empirical project to estimate influences of various environmental elements in the dynamics of population infection rates with the hope that the estimated model will serve as a vehicle for simulations of various scenarios. More on this will follow later in Chapter 5.

interventions never played a significant role. Perhaps this is partly explained by the fact that these environmental conditions were improving anyway in rural Korea since the early 1970s in the midst of rapid rural development in the country.[6]

In this chapter, we review in somewhat greater detail how the actual implementation worked in the national deworming strategy component by component.

## 1. Comprehensive School-based Examination and Treatment

Comprehensive examination of individual students' stool samples and treatment of children who tested positive of infection were administered twice a year (March to May in the spring season, and September to November in the fall) to cover all students in elementary, middle, and high schools throughout all metropolitan cities and provinces nationwide. This regime was sustained for 25 years from 1970 to 1995 with minor variations. When the national program was launched in 1969, the program targeted children in primary schools, but the program expanded right away to cover all school children from primary to high schools since 1970. Since 1987, the frequency of comprehensive examination and treatment was reduced from twice a year to once. Every child who tested positive was treated with deworming pills, including santonin and corsican weed, piperazine, pyrantel pamoate, mebendazole, and albendazole in succession, reflecting results from rigorous tests to determine the most cost-effective treatment. About 60% of the annual budget at the KAPE was spent on examinations and treatments.

## 2. Educational Campaigns for the Students and the Public

The KAPE developed educational materials of various sorts and distributed them through the nation's school system to raise public awareness for the diseases caused by intestinal worm infection and for the need to participate in the national deworming campaign, and also to teach the students and the public healthy habits and preventive tactics. The Association relied on different forms of outlets, ranging the whole gamut from posters and leaflets to slides, videos, and feature films. The common contents included the following:

- Health consequences and risks caused by intestinal worm infection,
- Infection routes, such as through hands, vegetables, fruits, etc. in the case of roundworms, and
- Practical habits for prevention of infection including washing vegetables 2-3 times with running water before eating, washing your hands before meals, cleaning hands

6. See Kim and Kim (2012) for an account of the changes in the rural communities during the 1970s, focusing on the Saemaul Undong.

and clothes after going out or playing with earth, having baths often, and keeping fingernails short.

## 3. Sanitation Improvement

The transmission of roundworms and other intestinal worms starts with leakages from un-sanitized toilets and latrines, and with use of night soil or human feces as fertilizer, especially for vegetables. The eggs thus released can survive in soil for a long period, and reenter the body of the human host through vegetables, fruits, and other food items, through the skin, and also through inhalation. Thus, improved sanitation such as flush toilets with septic tanks can work as a powerful break in the chain of worm transmission. The use of chemical fertilizers in the place of night soil should also disrupt the transmission chain. As noted earlier in the chapter, while the experts at the KAPE were certainly aware of these facts, the actual KAPE projects in the area of sanitation improvement were invariably small pilots and demonstration projects, accounting for a very small share of the annual budget of the Association. Serious undertaking of major projects would have almost surely been beyond the scope of the meager budget; the other possible reason for the practical ignorance of these supplementary lines of attack was the rapid rural development in Korea since the early 1970s and the accompanying improvement in the status of rural sanitation. As noted earlier, it not clear yet how important these concurrent environmental changes were in the secular reduction of the population infection rates.

## 4. Legal Foundation for the Government-KAPE Cooperation for Deworming

Before the arrival of the Korea Association for Parasite Eradication in the Korean deworming scene, there was the Korea Association for Sanitary Zoology (KASZ), established in December 1958. The KASZ sponsored ecological and epidemiological investigations of animal species posing sanitary challenges, and organized distribution of sanitary containers and medicine. In April 1964, the Korea Association for Parasite Eradication was newly established, replacing the older (and feebler) KASZ. The choice of the name for the new organization conveyed the strong proactive orientation of the KAPE. In particular, the choice of the word “eradication” over “control” reveals the professionals’ strong commitment, especially given the fact that the name of the Japanese counterpart to the KAPE has the name of “Japan Association for Parasite Control”. Expectations were high for the new organization from the government and from the public at large, as virtually all Koreans, or over 90% of them, were infected with various sorts of intestinal worms in the 1960s.

The government enacted and proclaimed the Parasitic Disease Control Act in April 1966 with the purpose of improving public health through prevention and eradication of parasitic diseases. The Act defined the main targets for parasitie control to be the disease caused by roundworm infection (ascariasis), disease from hookworm infection (ancylostomiasis), liver distomiasis, disease from tapeworm infection (teniasis), and other diseases to be designated by the Ministry of Health and Social Affairs. Article 3 of the Act called for compulsory annual examination and treatment of personnel employed in sensitive industries in view of the intestinal worm transmission chain such as restaurants and food preparation. Crucially, the same Article also mandated examination and treatment of all students in schools primary to secondary to be conducted twice or more every year. Article 9 explicitly mandates the KAPE to carry out research and preventive activities to address the parasitic diseases. Article 12 imposed fines on those found in violation of the mandate for compulsory examination and treatment set out in Article 3. The other clauses in the Act called for installment of facilities necessary for preventive operations, limitation of fecal use, designation of examination institutions, task force, parasite prevention organizations, and delegation of authorities, and importantly, obligated the government's assistance for the whole or part of the operations for control of parasitic diseases.[7, 8]

The sustained national deworming campaign required a long-term commitment of multiple government ministries, and close coordination among central and local government units. Korean practitioners are united in their view that the successful national campaign would not have been possible in the absence of a strong legal framework that vouched for the government's commitment and coordination.

As a result of the rapid economic development of the whole country, per capita GDP rose remarkably during the period that witnessed the implementation of the national deworming campaign. Per capita income was a little over USD 200 in 1969. In 1997, per capita income

7. Reflecting the success of the national deworming campaign supported by the Parasitic Disease Control Act, the Act was revised in March 1991. The revision adjusted the list of parasitic diseases designated as main targets, and allowed for possible regional waivers from the strict compulsory examination and treatment and for reduction of the frequency of mandated examination and treatment in view of the reduction in regional infection rates. Article 8 of the revised Act did call for designation of an agency in charge of the control activities for the parasitic diseases without naming the KAPE as such. A subsequently legislated by law however did designate the Korea Association for Health Promotion (the successor organization for the earlier KAPE) as the agency in charge.

8. In 2009, the revised Act was absorbed into the newly legislated comprehensive Law on Prevention and Control of Infectious Diseases. The Article 2 of the new law recognized parasitic diseases in the "Group 5" of infectious diseases, and placed the Korea Association for Health Promotion in charge of the activities for prevention and control of the Group 5 diseases. When the KAPE was reconstituted into the KAHP in 1986, the government issued a license to the new Association to carry out physical examinations throughout the country. The financial surpluses from this additional line of operation have since provided funding for the engagements of the Association for control of the parasitic diseases in the country.

was exceeding USD 10,000. The wholesale transformation of the nation's economy brought remarkable improvement in the overall living standards of people. Apart from improvement of sanitation, these changes also raised the public awareness of and their interest in hygiene and health. Among other things, this meant that people started taking over-the-counter anthelminthics, which no doubt contributed to further reducing incidences of intestinal worm infection.

Mandatory group examination and treatment for students were held twice a year for 22 years from 1969 to 1990. Then, the frequency was reduced to once a year since 1991. The roundworm egg positive rate fell to 0.02% in 1995 and the school-based national deworming campaign was finally brought to an end.

# Chapter 5

## Epidemiological Assessment

# Epidemiological Assessment

The national deworming campaign bequeathed a huge amount of quality data. Mass stool tests were conducted for all school children, covering 5 to 8 million students in elementary, middle, and high schools nationwide twice every year between 1969 and 1990 and once every year between 1991 and 1995. In addition, eight National Surveys on the Intestinal Parasitic Infection Status were conducted on national 0.1% samples of the entire population once every five years (1971, 1976, 1981, 1986, 1992, 1997, 2004 and 2012). A major study commissioned by the Korea Association of Health Promotion in 2004 (KAHP, 2004) investigated various epidemiological aspects of the deworming campaign including:

- Secular reduction in egg positive rates,
- Changes in U-rate (ratio of unfertilized egg dischargers among all egg-positive individuals),
- Decreases in infection intensity,
- Fluctuations in ‘k’ and ‘R’ coefficients,
- Effective cure rates.

<Table 1-1> and <Table 1-2> and [Figure 1-1] and [Figure 1-2] have already demonstrated the dramatic decreases in infection rates to negligible levels in the course of the national campaign, a *prima facie* evidence for the success of the national deworming campaign in Korea in its choice of the basic strategy and its implementation.

Female adult worms produce two types of eggs inside the body of the human host: fertilized and unfertilized. Fertilized eggs develop into the embryonic form once released outside the host body, and obtain the capacity to infect the next host and launch a new cycle of infection. Unfertilized eggs, on the other hand, cannot mature outside and thus die out. The U-rate refers to the ratio of the unfertilized egg dischargers to the total number of persons who tested positive of worm eggs. A high U-rate in a given region is a strong sign that the worm prevalence is set to further recede in the future (Seo et al., 1983).

<Table 5-1> presents again the changes in student infection rates with the addition of the U-rates. The U-rate for all students in 1973-1974 was very low at around 0.2, but doubled to about 0.4 in 1980-1981 and tripled to 0.67 in 1988-1989 (<Table 5-1> and [Figure 5-1]). It reached a high of 0.7 in 1991 and since then remained at about 0.5 afterwards. The increases in the U-rate in conjunction with dramatic decline in infection rates are a further assurance that the prevalence of worm infection is indeed a thing of the past.

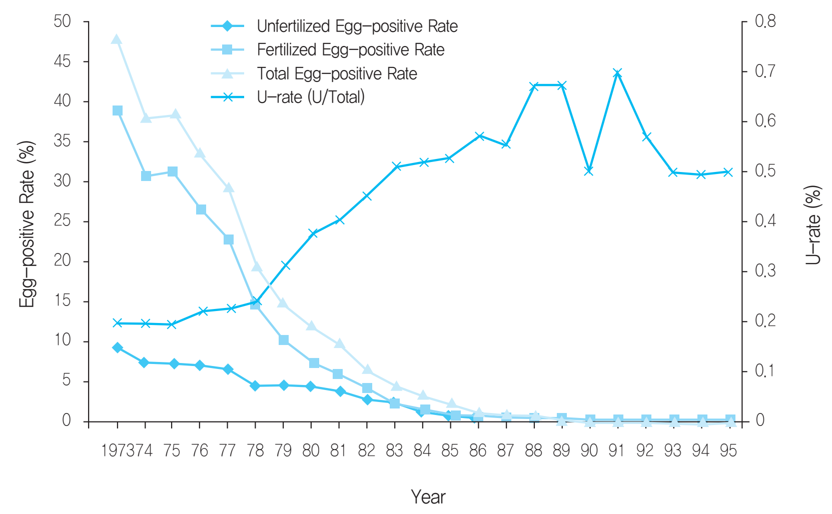
**Table 5-1 | Changes in *A. lumbricoides* Infection Rates for all School Levels: 1969-1995**

| Year | Number of Students Examined | Total number of Students Positive for Eggs (%) | | Number of Egg-positive Persons (%) | | | | | | U-rate (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Unfertilized ** | | Fertilized ** | | Total | | |
| 1969* | 6,551,926 | 5,046,216 | (77.0) | - | | - | | 3,631,699 | (55.4) | |
| 1970* | 10,871,280 | 8,095,911 | (74.5) | - | | - | | 6,042,588 | (55.6) | |
| 1971* | 11,813,868 | 8,429,031 | (71.3) | - | | - | | 6,100,187 | (51.6) | |
| 1972* | 11,243,033 | 7,179,521 | (63.9) | - | | - | | 5,148,951 | (45.8) | |
| 1973* | 12,116,892 | 7,903,665 | (65.2) | 1,133,687 | (9.4) | 4,696,540 | (38.8) | 5,830,227 | (48.1) | 0.20 |
| 1974* | 11,901,236 | 6,350,121 | (53.4) | 895,301 | (7.5) | 3,650,208 | (30.7) | 4,545,509 | (38.2) | 0.20 |
| 1975* | 12,480,942 | 6,459,819 | (51.8) | 934,247 | (7.5) | 3,901,162 | (31.3) | 4,835,409 | (38.7) | 0.19 |
| 1976* | 13,423,636 | 6,104,644 | (45.5) | 978,360 | (7.3) | 3,540,956 | (26.4) | 4,519,433 | (33.7) | 0.22 |
| 1977* | 14,160,212 | 5,601,692 | (39.6) | 965,005 | (6.8) | 3,246,719 | (22.9) | 4,211,724 | (29.7) | 0.23 |
| 1978* | 15,030,061 | 4,200,218 | (27.9) | 684,927 | (4.6) | 2,229,938 | (14.8) | 2,914,865 | (19.4) | 0.24 |
| 1979* | 15,592,977 | 3,620,058 | (23.2) | 746,000 | (4.8) | 1,601,664 | (10.3) | 2,347,664 | (15.1) | 0.32 |
| 1980* | 15,495,361 | 3,050,527 | (19.7) | 720,355 | (4.6) | 1,162,655 | (7.5) | 1,882,895 | (12.2) | 0.38 |
| 1981* | 16,229,764 | 2,589,943 | (16.0) | 661,154 | (4.1) | 996,606 | (6.1) | 1,657,760 | (10.2) | 0.40 |
| 1982* | 16,216,136 | 1,947,871 | (12.0) | 1,042,498 | (3.1) | 620,413 | (3.8) | 1,122,911 | (6.9) | 0.45 |
| 1983* | 16,220,369 | 1,356,812 | (8.4) | 386,771 | (2.4) | 374,132 | (2.3) | 760,903 | (4.7) | 0.51 |
| 1984* | 16,091,005 | 889,495 | (5.5) | 257,276 | (1.6) | 217,198 | (1.5) | 492,474 | (3.1) | 0.52 |
| 1985* | 15,812,300 | 622,285 | (4.0) | 176,837 | (1.1) | 142,961 | (0.9) | 319,798 | (2.1) | 0.52 |
| 1986* | 14,861,006 | 403,015 | (2.7) | 112,517 | (0.8) | 87,408 | (0.6) | 199,925 | (1.4) | 0.57 |
| 1987* | 13,206,807 | 241,584 | (1.9) | 60,884 | (0.5) | 52,205 | (0.5) | 112,693 | (0.9) | 0.56 |
| 1988* | 12,703,799 | 148,261 | (1.2) | 39,920 | (0.4) | 30,289 | (0.3) | 112,184 | (0.6) | 0.67 |
| 1989 | 9,594,316 | 76,640 | (0.8) | 20,328 | (0.2) | 12,928 | (0.3) | 33,256 | (0.6) | 0.67 |

| Year | Number of Students Examined | Total number of Students Positive for Eggs (%) | | Number of Egg-positive Persons (%) | | | | | | U-rate (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Unfertilized ** | | Fertilized ** | | Total | | |
| 1990 | 9,146,913 | 50,579 | (0.6) | 12,150 | (0.1) | 9,638 | (0.1) | 21,788 | (0.2) | 0.50 |
| 1991 | 8,212,776 | 24,058 | (0.3) | 5,693 | (0.07) | 3,597 | (0.1) | 9,290 | (0.1) | 0.70 |
| 1992 | 4,294,499 | 8,310 | (0.2) | 1,653 | (0.04) | 1,239 | (0.03) | 2,892 | (0.07) | 0.57 |
| 1993 | 1,699,141 | 4,121 | (0.2) | 444 | (0.02) | 661 | (0.02) | 1,105 | (0.04) | 0.50 |
| 1994 | 1,531,706 | 3,576 | (0.2) | 334 | (0.02) | 334 | (0.02) | 668 | (0.04) | 0.50 |
| 1995 | 1,334,517 | 2,245 | (0.2) | 156 | (0.01) | 85 | (0.006) | 241 | (0.02) | 0.50 |
| Total | 307,836,478 | | | | | | | | | |

* Sum of both spring and fall examination results. ** Unfertilized: unfertilized eggs, Fertilized: fertilized eggs.
Source: Reproduced from Chai JY (2011).

**Figure 5-1 | Changes in *A. lumbricoides* Egg-positive Rates and U-rates:1973-1995**




Source: Reproduced from Chai JY (2011).

The stool E.P.G. (Eggs Per Gram of feces) test for student groups in Korea started in 1974 and continued until 1995. The E.P.G. values for *A. lumbricoides* (roundworms) for the student population showed a clear downward trend along with the decreases in the egg-positive rate. <Table 5-2> presents this information together with a couple more epidemiological coefficients "k" and "R" to be explained shortly. According to the table, the average E.P.G. was over 3,000 in 1974-1975, and then decreased to 2,000 or less after 1980. It dropped to 1,000 or less after 1984, indicating a substantial decrease in the number of worms inside the infected host. Chai et al. (1981) estimated the number of worms based on the E.P.G. values and earlier estimates on the relationship between the number of adult worms and E.P.G. These estimates are presented in the column titled "Average worm burden per person", and show that the average worm burden decreased from about five worms per person in 1974 to less than two per person after 1984. Studies based on the national sample surveys register similar trends.

**Table 5-2 |** Changes in *A. lumbricoides* Egg-positive Rate, Average E.P.G., Average Number of Worms, and Other Epidemiological Indices in the Student Population: 1969-1995

| Year | Number of Students Examined | Overall Helminth Egg-positive Rate (%) | *A. lumbricoides* Egg-positive Rate (%) | Average E.P.G.** | Average Worm Burden per Person | [k] | [R] |
|---|---|---|---|---|---|---|---|
| 1969* | 6,551,926 | 77 | 55.4 | - | - | - | - |
| 1970* | 10,871,280 | 74.5 | 55.6 | - | - | - | - |
| 1971* | 11,813,868 | 71.3 | 51.6 | - | - | - | - |
| 1972* | 11,243,033 | 63.9 | 45.8 | - | - | - | - |
| 1973* | 12,116,892 | 65.2 | 48.1 | - | - | - | - |
| 1974* | 11,901,236 | 53.4 | 38.2 | 3,004 | 1.765 | 0.0 | 1.282 |
| 1975* | 12,480,942 | 51.8 | 38.7 | 3,264 | 1.942 | 0.0 | 1.311 |
| 1976* | 13,423,636 | 45.5 | 33.7 | 1,671 | 0.866 | 0.0 | 1.139 |
| 1977* | 14,160,212 | 39.6 | 29.7 | 2,894 | 1.322 | 0.0 | 1.214 |
| 1978* | 15,030,061 | 27.9 | 19.4 | 1,823 | 0.543 | 0.0 | 1.087 |
| 1979* | 15,592,977 | 23.2 | 15.1 | 2,509 | 0.583 | 0.0 | 1.093 |
| 1980* | 15,495,361 | 19.7 | 12.2 | 1,967 | 0.37 | 0.0 | 1.06 |
| 1981* | 16,229,764 | 16.0 | 10.2 | 1,850 | 0.291 | 0.0 | 1.047 |
| 1982* | 16,216,136 | 12.0 | 6.9 | 1,340 | 0.142 | 0.0 | 1.023 |
| 1983* | 16,220,369 | 8.4 | 4.7 | 1,336 | 0.097 | 0.0 | 1.016 |
| 1984* | 16,091,005 | 5.5 | 3.1 | 925 | 0.044 | 0.32 | 1.007 |
| 1985* | 15,812,300 | 4.0 | 2.1 | 848 | 0.026 | 0.32 | 1.004 |
| 1986* | 14,861,006 | 2.7 | 1.4 | 1,342 | 0.029 | 0.0 | 1.005 |
| 1987* | 13,206,807 | 1.9 | 0.9 | 1,170 | 0.016 | 0.0 | 1.005 |
| 1988* | 12,703,799 | 1.2 | 0.6 | 915 | 0.008 | 0.31 | 1.0014 |
| 1989 | 9,594,316 | 0.8 | 0.3 | 837 | 0.004 | 0.31 | 1.0007 |
| 1990 | 9,146,913 | 0.6 | 0.2 | - | - | - | - |

| Year | Number of Students Examined | Overall Helminth Egg-positive Rate (%) | *A. lumbricoides* Egg-positive Rate (%) | Average E.P.G.** | Average Worm Burden per Person | [k] | [R] |
|---|---|---|---|---|---|---|---|
| 1991 | 8,212,776 | 0.3 | 0.1 | - | - | - | - |
| 1992 | 4,294,499 | 0.2 | 0.07 | - | - | - | - |
| 1993 | 1,699,141 | 0.2 | 0.04 | - | - | - | - |
| 1994 | 1,531,706 | 0.2 | 0.04 | - | - | - | - |
| 1995 | 1,334,517 | 0.2 | 0.02 | - | - | - | - |

* Sum of spring and fall test results.

** Eggs Per Gram of feces.

Source: Hong et al. (2006).

The E.P.G. and the average worm burden can become high either when a large number of individuals are infected or when only a small portion of the population is infected but the worm burden of those infected is high. The distribution of intestinal worms across infected hosts is known to be highly skewed to the right. Seo et al. (1979) and other Korean parasitologists studied the degree of concentration among those infected using various parametric assumptions, or the degree of "endemicity". Roughly speaking, the degree of concentration or the endemicity is proportional to the inverse of the coefficient 'k' (Chai 1992) in <Table 5-2>. The data suggests that as the overall worm burden decreased in the course of the campaign there were reductions in the degree of concentration among infected individuals. The clinical significance of this change is that the number of severely infected patients must have decreased, reducing the risk of serious clinical problems. This perhaps explains the well-documented decrease in the reported incidences of surgical ascariasis reported from hospitals around the country (Chai et al., 1991).[9]

9. Chai et al. (1991) and Chai (1992) analyzed the number of reported cases of biliary ascariasis, pancreatic duct ascariasis, and intestinal obstruction due to ascariasis that required surgery at general or university hospitals in Korea from 1955 to 1990. Chai et al. (1991) thoroughly investigated a total of 102 studies on surgical ascariasis and longitudinally observed the frequency of biliary ascariasis among all surgical biliary diseases. There were 1,299 cases reported from 1955 to 1990 on surgical ascariasis. Among them, biliary ascariasis appeared most frequently in 1,198 cases (92.2%), followed by appendicitis due to ascariasis in 44 cases (3.4%), intestinal obstruction in 39 cases (3.0%), pancreatic duct ascariasis in 17 cases (1.3%), and ascariasis causing abdominal abscess in 1 case (0.1%). The ratio of ascariasis patients among all biliary surgery patients showed a high frequency of 8-20% in 1955-1970, which was lowered to 4-8% after 1970 and further to 0-4% after 1980. In addition, the ratio of biliary stone patients due to *Ascaris* infection among all cholelithiasis patients was also high, being 9-16% until 1958-1970, which rapidly decreased after 1970. Chai et al. (1991) identified the number of cases attributed to roundworm infection among all these cases, and the ratio of roundworm induced cases overall has significantly declined over time, exhibiting high temporal correlation with the changes in roundworm infection rates over time in the country. The control of *A. lumbricoides* in Korea is considered to have reduced not only the egg positive rate and worm burdens, but also the number of other diseases due to ascariasis, and thus greatly contributed to public health promotion.

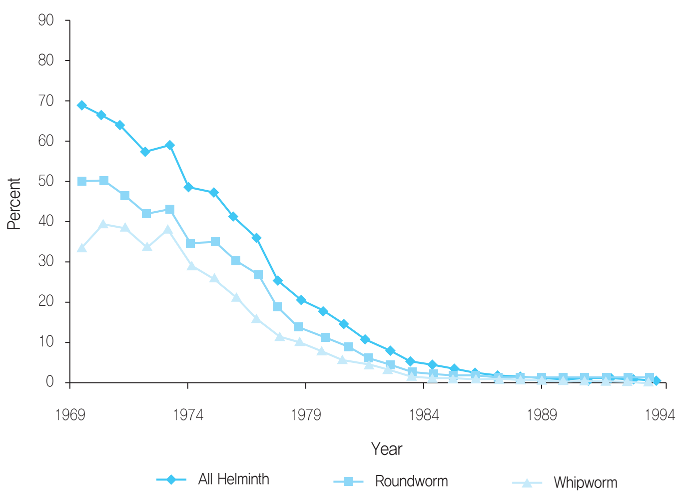
One female adult roundworm produces 100 to 200 thousand eggs per day. The basic reproductive rate (R) was proposed by Anderson and May (1982). R is an index indicating how many among these eggs successfully infect the next human host and complete maturation therein (Chai, 1992). The index cannot go below 1, and when the value of the coefficient is close to the limiting value of 1, it indicates that the worm population will not be able to rebuild itself even when left alone. Chai (1992) estimated the value of the coefficient for different years in Korea, and the results are reproduced in the last column of <Table 5-2>. Starting from the high range of 1.28-1.31 in 1974-1975, the value of R rapidly dropped to below 1.10 after 1978, and further decreased to less than 1.01 after 1984. The value stood at extremely low 1.0007 in 1989. At this low value of R, we can safely infer that the *A. lumbricoides* infection has virtually no possibility of becoming prevalent again, as long as the environmental conditions do not deteriorate substantially (Chai et al., 1985; Chai, 1992).

How effective was the mass drug administration in the comprehensive school-based examination and treatment regime? In other words, how high were the cure rates? It should be borne in mind that the stool tests examined the infection status of the individual students before the administration of drugs, but not after. Thus it is not an easy task to measure the effectiveness of the mass drug administration in the course of the national deworming campaign using the available data. Careful studies based on sophisticated epidemiological models have demonstrated that the cure rate was perhaps in the range of 80 to 85%, a very high level of effectiveness for such a massive operation that was the Korean national deworming campaign (Chai and Lee, 1997).

Epidemiological assessment of the national deworming campaign may be summarized as follows based on the findings discussed in this chapter. The campaign was a clear success from the epidemiological perspective. The prevalence of intestinal worm infection was dramatically reduced to very low levels. The worm population was pushed below the likely "break point", having suffered perhaps an irrecoverable blow. As well, there are signs that the incidence of severe infections has decreased over time, so concerns have receded that patients may emerge that require emergency clinical measures. It should be accepted that the decrease in the prevalence of soil-transmitted helminths in Korea, especially *A. lumbricoides*, is due to numerous factors including massive use of chemical fertilizers instead of human night soil fertilizers, great improvements in socioeconomic conditions such as sanitation owing to the Saemaul Undong, and the advancement of personal hygiene. However, the most important factor above all is the contributions made by the Korea Association of Health Promotion (formerly KAPE) and the Korean government ministries including the Ministry of Health and Welfare for over 27 years through mass examination and treatment targeting elementary, middle and high school students throughout the country, twice a year in spring and autumn. The high cure rate in the mass operation contributed to this success.

Changes in the whipworm infection rate among school children are shown in [Figure 5-2]. The prevalence in 1969 when the mass fecal examination first started was 36.9%, which slightly increased to 44.0% in 1970, then decreased to 11.5% in 1979, 0.3% in 1989, and reached 0.04% in 1995. This overall progress was almost similar as *A. lumbricoides*. The decrease of hookworm and *T. orientalis* prevalence rates is shown in [Figure 5-3]. The rates were 1.67% and 1.84%, respectively, in 1969, which fell to 0.0076% and 0.0026% in 1979, finally reaching 0.0002% and 0.00004% in 1989. The liver fluke, i.e., *C. sinensis*, showed an egg positive rate of 0.5% in 1969, which fell to 0.13% in 1979. It appeared to be 0.06% in 1989 ([Figure 5-4]). However, the curve does not appear to decrease anymore since then until 1995. Thus, the liver fluke should be dealt with as a major parasite that requires control in the future. *M. yokogawai* eggs started to be detected in 1978 (treated as *C. sinensis* before). Its prevalence rate barely changed as it marked 0.043% in 1978, 0.038% in 1988, and 0.04% in 1995. The prevalence of *Taenia* spp. (*T. solium*, *T. saginata*, and *T. asiatica*; eggs of these are indistinguishable) was 0.66% in 1969, which greatly decreased to 0.036% in 1979, and fell sharply again to 0.004% in 1989. It reached 0.0007% in 1995 and seemed to cause almost no harm at all. *H. nana* showed a similar progress as *T. solium*, *T. saginata*, and *T. asiatica*.

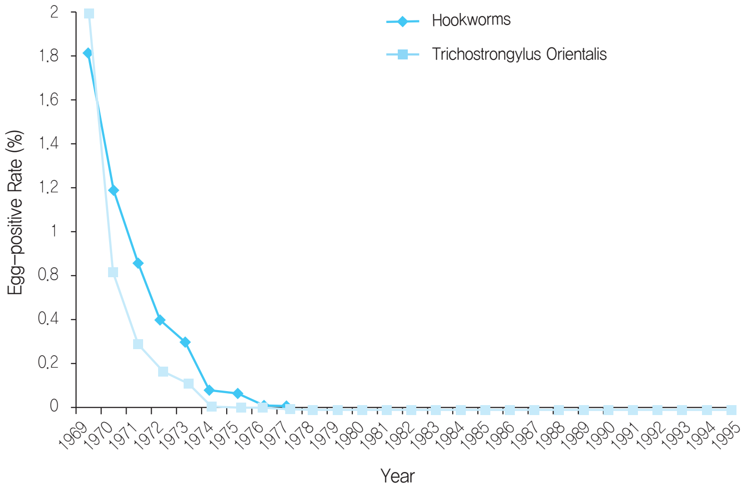
Figure 5-2 | Soil-transmitted Helminths Prevalence among Students in Korea




Note: The estimates for the period 1969 to 1988 are the average of the prevalence rates measured in spring and autumn of each year.

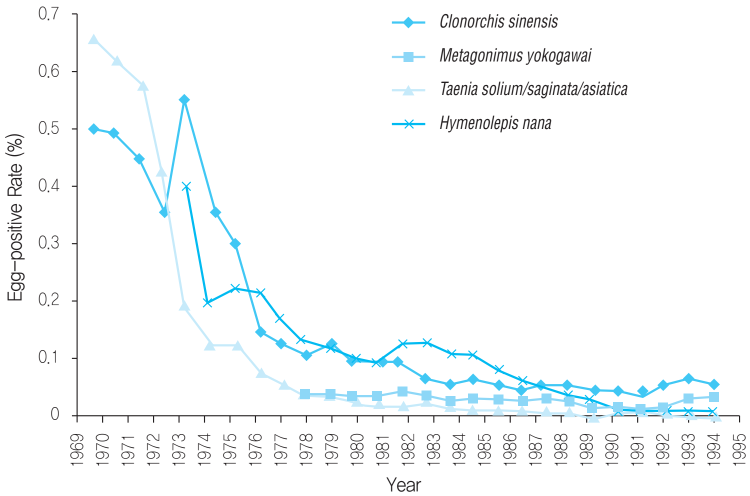
Source: Chai JY (2011).

**Figure 5-3 | Fluctuations in Egg-positive Rates of Hookworms and *Trichostrongylus orientalis* in Students (1969-1995)**




Source: Chai JY (2011).

**Figure 5-4 | Fluctuations of Egg-positive Rates of *C. sinensis*, *M. yokogawai*, *Taenia spp*., and *H. nana* in Students (1969-1995)**




Source: Chai JY (2011).

# Chapter 6

## Assessment of Long-term Socio-economic Impacts

1. Overview of the Assessment

2. Identifying Success Factors

3. Estimating Long-term Impacts of the Deworming Campaign on Education and Earnings Outcomes

# Assessment of Long-term Socio-economic Impacts

## 1. Overview of the Assessment

What are the impacts of the deworming campaign in Korea, beyond the dramatic but obvious fall in infection rates? Plausible speculations have been put forward by Korean parasitologists, regarding the likely impacts of the campaign on some health-related outcome measures, including increases in life expectancy; improvements in nutrition; and improvements in physical growth of children. These speculations are highly plausible, but in the absence of systematic analysis with the potential to gauge causal impacts, they remain speculations, with the possible exception of the reduction in the frequency of surgical ascariasis, presumably most well documented of the potential impacts. Furthermore, there has been no serious attempt to quantitatively measure the likely impacts of the deworming campaign on educational outcomes and also on productivity of workers, as measured by real earnings of workers.[10]

To our best knowledge, Kim and Kim (2014) was the first attempt to study, using the Korean data, the impacts of the deworming campaign on these very measures. The essential idea of the study is the observation (as established below) that the sustained national deworming campaign should have reduced the worm infection rates to zero virtually everywhere in the country. If true, this should mean that the reduction in infection rates between different birth

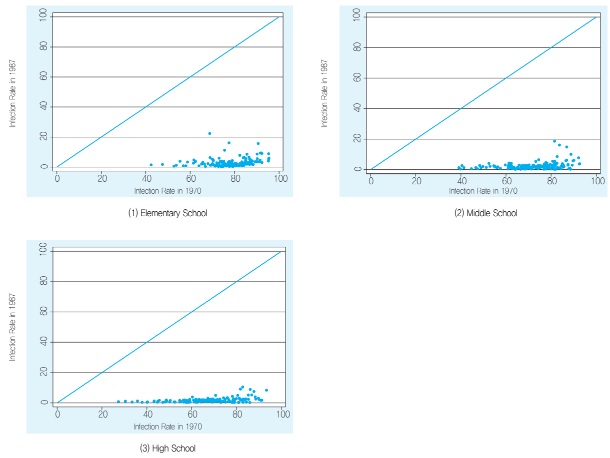
10. Recent studies show that the exposure to risk of parasitic infection during childhood generates a serious negative effect in the long run. Based on the analysis of data from four countries in the Americas, Bleakley (2010) argues that full exposure to malaria infection over childhood leads to a 50% reduction in earnings in adult life. Bleakley (2007) suggests that full exposure to hookworm infection during the childhood reduces lifetime income by 43%. Lucas (2010) concludes that malaria infection during the childhood hampers education attainment and literacy, analyzing a sample of females in Sri Lanka and Paraguay. Cutler et al. (2009) reports that 40-percentage point reduction in the spleen rate experienced in most malarious states in India is associated with a 2 percent increase in per-capita household expenditure for males.

cohorts should be larger in places where the initial level of prevalence of worm infection was higher. To the extent that reduction in worm infection has positive impacts on measures of concern, the gains in these measures across birth cohorts, say between those born before the campaign and those born when it was in full swing, should be also larger for places in Korea with initially higher levels of worm infection prevalence. The following graphs are based on data culled from two separate sources: administrative records of county-by-county infection rates in different years kept by the KAPE and public use files from the Korean Census of 2000. Individuals in the Census file are assigned the worm infection rates that used to prevail in the county where they were spending part of their life in middle school.

The graphs in [Figure 6-1] present comparisons of worm infection rates in 1970 (horizontal axis) vs. 1987 (vertical axis) across countries by level of school, primary, middle, and high school. The graphs establish that regardless of the initial levels of worm prevalence by the late 1980s the level of worm infection essentially fell to zero. This means that the reduction in infection rates during the time period was larger, the higher the initial level of prevalence. If investment in human capital (in other words, investment in education) and productivity gains result from deworming, then the gains with these outcome measures achieved between different birth cohorts should be larger for the counties with initially higher levels of worm prevalence.

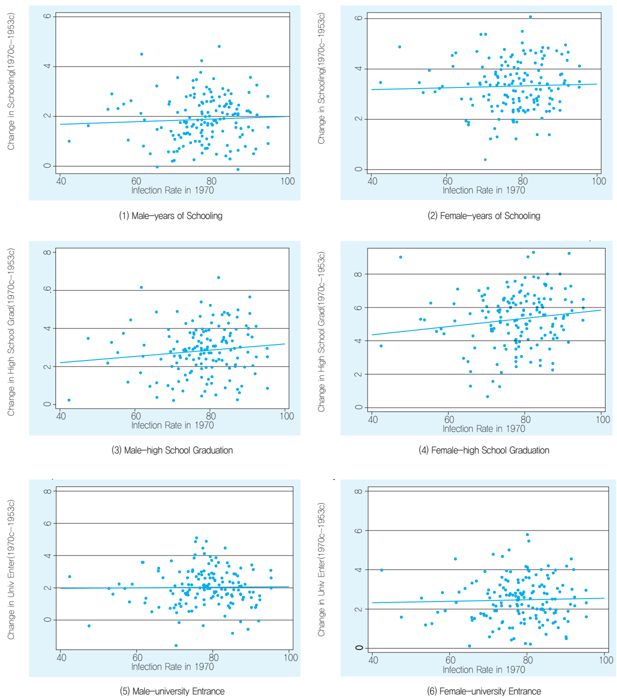
Panels in [Figure 6-2] demonstrate that it was indeed the case with several different measures of investment in education (including average years of schooling; proportions with high school diploma; proportions entering college). Panels in [Figure 6-3] show that gains in average earnings between birth cohorts were indeed larger for counties with initially higher levels of worm prevalence.

Figure 6-1 | County Infection Rates in 1970 vs. 1987 by School Level (%)



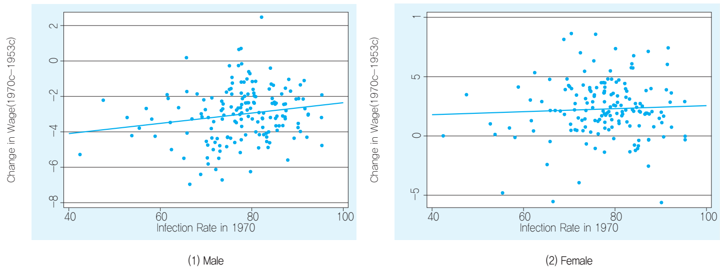

Source: Reproduced from Kim and Kim (2014).

Figure 6-2 | Change in Education between Birth Cohorts (1970-1953) and Pre-intervention Parasite Prevalence




Source: Reproduced from Kim and Kim (2014).

**Figure 6-3 |** Change in Log Wage between Birth Cohort(1970-1953) and Pre-intervention Parasite Prevalence




Source: Reproduced from Kim and Kim (2014).

Kim and Kim (2014) also carry out statistical analysis to formalize the intuitive idea presented above, and to provide specific estimates for the impacts of the national deworming campaign on educational outcomes and earnings. The results suggest that full exposure to the risk of soil-transmitted helminths infection during childhood lowers years of schooling by 1.0-2.4 years, the probability of achieving a high school diploma by 20-51% points, and adult earnings by 5% points. Further, the effect is estimated to be larger for women than for men, which suggests that the soil-transmitted helminths eradication campaign was more beneficial to the more disadvantaged of the genders.

## 2. Identifying Success Factors

**Box 6-1 |** Population Dynamics of the Intestinal Worm Infection

An interesting question in the epidemiology of intestinal worm infection is whether there is a "break point" below which the worm infection rate will naturally converge to zero without further intervention, say in the form of mass chemotherapy. The presumption of course is that the infection rate will shoot back to the level of prevalence prior to the beginning of the intervention, if the cessation comes before the infection rate reaches the break point. It can be shown mathematically that such a break point does exist, assuming the existence of a stable steady-state infection rate. The latter assumption seems itself natural, since each developing country with endemic intestinal worm infection does seem to have a characteristic, stable infection rate to which the infection rate shoots back, once intervention (prematurely in our view) comes to a halt.

To show this, let $x_t$ denote the proportion of the population (whose size is normalized to unity) infected with both male and female worms and thus capable of releasing fertilized eggs for further rounds of infection. We may consider $x_t$ as representing the proportion of "active" hosts who are themselves infected and are also capable of releasing fertilized worm eggs. Then the "law of motion" describing the evolution of the infection rate $x_t$ is given by the following difference equation:

$$x_t = \{\beta + (1 - \beta)\alpha^2 x^2_{t-1}\}x_{t-1} + \alpha^2 x^2_{t-1}(1 - x_{t-1}), \quad (1)$$

where the quantity $\alpha x_{t-1}$ represents the probability or the likelihood of an individual contracting a worm egg (of either the male or the female sex) when the population infection rate is given by $x_{t-1}$, and the coefficient $\beta$ the proportion of infected population that remains infected one period into the future. The law of motion equation above is based on three natural assumptions, or rather stylized facts: (a) some uninfected individuals become newly infected and turn into active hosts when they contract both male and female eggs (with the further simplifying assumption that all eggs hatch, match and produce eggs once inside the body of the host), (b) some infected individuals remain infected (the proportion being given by $\beta$), and (c) some of the naturally cured former hosts, $(1 - \beta)$, will be re-infected and turned into active hosts once again.

This law of motion implies then that there are three different "steady states", or infection rates from which there should be no further change so that $x_t = x_{t-1}$. We can further show that (a) one of these three steady states is zero, (b) two other steady states are located between zero and one (we may refer to them as $x_1$ and $x_2$, respectively), (c) the larger of the two ($x_2$) and zero are stable steady states, and finally, (d) the smaller of the two ($x_1$) is an unstable steady state, or the "break point". To see these implications, let $x$ denote any of the (yet-to-be-determined) steady states. The law of motion then turns into the following cubic equation:

$$x = \{\beta + (1 - \beta)\alpha^2 x^2\}x + \alpha^2 x^2(1 - x). \quad (2)$$

We see immediately that $x = 0$ does satisfy the equation, establishing that zero is indeed one of the steady states. When $x \neq 0$, we can divide both sides of the equation above to show that the other two steady states $x_1$ and $x_2$ must satisfy the following quadratic equation:

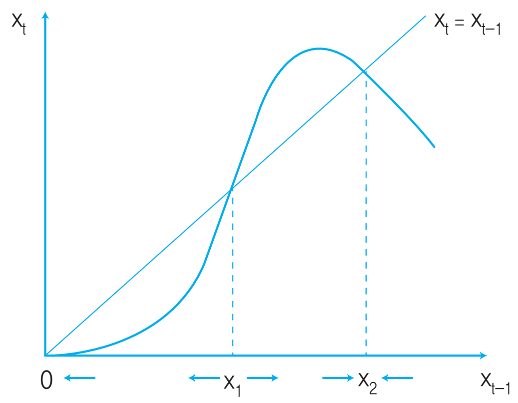
$$1 = \{\beta + (1 - \beta)\alpha^2 x^2\} + \alpha^2 x(1 - x), \text{ or} \quad (3)$$

$$\beta\alpha^2 x^2 - \alpha^2 x + (1 - \beta) = 0$$

Under some suitable conditions (making sure the determinant of the quadratic equation is positive), the equation above has two real solutions $x_1$ and $x_2$ Given that one of the two steady states (a stable one at that) is between zero and one, we can show that the third steady state must be between zero and the positive, stable steady state.

The resulting dynamics is illustrated in [Figure 6-4]. In the figure, the curve represents the law of motion in equation (1). The three intersections of this curve with the straight line $x_t = x_{t-1}$ are the steady states, $x_2$ the stable steady state the population infection rate reverts to if the mass intervention ceases prematurely and $x_1$ the break point or the unstable steady state. Once the deworming campaign succeeds in bringing down the population infection rate below this threshold, the worm infection problem should remain under control.

Figure 6-4 | Illustration of Intestinal Worm Population Dynamics




Population dynamics of intestinal worms imply the existence of a “break point” as discussed in somewhat greater detail in [Box 6-1] above. If the deworming campaign is prematurely ceased before the infection rate reaches the break point, the infection rate is bound to shoot back to the former level of prevalence. If the infection rate is brought below the point, however, then the worm population should remain under check. That the national worm infection rates have remained at negligible levels for close to two decades since the halt of the massive intervention in 1995 suggests that the national deworming campaign indeed succeeded in overreaching this break point. Results from epidemiological assessments are indeed in line with this view, as reviewed in Chapter 4.

The remarkable success of the Korean national deworming campaign was achieved at modest costs to the public purse. Perhaps this had to do with the fact that the leading agency in charge of the national deworming campaign, KAPE, was a voluntary association of accomplished professionals dedicated to the mission of national deworming. The overhead at the Association was less than one third of the outlay, even including costs for construction of testing facilities. The Association was nimble and entrepreneurial. The Korean deworming campaign was the world's first mass deworming campaign to adopt the newly developed, much cheaper, Kato stool examination method. The parasitologists at KAPE also worked closely with a local pharmaceutical company to develop and test effective treatments. This collaboration made effective medications optimized for the mixture of worms usually found in the host in the country available for the deworming campaign at a fraction of the financial burden it might have cost otherwise. These innovations undoubtedly saved taxpayers' money, and helped sustain the national campaign for as long as it was needed.

Perhaps the three most important lessons that we may draw from this study of the Korean national deworming campaign are (a) that sustained, national deworming is a highly sensible public investment with the potential of huge returns, (b) that comprehensive school-based examination and treatment is a sound strategy, and (c) that to maximize the return for the public investment it is crucial that such a campaign be sustained long enough, until the campaign breaches the "break point".

Sustaining a huge, national operation over a long period is not an easy task in any society, and should pose a particularly difficult challenge to developing countries struggling with poor government finance, inadequate institutions, and lack of quality human capital in critical mass among other things. That Korea was able to pull this off should be an encouragement to them. For those considering design and implementation of a similar comprehensive national deworming strategy, we offer the following practical observations based on the Korean experiences:

(a) an integrated legal foundation is essential for coordination among multiple stakeholders, including various government ministries and local government authorities, as well as to sustain the momentum,

(b) an independent body, like the KAPE, formed by accomplished and dedicated practitioners, should bring vitality and necessary agility, saving costs and helping sustain the momentum,

(c) it is important that the examination and treatment regime be accompanied by rigorous, scientific efforts to monitor the progress of the campaign, so that the results might be deployed for on-going assessment and public awareness campaigns[11], and

(d) efforts should be made to maximize leverage from opportunities to collaborate with donors and technical cooperation, in the form of policy consultation and manpower training, may prove to be as important, if not more, as in-kind aid or financing.

It is a good question as to what made this possible, setting apart the Korean deworming campaign from many massive deworming interventions. That Korea had a dedicated, professionally run body of advocacy in the Korea Association for Parasite Eradication certainly helped, and so did putting it in charge of the implementation of the national campaign. The Association was very efficiently run, able to deliver the outputs (screenings and administration of treatment) on lean budgets, and was led by generations of dedicated researchers who were able to overcome the bureaucracy and secure continued fiscal support.

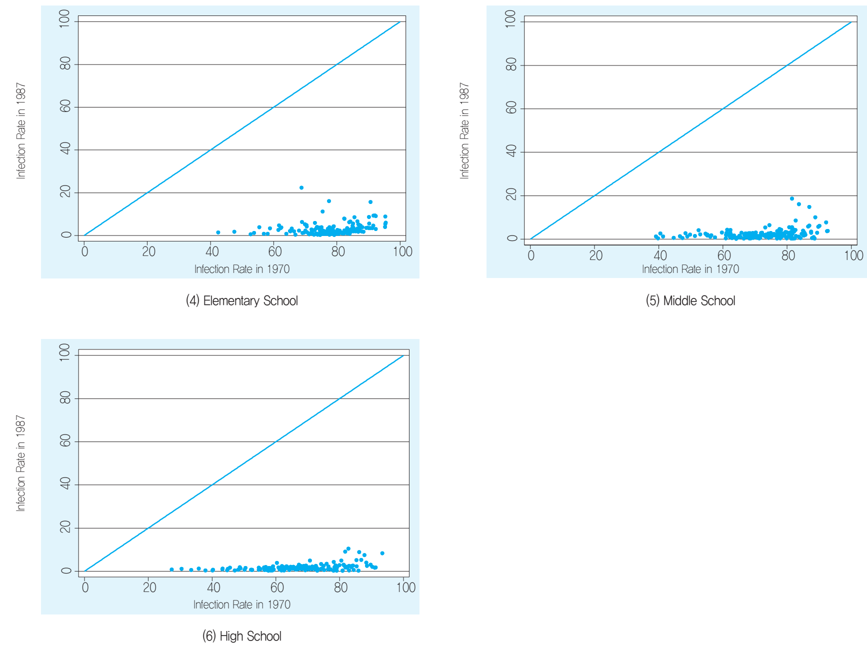
The Korean community of practitioners in parasite control was able to turn the initial government buy-in into a lasting commitment, when it helped the National Assembly enact the basic legislation that *mandated* the Korean government to organize and fund a national campaign for deworming.

## 3. Estimating Long-term Impacts of the Deworming Campaign on Education and Earning Outcomes

[Figure 6-5] plots the infection rates in 1970 and 1987 for different school levels. Although there is a wide variation in STH prevalence across counties in 1970, the infection rate converges to zero in most areas by 1987. This tendency is observed in all levels of school.

11. Meticulous compilation of administrative data was always a very important part of the integrated strategy in Korean national deworming. As noted earlier, the Korean practitioners recorded the results from the twice-a-year screenings of the entire student population of the nation, supplemented by representative sampling studies of the entire national population every five years. The KAPE and its practitioners were able to demonstrate the real and substantial impacts of the deworming campaign, thus bolstering political and public support for the public investment of deworming.

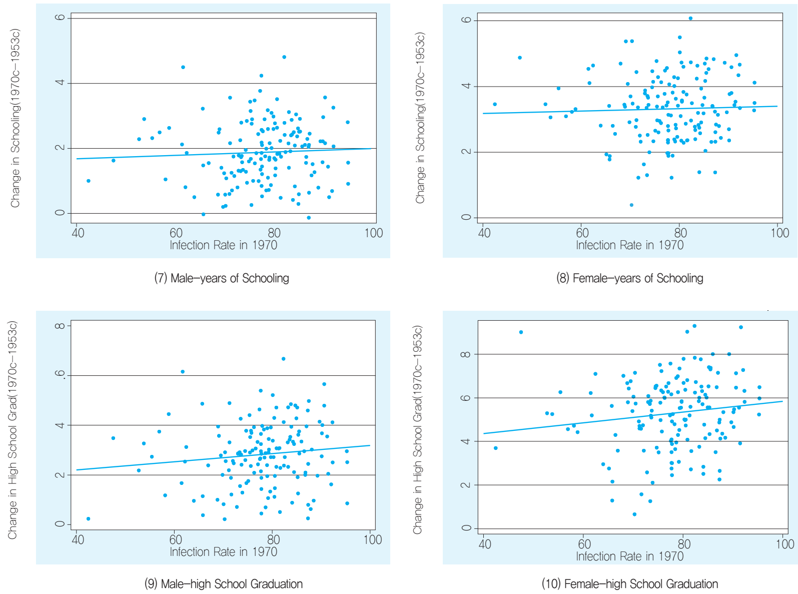
Figure 6-5 | STH Infection Rates at County in 1970 and 1987(N=179)




Source: Reproduced from Kim and Kim (2014).

Given that those areas with high STH prevalence before the intervention experienced a larger drop in infection rate during the campaign, the outcome measure would increase more in high prevalence areas compared to low prevalence areas if the campaign had any positive impact. [Figure 6-6] exhibits the correlation between pre-intervention STH prevalence and change in education measure across cohorts. The education measure by birth cohort and birth county is constructed from the Korean Population Census in 2000. The vertical axis in panel (1) in [Figure 6-6] indicates the change in the completed years of schooling between 1970 birth cohort and 1953 birth cohort in the same county, whereas the horizontal axis measures the STH infection rate in 1970. Panel (1) and (2) in [Figure 6-6] show that the high prevalence areas experienced a larger increase in the completed years of schooling during the campaign period for both male and female population. The same correlation is observed when the high school graduation is considered as an education measure.

Figure 6-6 | Change in Education between Birth Cohort (1970-1953) and Pre-intervention STH Prevalence




Source: Reproduced from Kim and Kim (2014).

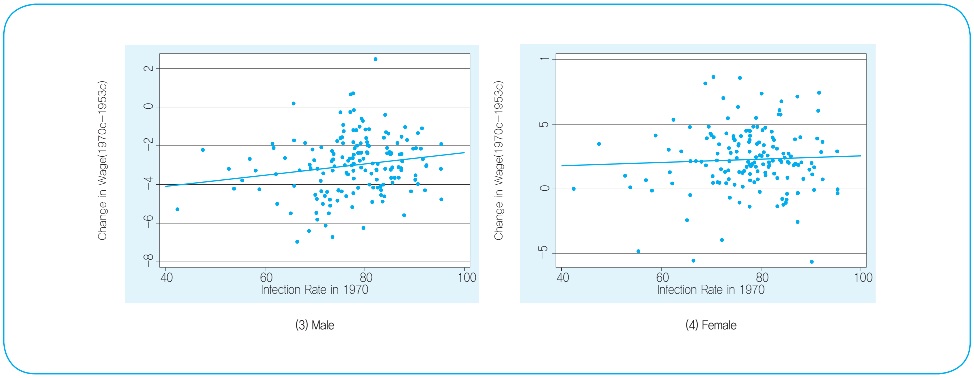
Next, wage is taken as an outcome variable. The population census in 2000 does not include the information on earnings, but it does have the employment status and industry and occupation code for workers. First, a wage equation is estimated using the 2000 Wage Structure Survey in Korea. The Wage Structure Survey is annually conducted for a representative sample of workplaces and has information on working hours and compensation of individual employees.[12] Then, the coefficients are utilized to predict the wage for the employees in the population census.[13]

[Figure 6-7] presents a scatter plot of the change in the wage between the 1970 birth cohort and 1953 birth cohort who were born in the sample county and the STH infection rate in 1970. As in the case of education measure, it is observed that high prevalence areas faced a larger increase in the wage level than low prevalence areas. It is also found that the correlation is stronger among male employees than among female counterparts.

12. The population is all the workplaces with more than four employees except those in the industries of public administration, military, social security, domestic service, international and other foreign organizations. The sample in year 2000 consists of 5,400 workplaces and 495,315 employees.

13. The prediction is made separately for male and female workers. The explanatory variables in a wage equation include age, gender, education, marital status, tenure, industry dummies (35 groups), occupation dummies (44 groups) and province dummies (16 groups).

**Figure 6-7 | Change in Log Wage between Birth Cohort (1970-1953) and Pre-intervention STH Prevalence**




Source: Reproduced from Kim and Kim (2014).

Bleakley (2010) estimated the long-term consequences of malaria eradication taking advantage of the variations with respect to birthplace and cohort. He hypothesized that those born after the campaign in high prevalence area will benefit more than those born in low prevalence area. In this subsection, we employ the idea to estimate the impacts of infection rates on education and wage using the Korean Population Census from year 2000. Population census covers a representative sample of Korean population, but does not have direct information on earnings.

The measure of exposure to the deworming campaign is constructed as in Bleakley (2010). Although the intervention of deworming was implemented through the regular school system, it was accompanied by the occasional deworming campaign for adult residents. Therefore, the level of exposure is measured with the ratio of the number of years after 1969 to the first 18 years of life.[14] [Figure 6-8] displays the exposure level by different birth cohort. In the analysis below, it is assumed that people lived in the same county since birth to the age 18.

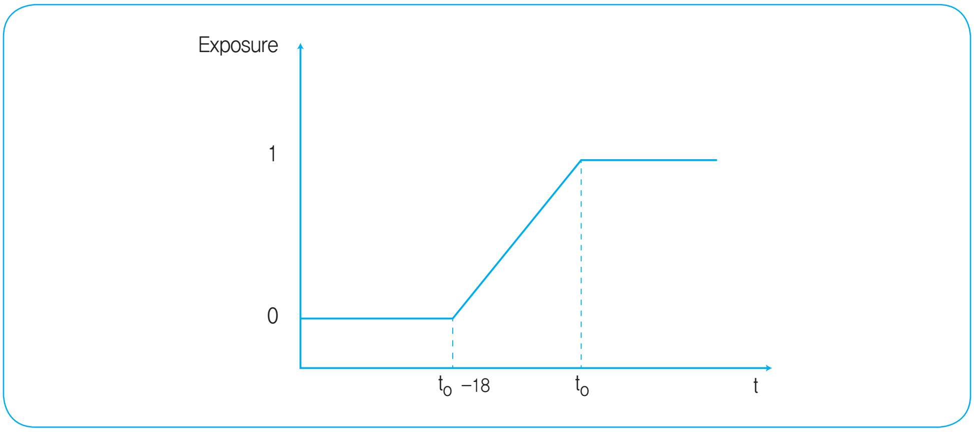
In the statistical model, the initial prevalence is measured with the STH infection rate at the county level in 1969 ($E_i$), and it is interacted with a measure of exposure to the eradication program ($Exp_j$), which is the ratio of years spent after 1969 over the first 18 years of life. The area ($i$), cohort ($j$) and time ($t$) specific effects are controlled for in the model.[15]

14. In the actual estimation, the first year of the campaign is set to the year 1970 because the information on STH infection rate is available only since 1970 in KAPE.

15. In equation (3), time dummies are included only for the case of estimating the effect of STH exposure on wage using KLIPS, in which there are multiple observations of wage for an individual.

$$Y_{ijt} = \theta E_i \times Exp_j + X_{ijt}\beta + \sigma_i + \phi_j + k_t + \mu_{ijt} \quad (4)$$

**Figure 6-8 |** Measuring the Duration of Exposure to the Nation-wide Deworming Campaign




Note: The time along the horizontal axis indicates the year of birth. The first year of the campaign is in 1969.
Source: Reproduced from Kim and Kim (2014).

The effect of STH eradication is estimated using the 2000 Population Census data. The birth county is identified for each individual, and it is assumed that the respondents lived in the birth county throughout their childhood. The final sample consists of 541,184 individuals who were born between 1930 and 1979. <Table 6-1> reports sample statistics. The mean age in year 2000 is 41 years and about half of the sample is female. The mean years of schooling are 11.3 years and the proportion of those with high school diploma is 69%. On average, the exposure level is 0.48 and the STH infection rate in 1970 is 78%.

The estimate results in <Table 6-2> suggest that the exposure to the deworming campaign had a positive impact on education. To be specific, full exposure to the campaign during childhood increases schooling by 0.95 years and the probability of graduating high school by 19.6% points. Both estimates are statistically significant at the 1% level. This suggests that the effect of STH eradication on education is larger for population conditional on middle school education than for the general population. It is also found that the consequence of STH infection risk is larger for the female group than for the male group. According to <Table 6-1>, full exposure during childhood increases schooling by 0.6 years for men and by 1.3 years for women, and the probability of high school graduation by 12.2% p for men and by 26.2% p for women.

Table 6-1 | Summary Statistics (N=541,184)

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Year of Schooling | 11.29 | 3.92 | 0 | 21 |
| Index of high School Graduation | 0.69 | 0.46 | 0 | 1 |
| Birth Year | 1958.89 | 12.70 | 1930 | 1979 |
| Female | 0.51 | 0.50 | 0 | 1 |
| Exposure | 0.48 | 0.41 | 0 | 1 |
| County Infection Rate in 1970 | 0.78 | 0.09 | 0.42 | 0.95 |

Source: Reproduced from Kim and Kim (2014).

Table 6-2 | Effects of Exposure to the Deworming Campaign on Education (Census)

| Dependent Variable | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Completed Years of Schooling | | | Index of High School Graduation | | |
| | All | Male | Female | All | Male | Female |
| Exposure × Infection Rate | 0.9460<br>(0.1162)*** | 0.5685<br>(0.1711)*** | 1.3104<br>(0.1510)*** | 0.1956<br>(0.0141)*** | 0.1221<br>(0.0207)*** | 0.2622<br>(0.0188)*** |
| Female | -1.4221<br>(0.0082)*** | | | -0.1266<br>(0.0010)*** | | |
| $R^2$ | 0.36 | 0.19 | 0.48 | 0.33 | 0.21 | 0.42 |
| *No. of Obs* | 541,184 | 263,770 | 277,414 | 541,184 | 263,770 | 277,414 |

Note: The values in parentheses are robust standard errors. Statistical significance: * = 10%,** = 5%, *** = 1%. Other explanatory variables include dummies for birth years and counties.

Source: Kim and Kim (2014).

Next, the consequence of risk of STH infection during childhood in terms of wage is estimated. The final sample is composed of 185,526 employees who were born between 1940 and 1979. The sample statistics is summarized in <Table 6-3>. The mean age in 2000 is 36 years and the ratio of females is 36%. The mean value of exposure is 62% and the initial STH infection rate is 78%. The mean predicted log wage is 8.84.

The estimation results are reported in <Table 6-4>. Column (1) indicates that full exposure to the deworming campaign under age 18 increases the wage by 5% p. The magnitude of the effect is smaller compared to those suggested by recent studies (Bleakley, 2010; Lucas, 2010). The difference in wage gain due to eradication may stem from the difference in species of parasite or in the institution. Further, column (2) and (3) suggest that the effect of

STH eradication is larger for the female sample than for the male sample. The effect of full exposure during childhood is estimated to increase wage by 2.3% p for men and by 18.7% p for women, and the former is not statistically significant. These results suggest that STH eradication is beneficial to the more disadvantaged group of the population.

**Table 6-3 | Summary Statistics (N=185,526)**

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Birth Year | 1963.69 | 9.42 | 1940 | 1979 |
| Female | 0.36 | 0.48 | 0 | 1 |
| Exposure | 0.62 | 0.37 | 0 | 1 |
| County Infection Rate | 0.78 | 0.09 | 0.42 | 0.95 |
| Log Wage | 8.84 | 0.45 | 7.51 | 10.39 |

Source: Kim and Kim (2014).

**Table 6-4 | Effects of Exposure to the Deworming Campaign on Log Wage (Census)**

| Dependent Variable: Log Real Wage | (1) | (2) | (3) |
|---|---|---|---|
| | All | Male | Female |
| Exposure × Infection Rate | 0.0496 | 0.0230 | 0.1872 |
| | (0.0273)* | (0.0309) | (0.0449)*** |
| Female | -0.3582 | | |
| | (0.0019)*** | | |
| *$R^2$* | 0.27 | 0.29 | 0.06 |
| *No. of Obs* | 185,526 | 118,838 | 66,688 |

Note: The values in parentheses are robust standard errors. Statistical significance: * = 10%,** = 5%, *** = 1%. Other explanatory variables include dummies for birth years and counties.
Source: Kim and Kim (2014).

This section investigated the long-term impacts of STH infection during childhood on educational attainment of workers and their productivity in Korea. The Korean experience presents a successful case of a sustained, nation-wide school-based deworming campaign from 1969 till 1995. For our study's purpose, we match a current generation of workers from the 2000 Korean Population Census and the annual administration data on school-by-school infection rates, taking advantage of the identification of the middle school attended by the respondents in the census.

The empirical results based on a simple model suggest that an increase from zero to full risk to STH infection during childhood is associated with a decrease in years of schooling by 1.0-2.4 years, a decrease in the chance of achieving a high school diploma by 20-51% p, and a reduction of adult earnings by 5% p. It is found that the consequence of exposure to the risk of infection is largely conditional on entering middle school. They indicate a smaller but still significant productivity impact compared to Bleakley's estimate for the American South. Further, the effect of exposure to STH infection risk is estimated to be larger for women than for men, which suggests that the STH eradication was more beneficial to the more disadvantaged group of the population.

This partial divergence of our results from previous studies might reflect the differences in the infection-productivity nexus due to differences in prevalent worm types or differences in institution. Our results suggest that the consequence of the risk of parasite infection should be understood in the context of biological, geological and socioeconomic conditions of the population under study. There are a couple of caveats in the analysis. The analysis based on cohort variation requires the assumptions that individuals lived in the same county throughout their childhood. The exposure to the deworming campaign may be correlated with other factors of economic development. The robustness of the analysis regarding these issues needs to be addressed.

# Chapter 7

## Implications for Developing Countries

# Implications for Developing Countries

This remarkable feat was achieved at modest costs to the public purse. Perhaps this had to do with the fact that the leading agency in charge of the national deworming campaign, KAPE, was a voluntary association of accomplished professionals dedicated to the mission of national deworming. The overhead at the Association was less than one third of the outlay, even including costs for construction of testing facilities. The Association was nimble and entrepreneurial. The Korean deworming campaign was the world's first mass deworming campaign to adopt the newly developed, much cheaper, Kato stool examination method. The parasitologists at KAPE also worked closely with a local pharmaceutical company to develop and test effective treatments. This collaboration made effective medications optimized for the mixture of worms usually found in the host in the country available for the deworming campaign at a fraction of the financial burden it might have cost otherwise. These innovations undoubtedly saved taxpayers' money, and helped sustain the national campaign for as long as it was needed.

To study long-term impacts of this sustained deworming campaign on educational attainment and productivity gains on the part of beneficiaries, we match individual workers from the 2000 Korean Census with the prevailing worm infection rate in the region where the worker attended middle school. The empirical strategy is inspired by a series of investigations by Hoyt Bleakley in his study of the long-term impacts of deworming in the American South. The results from our empirical analysis suggest substantial gains in years of schooling and other indicators of educational attainment, and also gains in earnings (and hence presumed gains in productivity).

Perhaps the three most important lessons that we may draw from this study of the Korean national deworming campaign are (a) that sustained, national deworming is a highly sensible public investment with the potential of huge returns, (b) that comprehensive school-based examination and treatment is a sound strategy, and (c) that to maximize the return for public investment it is crucial that such a campaign be sustained long enough, until the campaign breaches the "break point".

Sustaining a huge, national operation over a long period is not an easy task in any society, and should pose a particularly difficult challenge to developing countries struggling with poor government finance, inadequate institutions, and lack of quality human capital in critical mass among other things. That Korea was able to pull this off should be an encouragement to them. For those considering design and implementation of a similar comprehensive national deworming strategy, we offer the following practical observations based on the Korean experiences: (a) an integrated legal foundation is essential for coordination among multiple stakeholders including various government ministries and local government authorities, as well as to sustain the momentum, (b) an independent body, like the KAPE, formed by accomplished and dedicated practitioners, should bring vitality and necessary agility, saving costs and helping sustain the momentum, (c) it is important that the examination and treatment regime be accompanied by rigorous, scientific efforts to monitor the progress of the campaign, so that the results might be deployed for on-going assessment and public awareness campaigns, and (d) efforts should be made to maximize leverage from opportunities to collaborate with donors and technical cooperation, in the form of policy consultation and manpower training, may prove to be as important, if not more, as in-kind aid or financing.

The Korean case study corroborates the findings from the recent studies set in other countries in the Americas and Africa, and confirms that public investment in deworming makes excellent sense as a worthy high-return investment opportunity. The Korean episode also demonstrates that, to raise efficiency and efficacy, it makes sense to go for the largest geographic scale possible, that is national if possible, and to sustain the efforts until the population worm infection rate is pushed below a certain threshold level, which may vary from country to country, depending on the types of worms commonly found. One can very easily show that the Korean-style national, sustained deworming campaign should be able to more than pay for itself from the increases in government revenue resulting from the large increases in productivity, as captured by the increases in real earnings of workers. Even cash-strapped governments in the developing world should thus consider funding a sustained, national deworming campaign, even if they have to borrow the necessary funds from overseas to do so.

A subtler point that is nonetheless as important is that the domestic pool of human resources, efficiently organized and coordinated as in the case of the KAPE, is a crucial success factor. It is impossible to overstate the significance of the role the KAPE played in the successful implementation of the national deworming strategy. Governments in developing countries that are serious about implementation of their own national deworming strategy should consider the development of the domestic human resource base as a top priority.

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