Ancillary Benefits Due to Greenhouse Gas Mitigation, 2000-2020

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ANCILLARY BENEFITS DUE TO GREENHOUSE GAS MITIGATION, 2000 to 2020 -The International Co-Control Analysis Program for Korea

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Foreword

Climate change is recognized one of the most important issues to overcome in the Earth in the 21st century in the international society. Taking actions to prevent climate change seem to result in harmful consequences of economy. Meanwhile controlling greenhouse gas yields additional benefits among them an improvement of local air quality. This aspect deserves to draw attention in Korean situation in which the air quality is becoming serious problem as economic activities are expanding. In 1998, Korea Environment Institute and the United States Environmental Protection Agency launched a program of extended research on the ancillary benefit issues in an effort to reach policy recommendation on climate change issue. This is a series of International Co-control Analysis Program(ICAP) which was initiated by US EPA. The ICAP-Korea assessment found that the ancillary benefits of implementing GHG mitigation measures were useful in informing policy makers and the public of the co-benefit impacts of policy decisions and assisting with the development of cost-effective integrated strategies to address both local air quality issues and GHG mitigation concerns simultaneously.

This report is the result of a collaborative effort by many people. First of all, as president of lead institute of the project, I express my profound gratitude to especially Mr. Paul Schewengels and Dr. Jin Kim at US EPA and Mr. Ron Benioff and Mr. Collin Green at National Renewable Energy Laboratory for financial assistance and technical guidance. In addition to principal investigator Dr. Seunghun Joh, Ms. Yunmi Nam at KEI, Dr. Shang Gyoo Shim at KIST, Prof. Joohon Sung at Kangwon National University and Prof. Youngchul Shin at Daejin University worked for the project as Korea ICAP team. Dr. Alan Krupnick at RFF played a key role in designing a CVM survey and Prof. Sungwhee Shin at University of Seoul made a timely and useful contribution. Ms. Soohee Chung and Yonhee Cho gave editorial assistance.

Opinions expressed here are the authors', and do not represent the opinions of KEI.

June 2001
Korea Environment Institute
President
Suh Sung Yoon

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CHAPTER 1: INTRODUCTION

1.1 Background and Purpose

It is widely recognized that developing countries will make the most progress in reducing the growth of their greenhouse gas emissions by implementing measures that are consistent with their development objectives and that provide near term economic and environmental benefits. While many developing countries have conducted extensive analysis of possible greenhouse gas measures, little attention has been given to full characterization of the more immediate environmental and health benefits that would result from these measures. The International Co-Control Analysis Program or ICAP is a new initiative to assist developing countries in evaluating the environmental benefits of technologies and policies for reducing greenhouse gas emissions. ICAP is a cooperative program involving the U.S. Environmental Protection Agency (U.S. EPA) and government agencies in Argentina, Brazil, Chile, China, Korea, and Mexico. The National Renewable Energy Laboratory (NREL) and the World Resources Institute together with other cooperators and contractors will implement the program. The mission of the International Co-control Benefits Analysis Program of Korea is primarily two folds;

- Estimate ancillary benefits: Assess and quantify the environmental benefit resulting from greenhouse gas mitigation.

- Provide policy recommendation for climate change and air quality programs: Help government officials and stakeholders understand the air pollution benefits of energy technologies that will reduce greenhouse gas emissions, thus the results of this analysis can enhance support for appropriate policy for UNFCCC and air quality control program.

1.2 Relationship to Other Related Studies

The first cost-benefit study of air quality control programs that applied the impact analysis approach was carried out by Joh(2000) for the Kyonggi area (a part of the Seoul Metro.) in 1999. Continuing to apply the impact analysis framework, KEI is currently conducting a project funded by Korean Ministry of Environment targets to quantify the ancillary benefits of reduction of SOx and NOx at the national level. This project will last through August 2001.

1.3 Project Team

The Korean team includes the following institutions and experts:

- Lead Institution: Korea Environment Institute(KEI)
- Team Members:
  - Principal Investigator: Dr. Seunghun Joh, KEI
  - Energy : KEI
  - Air Quality: Dr. Shang Gyoo Shim, Korea Institute of Science and Technology(KIST)
  - Health Effect : Prof. Joohon Sung, Department of Preventive Medicine, Kangwon National University College of Medicine
  - Economic Valuation: Prof. Yeongchul Shin, Daejin University
- International Collaboration:
  - Technical advice: National Renewable Energy Laboratory
  - CVM: Dr. Alan Krupnick, Resources for the Future

1.4 Schedule of Key Activities

Tables 1.1 describes the schedule of key project activities:

Table 1.1 : Activities of Korea-ICAP

Date	Activities
Feb. 1999	Scoping meeting in Korea
Aug. 1999	Contract made between Korea and NREL
Mar. 2000	IPCC Expert Workshop on Assessing The Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies
Sep. 2000	Final report on Health Effect
Oct. 2000	Policymaker review workshop
Nov. 2000	COP6 meeting
June 2001	Final Report

1.5 Key Scoping Decisions

The following project scoping decisions were made through a scoping workshop and further consultations with climate change, air pollution, health, and economic valuation experts.

- Area : Largely due to data availability, the metropolitan area(Seoul, Kyounggi, Inchon), was chosen which covers about a half of all Korean population (22 million out of 47 million, 46.5%)
- Time Period : 1995, 2000, 2010, 2020. Year 1995 plays the role of base year and 2010 and 2020 were selected to consider the potential timing of GHG mitigation under the UNFCCC.
- Pollutants of Concern: PM10 was the only pollutant considered in this initial analysis. Here, only direct PM10 was considered and that the effects of secondary PM10 such as sulfates and nitrates were excluded from the analysis. In estimating PM10 health effects, SO2 effects were considered simultaneously. Ozone was not considered in this study, as the ozone pollution modeling/projection could not be supported.
- Economic Valuation Methods: A CVM survey to develop unit values for premature mortality was administrated only in Seoul because of cost restrictions.

1.6 Analytical Design

Starting from GHG mitigation scenarios applied in the Seoul Metro., emission inventories and concentration levels for PM10 are estimated. Reductions in occurrences of premature mortality and morbidity of asthma and respiratory diseases are calculated based on concentration-response functions. Contingent valuation method for premature mortality is employed along with benefit transfer method. Cost of illness is applied for morbidity effects. Figure 1 illustrates a methodology applied to the study.

	[Output]	[D/B]	[Methodology]
Mitigation	S1~S4	MOCIE	Bottom-Up
↓			
Emission	156Grid	ICAP	Area coef. – GHG, NIER, EPA
↓			

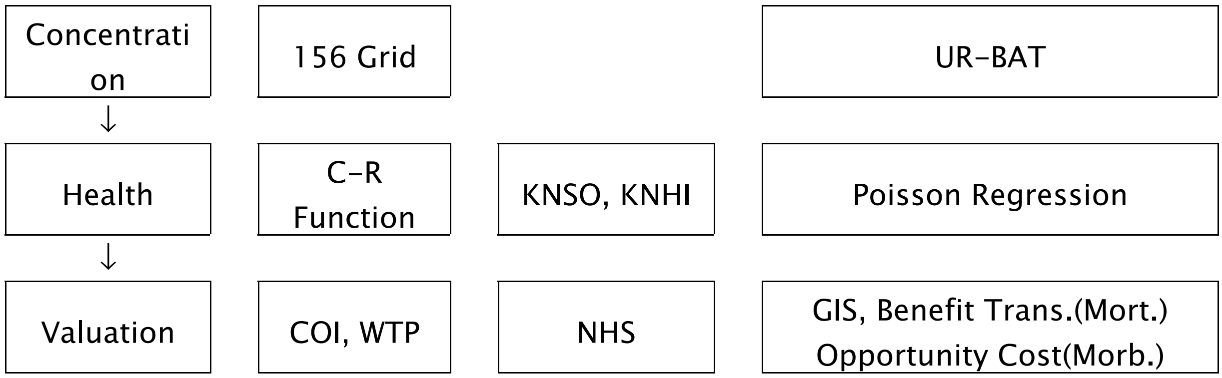


Figure 1. 1 : Overview of ICAP methodology

CHATER 2: GHG MITIGATION SCENARIOS

2.1 GHG Projections

The Rational Energy Utilization Act made it mandatory to establish a "Basic 10-Year National Energy Plan" and to revise it every fifth year to reflect changes in economic circumstances and population growth as a rolling plan. As a part of the plan, an energy demand forecast has been made and updated (Table 2. 1).

Table 2. 1 : Projections of economic and social indicators

	1995	2000	2010
GDP (1990 constant prices, trillion won)	257.5 (100)	357.7 (139)	610.9 (237)
Population	44,851,000 (100)	46,789,000 (104)	49,683,000 (111)
Number of households	12,961,000 (100)	13,967,000 (108)	16,561,000 (128)
Number of cars	8,469,000 (100)	15,148,000 (179)	30,062,000 (355)

Source: Table 4-1, National Communication of the Republic of Korea, 1998.

The energy demand forecast used a modified version of LEAP (Long-range Energy Alternative Program) which was developed by the TELLUS Institute in the U.S.A. The model adopts a bottom-up approach and forecasts energy consumption by sector and projects national energy demand by summing up sectoral energy consumption. The LEAP model is one of the most widely used models in the world. It is similar to other models, such as MEDEE and STAIR.

The projected CO2emissions are shown in Table 2.2 CO2 emissions in Korea are expected to grow from 101.1 million TC in 1995 to 148.5 million TC in 2000, to 187.4 million TC in 2005, and to 217.0 million TC in 2010 as energy demand for economic growth increases. The annual average growth rate of CO2emissions from 1996 to 2010 is projected at 5.2%. Tables 2.3 and 2.4 show newly updated policies and measures for mitigation options and GHG mitigation potential and cost-effectiveness.

Table 2. 2 : GHG projections under BAU

(Unit: Million TC, %)

	1995	2000	2010	2020	AAGR
					1995-2020

Energy-Related Emission	102.65 (82.4)	121.64 (84.0)	168.43 (83.8)	206.16 (82.9)	2.8
Industrial Processes	11.53 (9.3)	11.79 (8.1)	15.70 (7.8)	18.24 (7.3)	1.9
Agriculture	4.04 (3.2)	4.02 (2.8)	4.02 (2.0)	4.02 (1.6)	0.0
Waste Management	12.21 (9.8)	14.74 (10.2)	19.60 (9.7)	26.82 (10.8)	3.2
Managed Forest (Removed)	-5.95 (-4.6)	-7.40 (-5.1)	-6.64 (-3.3)	-6.66 (-2.7)	0.0
Total net	124.64 (100.0)	144.79 (100.0)	201.11 (100.0)	248.58 (100.0)	2.8

Source: Table 11, National Action Plan, 1998.

Table 2. 3 : Policies and measures for promotion major options

Option	Barriers and Constrains	Policies and Measures
Efficient lighting	- High price - Product quality reliability	- Introduction of financial incentive program - Strengthening minimum efficiency standard - Introduction of energy saving design standard in building code - Recommending public buildings to use efficient lighting - Activating energy service company - Green Lighting Program
Solar Water heater	- Space - High cost	- R&D support - Financial aid for establishment
Efficient home appliances (Air-con. Refrigerator)		- R&D support
Condensing gas boiler in building	- Domestic technology is not developed yet - High price	- Technology development - Promoting consumer awareness

Strengthening insulation standard	- Coordination of position between gov't agencies	- Making energy regulations consistent
Vehicle fuel efficiency		- R&D support
CNG vehicle	- Lack of infrastructure - High price	- Basic infrastructure such as recharging station - Incentives to the purchase and use of CNG vehicle - Revision of related laws such as high-pressure gas safety and management law, petroleum business law, and urban gas law
LPG vehicle	- Lack of infrastructure	- Build LPG station - LPG compact car
Electric vehicle	- Technology - Lack of infrastructure - High price	- Support for technology development - Basic infrastructure - Financial support to purchasers - Public sector's purchase
Replacement of old furnace and kiln with new ones	- Low fuel price - High investment - Low production tech.	- Financial support - Increase fuel price
Industrial condensing boiler	- Low credibility for equipment - Consumer's low acknowledgment	- Advertisement - Advice for use of high efficient equip.
Replacement of old furnace and kiln with new ones	- Low fuel price	- Financial support(Fund for Rational Energy Use) - Upward adjustment of fuel prices(Carbon tax)
Efficient motor	- Lack of technology development - Product reliability	- Technical assistance program for small manufacturers - Setting minimum efficiency standard - Green Motors Program
Inverter	- High investment	- Financial support for

		purchase
Pressurized fluidized bed combustion(PFBC) Integrated gasification combined cycle Fuel cell	- High capital cost - Lack of technology development	- Technology transfer from developed countries - R&D investment
LNG combined cycle power plant	- High fuel cost - Lack of LNG infrastructure	- LNG infrastructure - Adjustment of fuel prices
Forest conservation	- Urbanization	- Forest planning system - Designation of "Reserve Forests" - Control of forest fire and insects/diseases
Afforestation	- Low profitability	- Financial support
Waste minimization		- Unit pricing system(Volume-Based waste fee system) - Deposit fund System - Clean technologies - Changing consumption pattern
Waste recycling	- Insufficient market value of recyclables - Quality problems of recyclables - Cost ineffectiveness	- Expanding recycling facilities - Setting up source separations-
Incineration	- Emissions of hazardous air pollutants - siting problems(NYMBY syndrome) - Low level of incineration technology	- Support of R&D

Source: Table 12, National Action Plan, 1998.

Table 2.4 : GHG mitigation potential and Cost-effectiveness per unit of option

(1 US$ =1,200 Korean Won as of 1998)

	Annual GHG Mitigation	Incremental Cost

	Potential (Thousand TC, 2020)	(Thousand Won/TC)
1. Compact car	608	-2,210
2. Continuously variable transmission	1,168	-1,234
3. Efficient Air Conditioner(Commercial)	60	-979
4. Industrial condensing Boiler	12	-333
5. Replacement of old boilers	102	-295
6. Lean burn engine	1,797	-284
7. Power saving motor (commercial)	34	-280
8. Power saving motor (manufacture)	70	-212
9. Efficient Florescent Lamp(Commercial)	554	-187
10. Efficient fluorescent lamp	177	-178
11. Efficient motor	37	-143
12. Efficient Air Conditioner(Residential)	26	-122
13. Efficient motor (manufacture)	276	-96
14.Nuclear power	9,480	-46
15. Condensing gas boiler(Commercial)	46	-5
16.Afforestation	21	3
17.Reforestation	25	3
18.Forestry conservation	55	19
19. Weight reduction of Vehicle	929	31
20. Genetic Improvement of Performance(Livestock)	53	39
21. LNG C/C(power generation)	1,109	59
22. Methane restraint animal diet	21	67
23. Efficient fluorescent lamp(residential)	81	142

24. Inverter system(other Industrial)	61	147
25. Pressurized fluidized bed combustion(PFBC)	0.5	165
26. Strengthening insulation standard	512	173
27. Inverter system(Commercial)	50	234
28. Efficient refrigerator	354	280
29. Integrated gasification combined cycle	1	323
30. Condensing gas boiler(Residential)	56	436
31. Bulb type fluorescent	76	466
32.Small Thermal generation(200kw)	13	543
33. Washing machine	10	1,023
34. Solar water heater	31	1,922

Source: Table 13, National Action Plan, 1998.

2.2 Mitigation Options Considered in the ICAP

1. Household Sector
   - -Condensing boiler
   - -Solar heating
   - -Insulation
   - -Town gas
   - -Energy efficiency appliances (compact fluorescent lamp, 32W fluorescent lamp, refrigerator, TV, air-conditioner, washing machine, PC)

2. Commercial Sector
   - -Condensing boiler(10T/h)
   - -Inverter
   - -Air conditioner
   - -Motor
   - -Co-generation(200KW, 1MW)
   - -Compact fluorescent lamp,
   - -32W fluorescent lamp,

3. Transportation
   - -CNG bus

-Lean burn engine
-Weight reduction
-Continuously variable transmission
-Electric vehicle
-LPG vehicle

4. Other Industry
   -Replacement of out-of-date boiler
   -Condensing boiler
   -Efficient motor
   -Inverter

5. Industry sector
   : Classification
   Major industry(steel, non-metalic minerals, petrochemical); 70% energy consumption. Option-specific data are not available but dealing with in sector anlaysis
   Other industry: foods, textiles, pulp, and electronics,

Agriculture, fishery, mining, and construction: 9% of energy consumption: excluded in the study

2.3 Sectoral Mitigations

➢ Household

- Condensing Boiler
: improvement of energy efficiency form 89% to 99%

Year	1995	2000	2010	2020
Market size(1000ea)	1,323	1,463	1,743	2,144
Replacement_BAU(%)	0.0	0.4	25.4	38.0
R_control(%)	0.0	1.1	46.9	58.5

- Insulation
:applies to floor, ceiling, and wall,
:energy savings: e.g. for 82.5 m^2 housing energy requirement amounts to 9031.9Mcal/year, resulting in 18% saving, 9% decrease in heating energy consumption. Here assumption made include for household heating light oil and gas boiler are utilized with 85% efficiency.

Year	1995	2000	2010	2020
Market size(1000ea)	8,954	10,879	13,750	15,788

Replacement_BAU(%)	0	0	0	0
R_control(%)	0	11	44	64

-Air-conditioner
: 15% improvement of energy in case of air-con for 29.7 m2 from 1.94kwh 1.65kwh

-Florescent lamp(with bulb type)
:Substitution 17W florescent lamps for 60W bulbs

Year	1995	2000	2010	2020
Market size(1000ea)	43,634	50,629	66,489	82,025
Replacement_BAU(%)	-	5.9	36.4	44.2
R_control(%)	-	10.0	50.4	61.6

-Efficient florescent lamp

Year	1995	2000	2010	2020
Market size(1000ea)	18,991	22,036	28,938	35,700
Replacement_BAU(%)	0.1	2.6	59.8	74.3
R_control(%)	0.1	3.0	80.2	99.8

-Refrigerator

Year	1995	2000	2010	2020
Market size(1000ea)	21,859	29,093	50,072	59,904
Replacement_BAU(%)	0.0	0.0	0.0	0.0
R_control(%)	0.0	0.1	16.3	40.4

Energy saving in household sector

Options	BAU	Control
Air-con(Kw/hr)	1.94	1.65
Effi. Florescent(W/hr)	92.6	59.7
Con.boiler(kw/hr)	0.00180	0.00162
Bulb. FlorescentW/hr)	60	17
Refregerator/hr)	53.9	39.0
Insulation(TOE/hr)	0.0012	0.0001

- Commercial and Public sector

-Condensing boiler
10% improvement of energy efficiency in base-case of 10 ton of boiler

Year	1995	2000	2010	2020

Market size(1000ea)	10,190	10,950	13,142	15,035
Replacement_BAU(%)	0.0	2.1	71.5	89.2
R_control(%)	0.0	2.8	93.0	100.0

-Energy saving windows
10% improvement of energy efficiency by installing energy saving windows
-Air-conditioner
: 15% improvement of energy in case of air-con for 29.7 m2 from 1.94kwh 1.65kwh

Year	1995	2000	2010	2020
Market size(1000ea)	653	1,194	2,519	4,153
Replacement_BAU(%)	-	17.2	57.5	57.5
R_control(%)	-	17.2	100.0	100.0

-Motor
3% improvement of efficiency in case of 22.5kw(30HP) motor

Year	1995	2000	2010	2020
Market size(1000ea)	6,850	11,400	21,713	31,749
Replacement_BAU(%)	0.0	0.8	38.3	52.0
R_control(%)	0.0	2.6	69.5	72.0

-Inverter
3% improvement of efficiency in case of 22.5kw(30HP) motor

Year	1995	2000	2010	2020
Market size(1000ea)	2.626	4,104	7,816	11,428
Replacement_BAU(%)	0.6	0.7	6.1	10.0
R_control(%)	0.6	0.8	19.7	21.0

-Energy saving motor
:16% improvement of efficiency
-Co-generation for 200kw and I MW
: 30-40% energy saving

-Florescent lamp(with bulb type)
:Substitution 17W florescent lamps for 60W bulbs, 105kwh with assumption of yearly use of 2,434hours

Year	1995	2000	2010	2020
Market size(1000ea)	18,860	26,942	45,925	63,551
Replacement_BAU(%)	11.1	18.1	63.3	65.0
R_control(%)	11.1	18.7	85.5	88.0

-Efficient florescent lamp

Year	1995	2000	2010	2020
Market size(1000ea)	43,721	62,457	106,463	147,324
Replacement_BAU(%)	1.0	10.6	73.4	75.7
R_control(%)	1.0	11.2	96.8	100.0

-Energy saving in household sector

Options		BAU	Control
e-saving motor(Kw/hr)		14.63	23.29
Air-con(Kw/hr)		1.94	1.65
Eff.florescent(W/hr)		62.6	59.6
Bulb flo.(W/hr)		60	17
Eff.motor(Kw/hr)		15.75	15.28
Inverter(Kw/hr)		15.75	10.3
Condensing boiler(TOE/hr)		0.758	0.686
Windows (TOE)	Heating	10.8	9.5
	Cooling	70.6	63.0

- Transportation

-Fuel Efficiency Improvements with Lean Burn Engine
: 20% improvement of fuel in local driving

-Weight reduction
: 10% reduction results in 10% efficiency

-Continuously variable transmission
;10% increase in efficiency

-Compact car

Fuel efficiency (km/l)

Options	BAU	Control
Compact car	11.0	15.3
CVT	9.9	10.8
Lean burn	11.0	13.1
Weight reduction	11.0	12.0

- Industry sector

: Classification

Major industry(steel, non-metalic minerals, petrochemical); 70% energy consumption. Option-specific data are not available but dealing with in sector analysis

Other industry: foods, textiles, pulp, and electronics,

Agriculture, fishery, mining, and construction: 9% of energy consumption: excluded in the study

- Other industry

-Replacement of out-of-date boiler

;15% of efficiency improvement

Year	1995	2000	2010	2020
Market size(1000ea)	720	490	1197	1833
Replacement_BAU(%)	50	50	50	50
R_control(%)	50	61.1	83.3	94.5

-Condensing boiler

;15%p of efficiency improvement (90%→99%)

Year	1995	2000	2010	2020
Market size(1000ea)	14	60	129	194
Replacement_BAU(%)	0.0	13.6	37.6	61.7
R_control(%)	0.0	21.8	65.4	98.0

-Efficient Motor

: 5% of efficiency improvement

Year	1995	2000	2010	2020
Market size(1000ea)	42,770	59,214	87,509	109,729
Replacement_BAU(%)	0.0	4.1	24.8	25.0
R_control(%)	0.0	24.9	71.8	72.0

-Inverter

36% energy saving

Year	1995	2000	2010	2020
Market size(1000ea)	5,859	8,112	11,989	13,937
Replacement_BAU(%)	3.1	4.5	9.8	10.0
R_control(%)	3.1	6.8	20.9	21.0

-Energy saving motor
:16% energy saving

Year	1995	2000	2010	2020
Market size(1000ea)	6407	8870	13109	15239
Replacement_BAU(%)	0.8	0.9	2.9	3.0
R_control(%)	0.8	2.9	7.0	7.0

Energy saving in other industry sector

Options	BAU	Control
Condensing boiler(TOE/hr)	0.758	0.686
Boiler replacement (TOE/hr)	0.251	0.212
e-saving motor(kw/hr)	14.63	12.29
Eff. Motor(kw/hr)	15.4	14.63
Inverter(kw/hr)	15.75	10.6

2.4 Data processing for ICAP

:Geographic scope of ICAP includes Seoul, Inchon, and Kyoggi
:The data set utilized is of national level
:Based on the national data, area unit(***gu, shi, gun***)data have been obtained in following way (See Figure 2.2)
a. National → Seoul, Inchon, and Kyonggi(A1)
:Portion of National energy to A1's (See Table 2.6 and 2.7)
b. Seoul, Inchon, and Kyonggi(A1) → area unit(***gu, city, gun***)(A2)
:A1*(portion of population and/or productions in A2)

Table 2.5 : Coverage of ICAP data out of national data.

Household: All except for renewables, generation, and local heating
Commercial: All except for renewables, generation, and local heating
Transportation: All except for renewables and generation
Industry
Major and Other Industry : All except for renewables
Non-manufacturing: not included in ICAP
Power transformation
Generation: All except for nuclear, hydro, and other

Figure 2.2 : Derivation of area factors

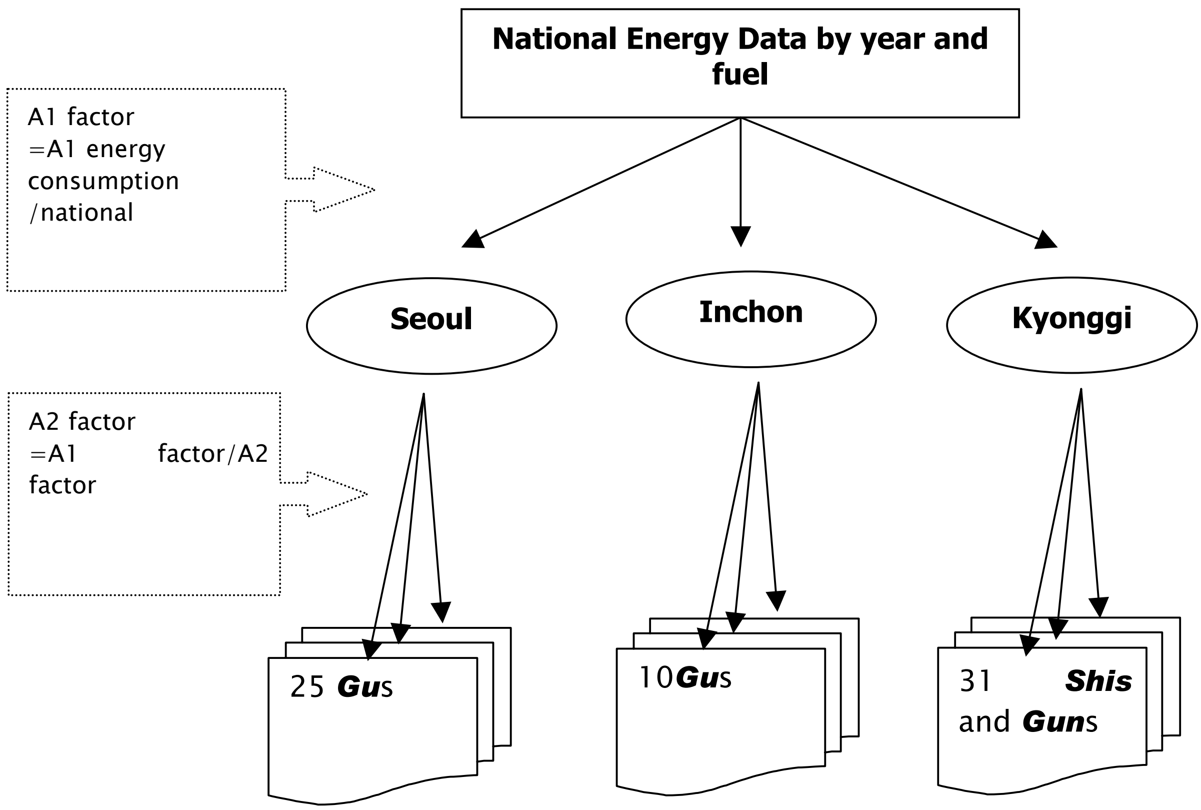


Table 2.6 : Comparison of national with ICAP by area

	ICAP_Seoul	ICAP_Inchon	ICAP_Kyonggi	National
1. Total (1000 TOE)	11360.02	7642.67	17053.90	150222.2817
2. Selected (1000 TOE)	11360.02	7642.67	17053.90	126071.9594
3. ICAP/National (%)	7.56	5.09	11.35	
4. ICAP/National (%)	9.01	6.06	13.53	

*"1.Total" indicates total energy consumption covered in ICAP and National,
"2.Selected" indicates sum of covered components in National,
"3. ICAP/National " implies ICAP/National using "1. Total "figures
"4. ICAP/National " implies ICAP/National using "2.Selected "figures
**The above relations applied to Inchon and Kyonggi as well.

Table 2.7 : Comparison of national with ICAP by sector

National Data					
-energy consumption (1000 TOE)					
1000 TOE	1995	2000	2005	2010	2020
Household	18477.04	20495.60	21719.82	24201.99	29392.78
Commercial, public	7026.80	7684.41	9160.84	10030.17	12296.51
Transportation	27013.60	30800.47	40033.97	47144.19	55332.29
Industry	54652.82	63495.57	70643.29	77828.06	93544.97
Transformation	43052.02	58338.79	76652.92	90025.53	115761.74
Sum	150222.28	180814.83	218210.84	249229.93	306328.30
ICAP					
-energy consumption (1000 TOE)					
1000 TOE	1995	2000	2005	2010	2020
Household	18212.04	20275.60	21404.82	23746.99	28515.78
Commercial, public	6977.20	7570.41	9004.84	9806.17	11855.52
Transportation	27013.60	30800.47	40033.97	47144.19	55332.29
Industry	48944.10	56156.46	62036.30	67741.98	79431.13
Transformation	24925.02	32067.54	44797.67	48910.03	56672.75
Sum	126071.96	146870.48	177277.60	197349.35	231807.47
- energy consumption covered ICAP/National (%)					
Household	98.57	98.93	98.55	98.12	97.02
Commercial, public	99.29	98.52	98.30	97.77	96.41
Transportation	100.00	100.00	100.00	100.00	100.00
Industry	89.55	88.44	87.82	87.04	84.91
Transformation	57.90	54.97	58.44	54.33	48.96
Sum	83.92	81.23	81.24	79.18	75.67

Primary Data Sources:

- The second-year study of planning national actions for the UNFCCC, KEEI, May 1999.
- Study for National Action Plan in Response to Climate Change, 1997.

- National Communication of the Republic of Korea, 1998.
- Report on Energy Census, 1996.
- Yearbook of Energy Statistics, various years.
- Unpublished government documents.

CHAPTER 3: AIR POLLUTION ANALYSIS

3.1 Key Assumptions

The target region for the analysis is the Seoul Metropolitan Area, which includes Seoul, Inchon, and most part of Kyonggi Province. Only primary TSP and PM10 (not secondary particulates) from fuel combustion and fugitive dusts from paved roads are considered. Emissions are calculated with emission factors and activity data for each economic sectors relying on fuel consumption data for the sectors and data on vehicle use. The atmospheric PM_{10} concentrations are calculated with the UR-BAT model, which is a revised urban scale version of ATMOS used in RAINS-Asia, with emission inventory and meteorological data compiled in this study.

Key assumptions include:

- The background atmospheric concentration of PM10 is assumed as 20ug/m^3

- The number of registered vehicles in a domain is calculated based on the assumption that there will be the growth rate of oil price of 4% and low economic growth rate of 2% every year.
- The same meteorological input data of 1995 are used for other future years.
- Relative patterns of energy use in each region of analysis do not change from 2000 to 2020 for any reason other than the impact of energy policies in the reduction scenarios

It is important to note that in Korea, PM10 has been measured only since 1995 (20 sites in study area). This relative short history and sparse networks make it difficult to precisely assess the health effects from PM10 pollution. There are only a few studies evaluating the health effect from PM10 to date in Korea, although a growing body of evidence is being established about the health effects of TSP. For this analysis, we started with the ambient concentration and monitoring system of PM10 and focused on PM10 data since 1996, which is considered the most reliable.

3.2 Emission inventory

Emission factors for TSP and PM_{10} are mainly based on Korea NIER(National Institute of Environment Research) and U.S. EPA. Summary of emission factors by fuels and by sectors are shown in Table 3.1 and 3.2.

Reference Scenario: National date from the Ministry of Commerce, Industry and

Energy (MOCIE) (MOCIE 1998) were used to develop bottom-up estimates for energy consumption and GHG emissions through 2020. Table 2.6 shows the proportion of national energy consumption that is covered by the study areas, with the three areas accounting for 24% of national total in energy consumption.

3.3 Scenarios

Reference scenario: Based on National data and mitigation options described
: The National data have been made through bottom-up type for energy consumption, and GHG emission. The limitation of the given data set is that it enables only one scenario. Making, thus, alternative scenarios is almost impossible unless obtaining back data.

In order for alternative scenarios to be carried out, a simple assumption is made such that based on national data set the identical energy input change applies to all sectors in ICAP data . Three alternative scenarios include 5 percent reduction of energy input, 10 percent, and 15 percent.

- Reduction scenario 1 – Assumptions include a portfolio of energy efficiency measures for all major energy sub-sectors including introduction of high-efficiency facilities, replacement of fuels according to MOCIE, and increasing efficiency of PM10 emission controls at industrial manufacturing facilities.
- Reduction scenario 2 – Assumes 5% reduction in energy use across economic sectors regardless of measures and the use of CNG fueled buses (CNG fueled buses are assumed to replace commercial buses by 10% in 2000, 75% in 2005, and 100% to 2010
- Reduction scenario 3 – Assumes 10% reduction in energy use across economic sectors regardless of measures and the use of CNG fueled buses
- Reduction scenario 4 – Assumes 15% reduction in energy use across economic sectors regardless of measures and the use of CNG fueled buses

Scenario 1 involves assumptions regarding an enhanced program for improved air quality control. Thus, we propose that reduction scenarios 2-4 be considered for analysis of GHG mitigation activities in this analysis. Scenario 1 applies additional levels of air pollution control for PM10.

Table 3.1 : TSP and PM_{10} emission factors used this study

Z3	Anthracite	Bituminous	Gasoline	Kerosene	□iesel	Bunker	Jet oil	Naphtha	LPG	LNG	City gas
Unit	Kg/ton	kg/ton	kg/kl	kg/kl	Kg/kl	kg/kl	kg/kl	kg/kl	kg/kl	kg/1000 m^3	kg/1000m^3
<Households>											
`	0.60	–	–	0.24	0.24	–	–	–	0.05	0.003	0.003
PM_{10}	0.54	–	–	0.13	0.13	–	–	–	0.05	0.003	0.003
<Commercial-Public>											
TSP	0.60	–	–	0.24	0.24	1.256 ~1.478	0.240	–	0.05		0.003
PM_{10}	0.54	–	–	0.13	0.13	0.779 ~0.916	0.130	–	0.05		0.003
<Industrial manufacturing – for 90 % removal efficiency>											
TSP	20	5.0	0.02	0.02	0.024	0.126 ~0.209	–	–	0.007	–	0.01
PM_{10}	12	3.3	0.01	0.01	0.012	0.119 ~0.197	–	–	0.007	–	0.01
<Conversion-Electricity – for 90 % removal efficiency>											
TSP	–	–	–	–	0.024	0.071 ~0.155	–	–	–	–	0.005
PM_{10}	–	–	–	–	0.012	0.050 ~0.110	–	–	–	–	0.005
<Conversion-District Heating – for 90 % removal efficiency>											
TSP	–	–	–	–	–	0.126 ~0.148	–	–	–	0.003	0.003
PM_{10}	–	–	–	–	–	0.078 ~0.092	–	–	–	0.003	0.003

Table 3.2 : TSP and PM_{10} emission factors for transportation

	Passenger car	Small bus	Heavy bus	Small truck	Heavy truck	Ship-Diesel	Ship – Heavy Fuel (ex. B-C)
Unit	g/km	g/km	g/km	g/km	g/km	kg/kl	kg/kl
TSP	0.01	0.35	2.02	0.37	2.07	1.80	1.20
PM_{10}	0.01	0.35	2.02	0.37	2.07	1.80	1.14

Table 3.3 : GHG emission estimates for each scenario

		1995		2000		2010		2020	
		1000TCE	(%)	1000TCE	(%)	1000TCE	(%)	1000TCE	(%)
Nationwide	BAU	102,132	100	117,539.9	100	160,349.34	100	188,323.12	100
Metropolitan area	BAU	28,036	27.45	31498.91	26.80	45023.43	28.08	56372.70	29.93
	Control	28,036	27.45	30963.45	26.34	42976.20	26.80	52113.75	27.67
	5% Reduction			29923.97	25.46	42772.25	26.67	53554.06	28.44
	10% Reduction			28349.02	24.12	40521.08	25.27	50735.43	26.94
	15% Reduction			26774.08	22.78	38269.91	23.87	47916.79	25.44

3.4 Air quality modeling

This UR-BAT(Urban Branching Atmospheric Trajectory) model is a three dimensional multi-layered Lagrangian model revised from ATMOS model. The resolution of this model is 5 minutes. Same meteorological data of 1995 are also used all future years, 2000, 2010 and 2020. Background atmospheric PM_{10} concentration of PM_{10} is assumed as 20 $\mu g/m^3$.

CHAPTER 4: HEALTH EFFECTS

4.1 Observation and Projection

Health effect analysis was performed based on both observation and projection. To get an effect size of PM10, we used actual PM10 level and morbidity data of the past (=observation). Then we projected the effect size (Concentration-Response function, C-R function) to predicted level of PM10 (=projection).
First, we concentrated on acquiring epidemiologically sound health effects of PM10 from available data sources. Then, we tried to estimate best estimators of magnitude of health effects from PM10, based on given effect size, prevalence and emission scenarios.
To get epidemiologically sound effect size of PM10, we estimated actual exposure from PM10 as the first step of analyzing "past observation"

4.2 Exposure Assessment of PM10

4.2.1 General Consideration about PM10 Monitoring in Korea

- Monitoring Sites: 22-36 sites between 1995 and 1998, nationwide.(Table 4.1)

Table 4.1 :. Number of PM10 and TSP (in parentheses) monitoring sites since 1995*.

Year	1995	1996	1997	1998
Number of PM10 Sites (TSP sites)	22 (57)	22 (57)	28 (80)	36 (96)

- The PM10 monitoring was first introduced in 1995 (about 20 monitoring sites). The PM10 data was not fully validated for an epidemiologic studies, yet. Especially, PM10 levels in 1995 have been augued, since even the administrative authorities does not guarantee that standard PM10 sampling method (tape sampler method) was uniformly applied from the beginning.
- NAAQS (National Ambient Air Quality Standards) in Korea and the standard measuring methods are shown in Table 4.2 PM2.5 is not being measured in Korea. There are still more TSP monitoring sites than PM10 sites in Korea,

although PM10 sites are gradually replacing TSP sites.

Table 4.2 : NAAQS in Korea vs in US and their measuring method for major air pollutants.

Pollutants		Standard	US EPA standard	Method
SO2		Annual 0.03ppm 24h average 0.14ppm 1h average 0.25ppm	Same	Pulse U.V. Fluorescence Method
CO		8h average 9ppm 1h average 25ppm	Same	Non-Dispersive Infrared Method
Nox		Annual 0.05ppm 24h average 0.08ppm 1h average 0.15ppm	Same	Chemiluminescent Method
PM	TSP	Annual 150□/□ 24h average 300□/□	Annual 75 □/□ (geometric) 24h average 260 □/□	β-Ray Absorption Method Sampled by High Volume Air Sampler
	PM10	Annual 80□/□ 24h average 150□/□	Annual 50□/□ (arithmetric) 24h average 150□/□	β-Ray Absorption Method Sampled by Tape Sampler Method
	PM2.5	Not monitored	Annual 15□/□ (arithmetric) 24h average 50□/□	
O3		8h average 0.06ppm 1h average 0.1ppm	8h average 0.08ppm 1h average 0.12ppm	U.V. Photometric Method
Pb		3 months average 1.5□/□		Atomic Absorption Spectrophotometry

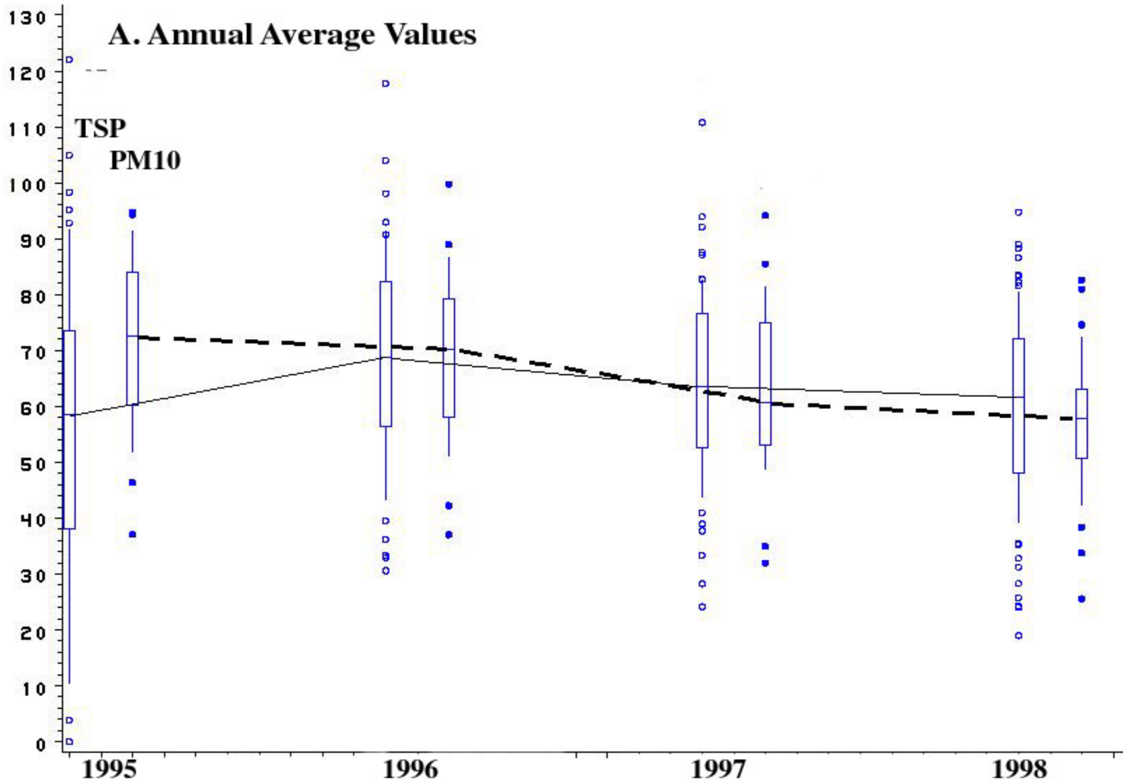
- In this study, PM10 exposure levels were assessed based on those from fixed monitoring sites

4.2.2 Indirect Assessment of PM10 Data Validity

- As PM10 data was not fuly validated for studies like ours, we tried to estimate the PM10 data in Korea. Since we did not have any gold standard for PM10 data, we evaluated PM10 data indirectly by comparing the trends of

PM10 and TSP around the year of 1995.

- Annual average value of overall monitoring sites and trends in every monitoring site was plotted to see the reliability of (especially 1995) PM10 data (Figure 4.1)
- As shown in Figure 4.1 there is a possibility that PM10 levels in 1995 were overestimated, if judging from the differences in their trend. However, the areas with PM10 monitoring are generally more polluted, we cannot rule out the possibility that they are the actual PM10 values.



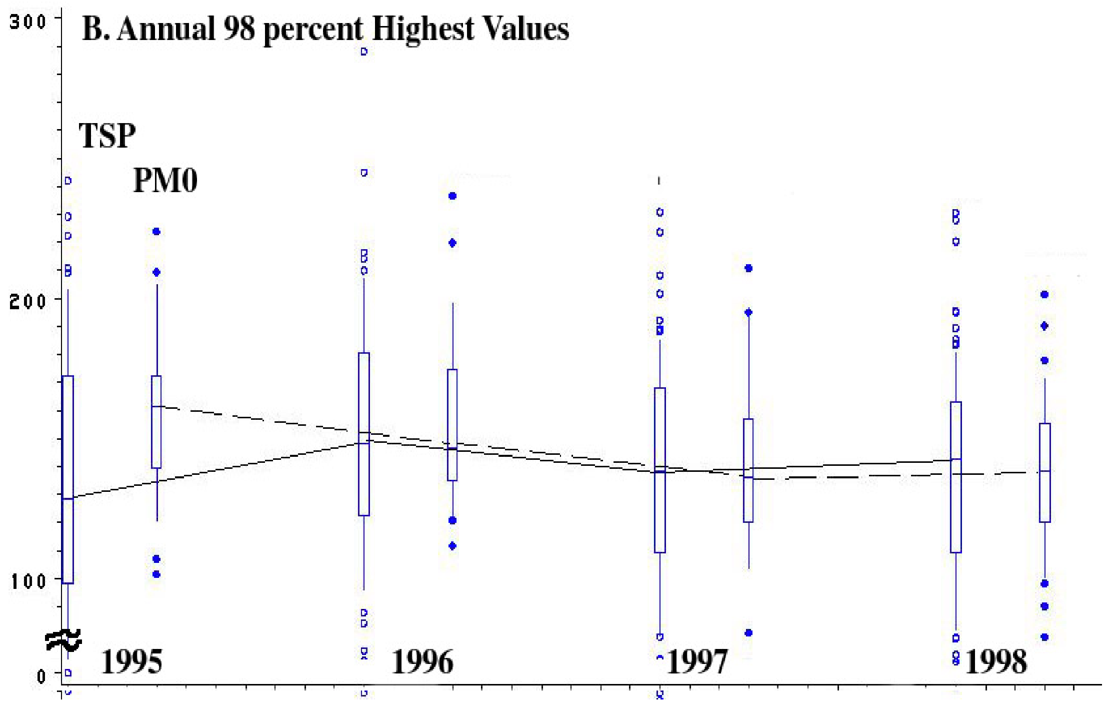


Figure 4.1 : Comparison of annual grand levels (1-A) and 98 percent highest levels (1-B) between TSP and PM10 along the year 1995-1998. Median levels of PM10 in 1995 are even higher than TSP levels.

- When we plotted the trend of PM10 and TSP level by the monitoring site, more sites monitoring TSP showed increased pollution level in 1996 compared with those in 1995 (Figure 4.2)

- The seasonal variation pattern of PM10 was same with that of TSP (Figure 4.3). Monitored PM10 level was slightly lower than the level of TSP

-

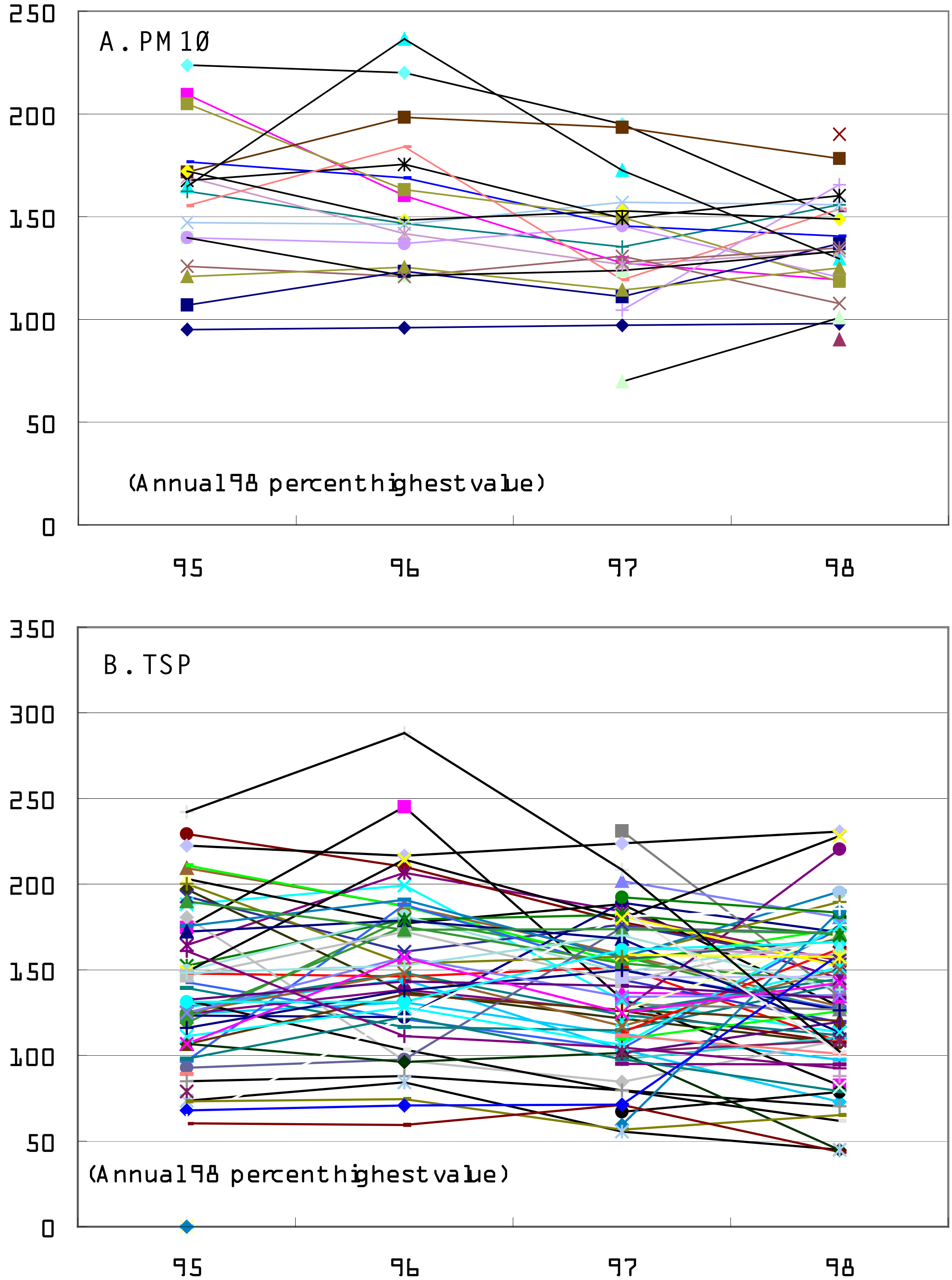
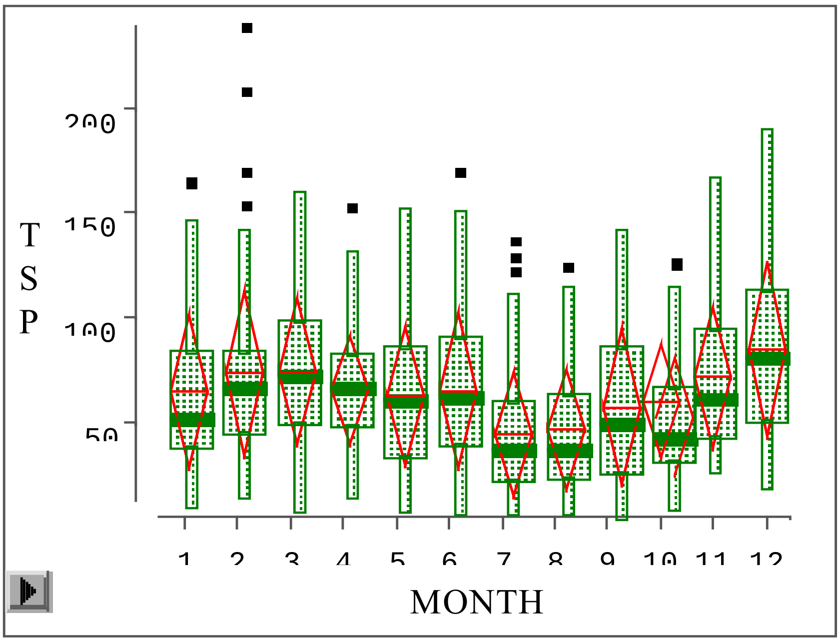


Figure 4.2 : Trend of PM10 and TSP level for the year 1995 and 1995. Each line connects the pollutant level of the same monitoring site.



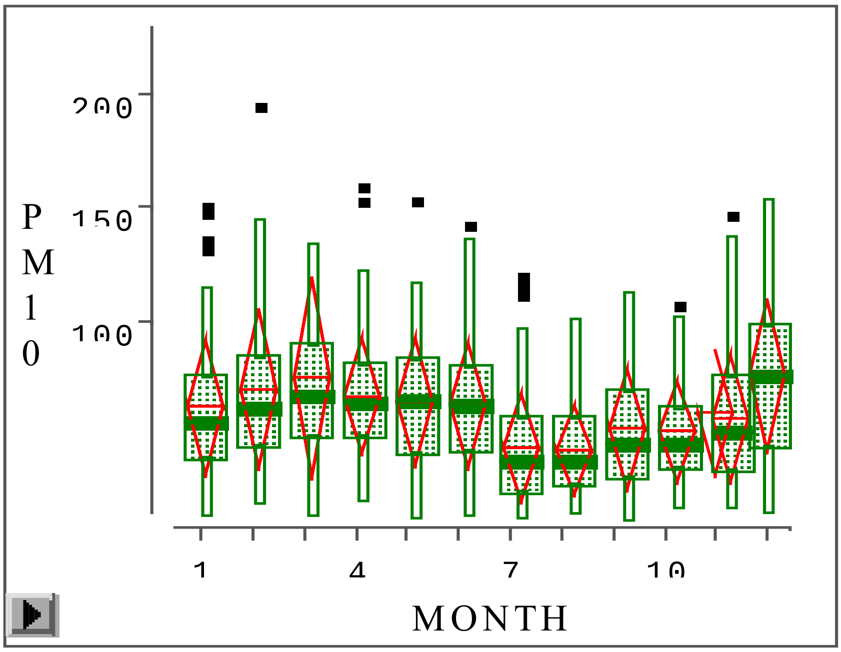


Figure 4.3 : Seasonal variation of TSP and PM10 (monthly average value, um/m3). Both pollutants show similar pattern, and PM10 levels are slightly lower than TSP level.

- Considering the substantial uncertainty of PM10 values in 1995, selected the PM10 data of the years between 1996-1998_for this study.

- Although the PM10 level in this study was relatively higher than could be expected from the conversion factor of “0.6” used in US, we could not conclude PM10 level was overestimated, because PM10 and TSP levels were not monitored in the same area. And areas where PM10 was monitored usually were usually more polluted areas.

- For a next step, more extensive validation of PM10 level would be needed, by comparing the PM10 level with modeled TSP level of the same area (for the areas where both PM10 and TSP levels are available), or by comparing with the past TSP level after controlling seasonal-diurnal variation and long term trends.

4.2.3 Exposure Assessment of PM10 levels in This Study

A. PM10 levels were assigned as following methods Daily average level was used for the representative exposure level of the area

B. Daily value less than 75% completeness (less than 18 hours) was treated as missing data

C. In case the daily average value of less than 75% completeness day exceeded 24-hour standard (of US EPA, 150□/□), it was included in the analysis (if not exceeded standard, then discarded).

D. Air pollution data and health outcome data were merged based on administrative unit area: “Gu” (ward-level subdivision of a larger city), “Gun” (county-level subdivision of a rural province) or the city itself (for smaller cities) when possible. All unit areas are as large as a typical county in the US, with 200 to 400 thousand residents.

- We assumed that centrally monitored PM10 levels represented average exposure level of the subjects in study areas.

- Same method of exposure assessment was used for SO2, which was considered in the model (PM10-helath effects)

4.3 Methods and Data Sources

4.3.1 Scopes of this study

Area : Greater Seoul Area (Seoul, Kyoungi, Incheon)
Period: Between 1996-1998Pollutants of concern: PM10 / PM10 adjusted for SO_2 (considered in the model)
Other environmental factors considered in this study:
meteorological factors
temperature : Daily average temperature
humidity: Daily average relative humidity
Health outcomes of this study:

A. Mortality: cardiovascular mortality (ICD 10, I00-I99), and
respiratory mortality (ICD-10, J00-J99)
B. Morbidity: Asthma, Chronic Obstructive Pulmonary Diseases (COPD)
C. Short-term health effects rather than long-term health effects
(Long-term health effects like occurrence of new COPD from normal subjects were not considred)

4.3.2 Data Sources

- Mortality data:

A. Death registry data of all Korean people between 1996-1998 (Korean National Statistical Office)
B. With individual information
a. the cause of death (international classification of diseases 10h revision code, ICD-10)
b. date and area of death : address code (as large as “Gu”-“Gun”-“City” level, equivalent to county level in US).
c. Age when death and gender
d. Occupation and marital status

- Morbidity data

A. Medical claim data of Nationwide Health Insurance data (KNHI) between 1996-1998 for the diseases of Asthma and COPD. KNHI covers more than 95% of all Koarean people (about 450 million people).

B. Providing

a. 13-digit ID number: enables exact data matching among various data sources (unified ID system)
b. ICD-10 code for the diagnosis
c. date of treatment (starting data) and duration of treatment
d. hospital (location and size of hospital)
e. inpatient or outpatient care
f. total cost for a spell of diasese.

C. About 45% of all KNHI members have insurance number based on their residence area so that residence area could be found. Finally we used the morbidity data whose residence area could be identified.

- Air quality data:

A. Continuously measuring particles (TSP or PM10), SO_2, ozone, nitrogen dioxide (NO_2), carbon monoxide (CO), and ambient lead level

B. There were about 110 (1996) –140 (1998) monitoring sites, nationwide.

C. There were 49 monitoring sites (1998) in the study area (greater Seoul area)

D. United States Environmental Protection Agency standard methods are used for measuring

- Meteorological data.

A. Meteorological data, including hourly temperature (degree C), relative humidity (percent) was gathered from 71 sites.

B. There were 3 major (KMA, Korean Meteorological Agency) and 3 minor meteorological monitoring sites in the study area. Data from 3 major site (KMA) were utilized.

4.3.3 Health Outcomes Definition

- Total Mortality: The count of daily deaths from non-external causes of each study area

- Cardiovascular mortality: deaths caused from any cardiovascular diseases (I00-I99 for ICD-10)

- Respiratory mortality: deaths caused from any respiratory diseases (J00-J99 for ICD-10)

- Asthma morbidity: Any medical uses claimed by Korean National Health Insurance Corporation from ICD-10 J45-J46 in study area

- COPD morbidity : Any medical uses claimed by Korean National Health Insurance Corporation from ICD-10 J42-44 (chronic bronchitis) J47 (emphysema) in study area

4.3.4 Parameters for Valuing Cost of Illness attributable to PM10

(1-Relative Risk)* x (disease prevalence) x (PM10 change) x (pop. size) x (unit cost per disease spell)

* Relative risk, RR (dimensionless)
–increased risk of diseases-deaths per unit increase of pollution level
□Disease prevalence/mortality rate (cases/person-year)*
–New estimation by age group, severity and diseases
ex) Asthma admission rate (spell based) among F, 65 or over
□Average cost/duration for a spell of asthma/COPD*
assumed to be constant over years

- This schemetic diagram of is as follows

Average Time Lost per a Spell of Disease (events can be recurred) - Time Lost d/t admission - Time Lost d/t outpatient visit - Time lost d/t medication at home?
Average cost per a death

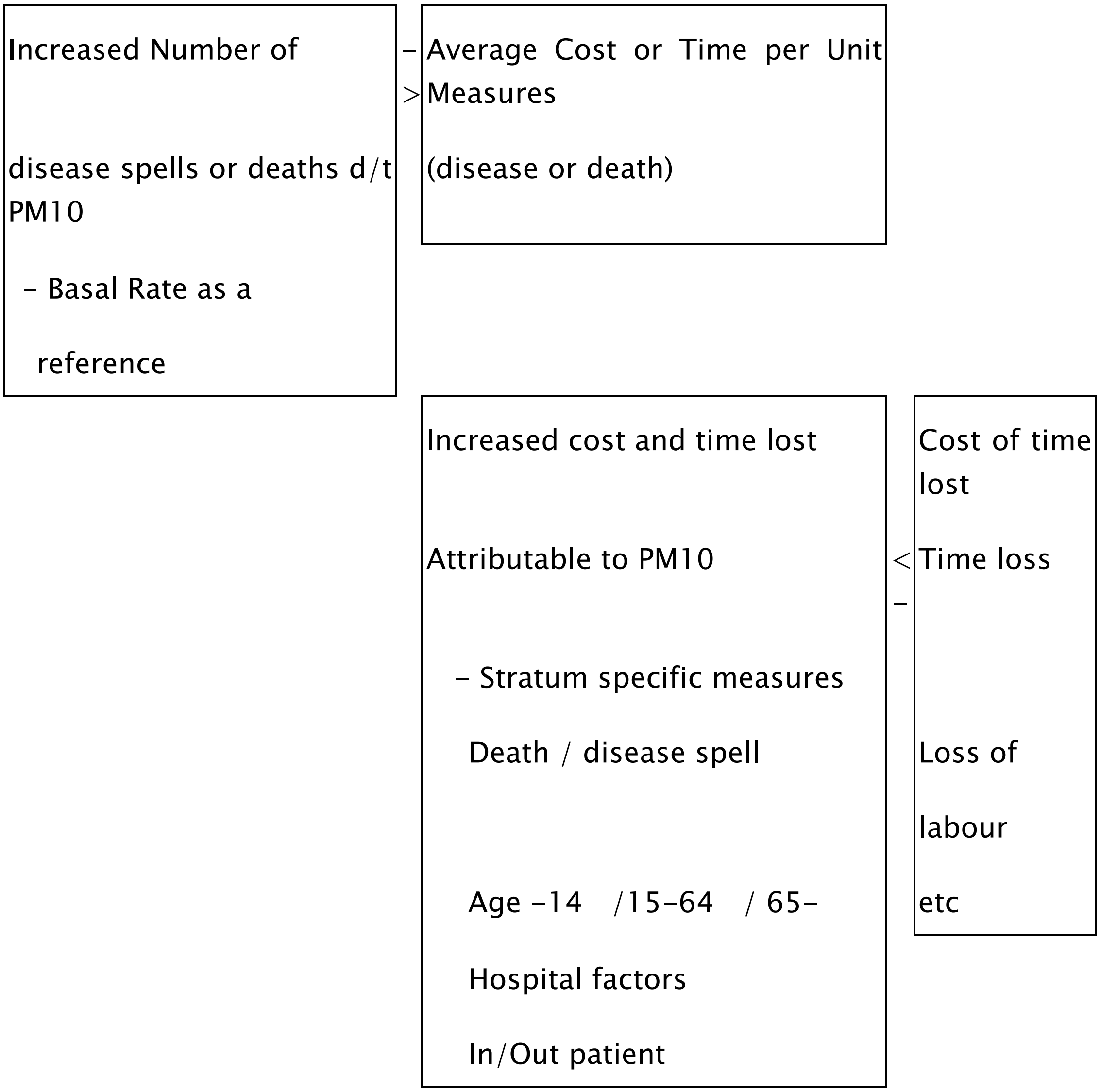


Figure 4.4 : Strategic frame work for COI calculation

4.3.5 Analytic Methods

- A Robust Poisson Regression Model was selected for several reasons

A. to control non-linear relation between temperature, humidity and health effects (by smoothing functions like loess)

B. the count of health outcomes could be assumed to follow Poisson distribution

C. this model allows considering couple of other factors like SO2, date of the week, year and so on which were related to either health outcomes or PM10 level.

- Model Selection

A. Meteorological Variables:

a. Daily average temperature and relative humidity was used as a smoothing function (loess)

b. As there were strong but non-linear relation between health effects and temperature, health effects and humidity, we selected a smoothing function for controlling weather factors (figure 4.5).

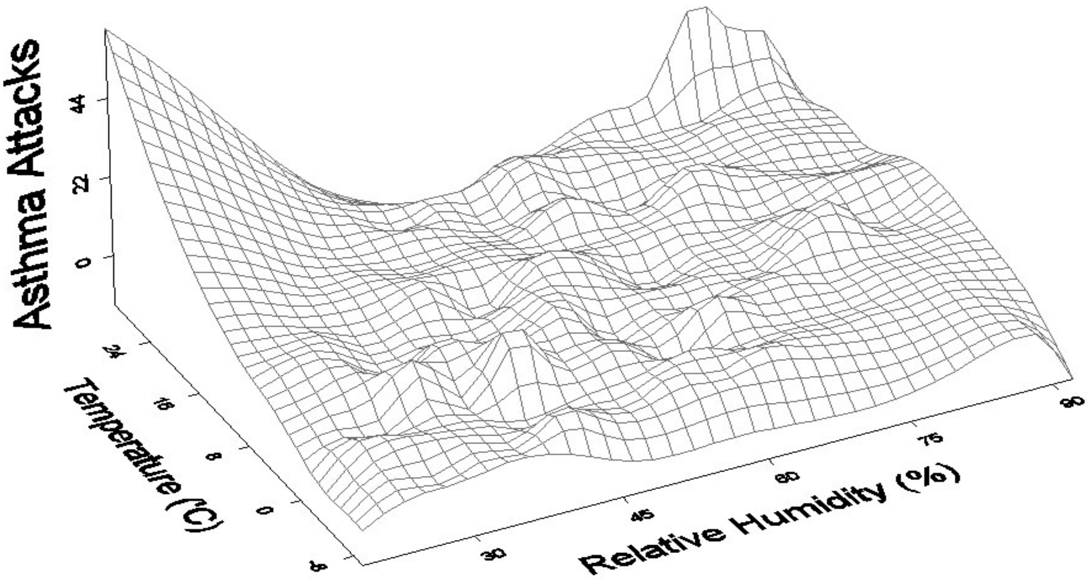


Figure 4.5 : Non-linear relation between, relative humidity, temperature and asthma attack.

- We also used indicator variables for day of the week, year, first and last days of the month (for morbidity data only).
- There were marked cyclic variations in a week especially for morbidity data (admission as well as outpatient)(figure 4.6)

A. Control of Marked Weekly Variation by modeling (Morbidity)

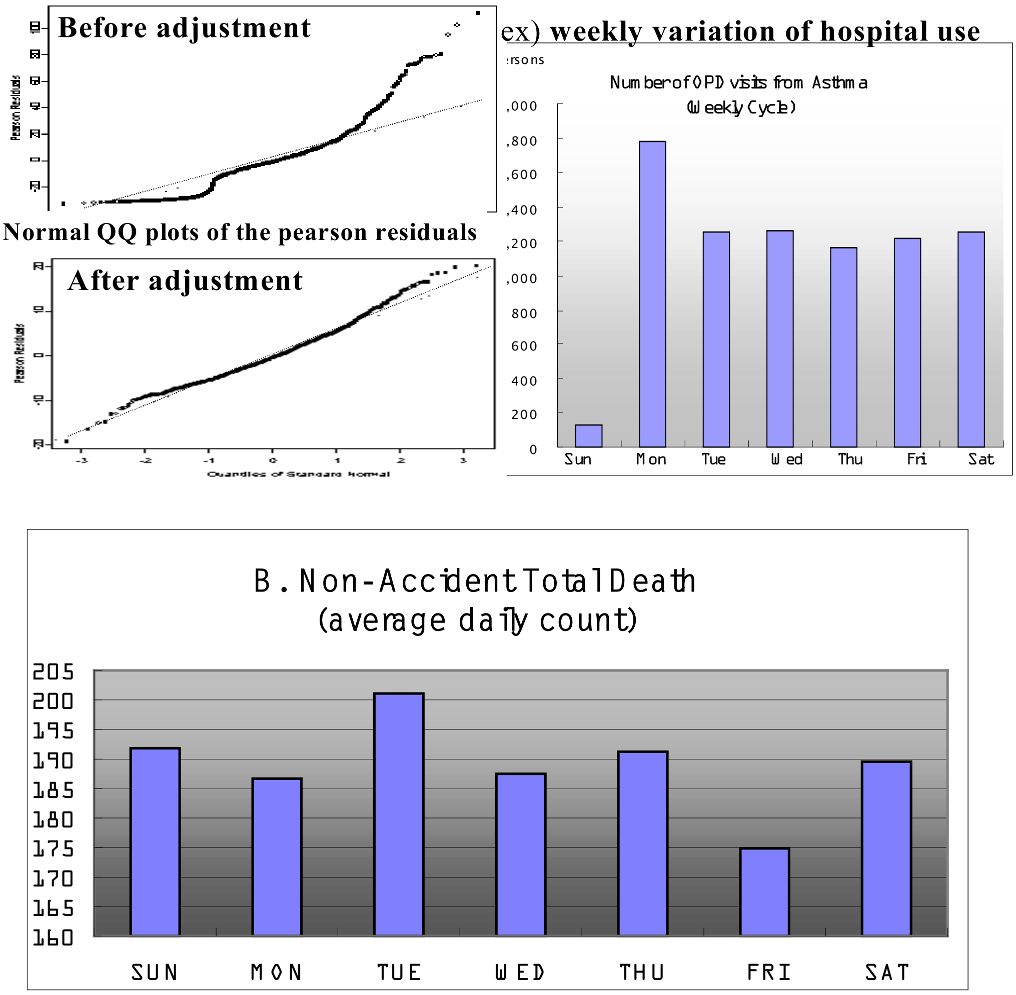


Figure 4.6 : A, B. Marked weekly variation of morbidity (A) and mortality (B) patterns. As shown in Normal QQ plot, adjustment of day of the week markedly improved model fitting especially for morbidity (A).

- To fit the daily count of health outcomes on air pollution levels (PM10).
- Meteorological factors (average temperature and relative humidity), SO2 effect, time trends, days of weak were considered.

- This model included loess smooth function on the time and meteorological factors to capture the seasonal/long-term time trend and any possible nonlinear relationship between the health outcome and meteorological factors.

Example of Analytical model for total mortality was expressed as:

log E(death) = S(time) + S(temperature) + S(relative humidity) + days of week (indicative variables) + PM10 level + other pollutants (if needed)

where log E(death) is a logarithm of expected deaths, S is a smoothing function to adjust for possible nonlinear and seasonal trends.

And an example of analytical model for morbidity was expressed as

log E(death) = S(time) + S(temperature) + S(relative humidity) + (Sunday and Holidays)* + Monday* + 1st day of a month* + 2nd day of a month* + 3rd day of a month* + 4th day of a month* +
First week of a month* + last 2 days of a month* + PM10 level + other pollutants levels (SO2)
(* indicative variables)

Generalized Additive Model (GAM) was used for this analysis

Loess smoother (S-PLUS ver 4.5) was used for a smoothing function.

4.3.6 Review of Korean Studies

(Studies since 1995)
–More than 15 qualified studies
–Growing body of evidence for the TSP, SO2, and Ozone relations
–More evidence is needed for quantitative functional/symptomatic chances, chronic health ef
fects, health effects other than respiratory and cardiovascular effects
- Studies in Western Countries or other countries were also considered, with less weighting scores for the evidence from them.

Proposed Method of Chronic Health Effect estimation for further study– Cohort Study Approach(figure 4.7)

- Reconstructing Cohorts for estimating chronic health effects from air pollution

- About 350 thousand peoples with individual information of smoking history, residence area, basic risk factors of health were being reconstructed

- Exposure level from air pollution is assigned according to the residence area office area
- The follow-up begins at 1988
- Follow-up of disease-death status is based on medical insurance data and death certificate data (Not yet fully combined)
- Analysis would be performed with survival analysis (Cox's proportional hazard model or other appropriate analytical models)

The Insured of Korean Medical Insurance Corporation		(about 1,000 thousand peoples)
↓		↓
Health examination and questionnaire (between1986-1990) Confirmed to be disease free at 1986 (About 350 thousand people)	←	Disease status follow-up :Respiratory diseases, cardiovascular diseases, cancers, congenital malformations
↓		↓
Combining airpollution data with individual cohort members	←	

Figure 4.7 : Schematic Flow of Cohort Construction in this study

4.4 Health Effects Results

Some parameters were calculated separately to get epidemiologically sound values for health benefit estimation; 1) relative risk (RR) from unit increase of PM10. Table 4.3) prevalence or mortality rate of health outcomes in Korea (Table 4.4). By combining projected PM10 levels and population size and structure in 2020, we could calculate estimated mortality and cases attributable to PM10. As for milder health outcomes, meta-analysis was applied such as respiratory symptoms and lung function (forced expiratory volume 1 second, FEV1). For references cases, employed are studies in Korea, Asian countries (China, Taiwan), western countries.

Table 4.3 : Relative risks from PM10 by the organ systems, severity and chronicity of health effects. Effect size was estimated per 50 ug/m3 increase of PM10 level.

Organs / Severity	Respiratory system		Cardiovascular system		Etc
	Acute	Chronic	Acute	Chronic	Birth outcomes Cancer
Functional change	3-5% decrease of FEV1				
Symptom and signs	RR: 1.32 (RR:1.21-1.43)				-low birth weight (Under pilot study)
Morbidity	-aggravation of asthma RR: 1.011 (RR: 1.007-1.015)		-aggravation of CHF		-congenital anomaly -increase of lung cancer (Under pilot study)
(premature) mortality	Respiroatory mortality RR: 1.053 (1.022-1.085)		Cardiovascular mortality RR:1.053 (1.038-1.068)		Increase of total non accident mortality RR: 1.024 (RR: 1.016-1.032)

Mortality rate and Prevalence rate (spell based, not person based) was estimated independently to provide “basal rate” or “reference rate” of mortality and morbidity (table 4). Note that we intentionally estimated spell-based prevalence to get more valid estimator of total medical cost.

Table 4.4 : Mortality rate and prevalence rate of health outcomes

(per 100,000 person-year)

	Mortality							
Age Groups	All (non-external)		Cardiovascular		Respiratory			
	Male	Female	Male	Female	Male	Female		
0-14	22	20	1.5	1.7	1.8	1.6		
15-64	289	125	67.7	37.0	10.8	3.6		
65-	5,657	4,142	1573.3	1287.1	447.9	227.9		
	Morbidity							
	Asthma				COPD			
	Admission		OPD visit		Admission		OPD visit	

	Male	Female	Male	Female	Male	Female	Male	Female
0-14	216	131	6307	5345	21	16	2496	2294
15-64	28	32	603	1105	30	19	1846	2731
65-	286	219	3664	3497	709	288	6809	5640

- Results of GAM model
- Quantiles of standard normal After adjusting for meteorological factors and cyclic variations like day of the week, we got relatively well fitted model (Figure 4.8)

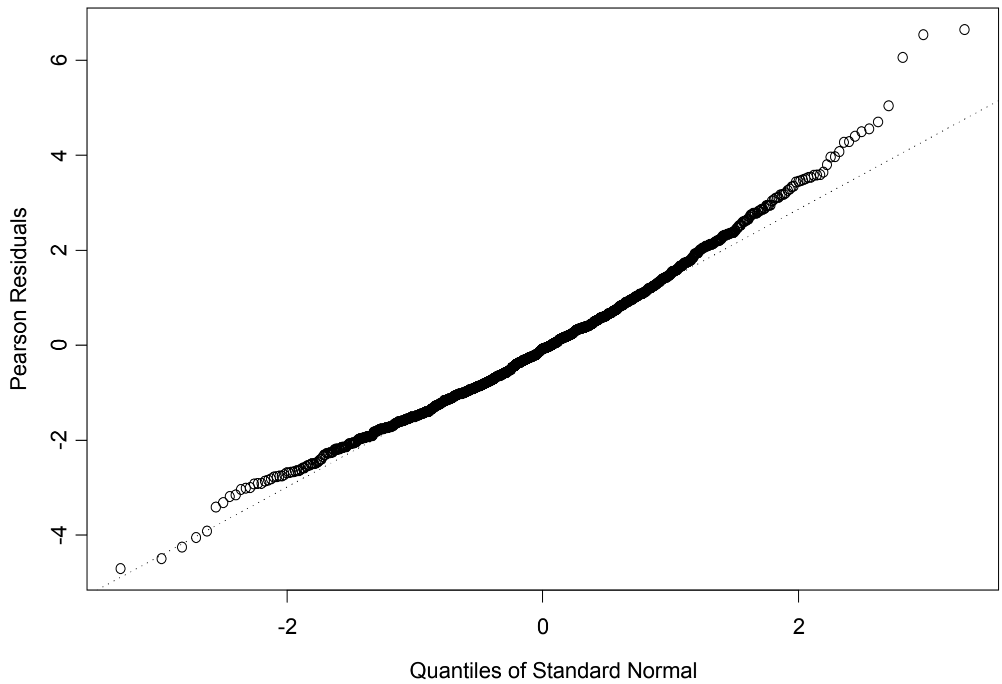


Figure 4.8 : GAM results

PM10 – Loess (PM10) = log(relative risk) plotting, which can be used as continous risk profile along the increase of PM10 level, was estimated as below for total mortality and cardiopulmonary mortality (figure 4.9)

We could assume a linear incrase of health effects within the windows of probable PM10 level (less than 150 ug/m3)

Health effects above this leve (150 ug/m3), there were few observations so that the estimated risk was unreliable.

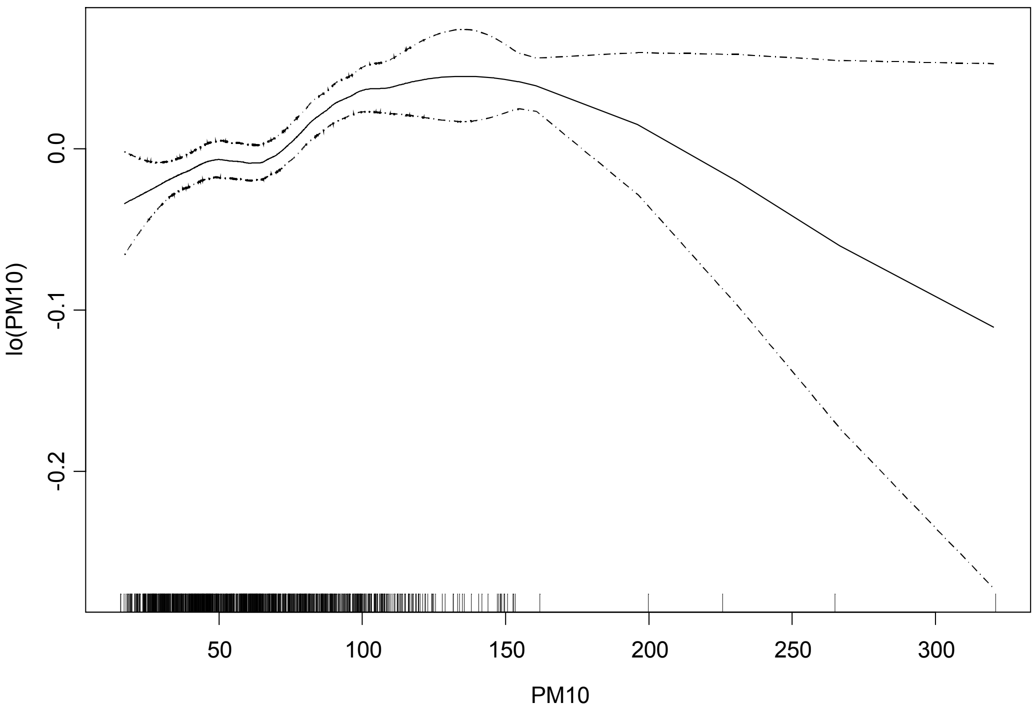


Figure 4.9 : PM10 – loess(PM10) (=log RR) plot of PM10 for cardiopulmonary mortality.

For morbidity (asthma attack), the shape of the curve was basically same, but the increase of risk was more blunted. (figure 4.10)

Also in the effect for asthma and COPD morbidity, we could assume linear increase of risk below the level of 150 ug/m3 (PM10). Above this point, best estimator of the risk profile was not reliable.

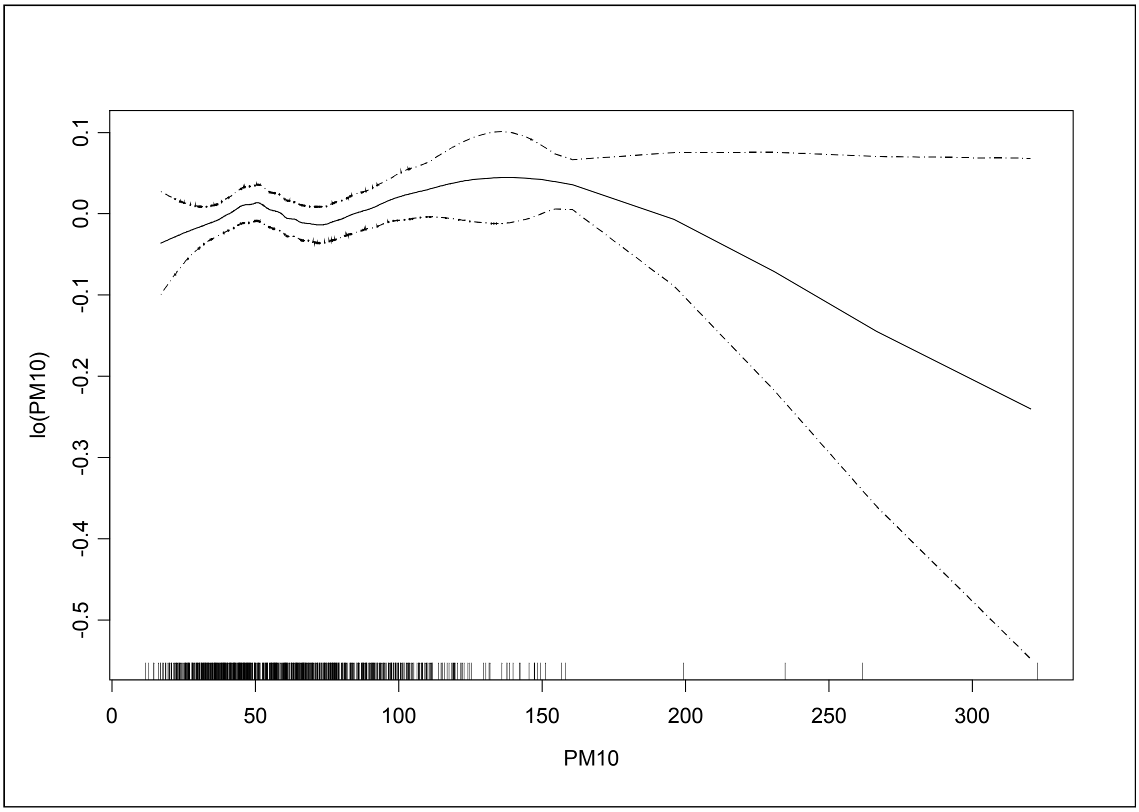


Figure 4.10 : PM10 – loess(PM10) (=log RR) plot of PM10. for asthma attack (hospital admission)

Also, as the case in mortality, increase of morbidity related to PM10 level was not conclusive above level of 150 g/m3 of PM10level)

The four GHG reduction scenarios result in significant decreases in mortality and occurrences of asthma and other respiratory diseases. Key results from the health effects analysis include(Table 4.5 and 4.6)

- The decreases in premature deaths range from 40 deaths/yr for scenario 2 to 120 deaths/yr. in scenario 4 in 2020.

- The reductions in asthma and respiratory diseases range from 2800 occurrences/yr. to over 8300 occurrences/yr. in 2020.

Table 4.5 : Health effects of PM10 on mortality

AREA		1996	1997	1998	Sum
Seoul	Cardiovascular	9,441	8,587	8,708	26,736
	Respiratory	1,872	1,891	2,008	5,771
	Non-Accident	19,174	16,629	30,085	65,888
	Total cause	37,923	37,498	32,197	107,618
Incheon	Cardiovascular	2,267	2,398	2,331	6,996
	Respiratory	443	480	475	1,398
	Non-Accident	4,699	4,427	7,742	16,868
	Total cause	9,534	10,080	8,378	27,992
Kyunggi	Cardiovascular	7,478	7,652	8,170	23,300
	Respiratory	1,364	1,524	1,723	4,611
	Non-Accident	17,085	15,357	28,686	61,128
	Total cause	34,334	35,418	31,043	100,795

Further results are depicted in Table 7.

Table 4.6 Decreases in annual mortality and morbidity under GHG reduction scenarios

		2000	2010	2020
Scenario 1	Mortality by Cardiovascular	6.22	55.46	83.37
	Mortality by Respiratory	0.71	6.36	9.56
	Asthma	471.54	4,207.48	6,324.48
	Respiratory Diseases	9.59	85.57	128.63
Scenario 2	Mortality by Cardiovascular	22.27	29.16	36.01
	Mortality by Respiratory	2.55	3.34	4.13
	Asthma	1,689.71	2,212.28	2,731.60
	Respiratory Diseases	34.37	44.99	55.56
Scenario 3	Mortality by Cardiovascular	44.55	58.32	72.01
	Mortality by Respiratory	5.11	6.69	8.26
	Asthma	3,379.43	4,424.56	5,463.21
	Respiratory Diseases	68.73	89.99	111.11
Scenario 4	Mortality by Cardiovascular	66.82	87.48	108.02
	Mortality by Respiratory	7.66	10.03	12.39
	Asthma	5,069.14	6,636.84	8,194.81

CHAPTER 5: Economic Valuation

5.1 Valuation Methods of Health Effects

5.1.1 Introduction

● One of the basic services provided by the environmental is the support of human life. Changes bin the life support capacity of the environmental brought about, for example, by reducing the pollution of air or water, can lead to decreases in the incidence of disease, reduced impairment of activities, or perhaps, increased life expectancy.

● The standard economic theory for measuring changes in individuals' well-being was developed to interpret changes in the prices and quantities of goods purchased in markets. This theory has been extended and applied to a wide variety of nonmarket or public goods and social programs, including public housing and other transfer programs, public investments in parks, transportation, the development of water resources, and improvements in environmental quality and health(Freeman, 1979). This theory is based on the assumption that individuals' preferences are characterized by substitutability between income and health. The trade-offs that people make as they choose among various combinations of health and other consumption goods reveal the values they place on health.

● According to the simplest models of individual choice, researchers can interpret an individual's observed trade-off between income and health as a measure of his willingness to pay(WTP) for improvement in his health.

● However, there are two qualifications to this statement. First, society has developed several mechanisms for shifting some of the costs of illness away from the individual who is ill and onto society at large. An individual's expressed willingness to pay to avoid illness would not reflect those components of the costs of his illness borne by or shifted to others. But the value to society of avoiding his illness includes these components.

● The second qualification concerns the emphasis given to the individual's concern for his own illness. This emphasis does not preclude altruism because an individual may have preferences about the health and well-being of others, especially close relatives and his spouse.

● Environmental pollution that impairs human health can reduce people's well-being through at least the following five channels: 1) medical expenses associated with treating pollution-induced diseases, including the opportunity cost of time spent in obtaining treatments; 2) lost wages; 3) defensive or averting expenditures associated with attempts to prevent pollution-induced disease; 4) disutility associated with the symptoms and lost opportunities for leisure activities; and 5) changes in life expectancy or risk of premature death.

- The first three of these effects have readily identifiable monetary counterparts. The latter two may not. Since reducing pollution may be benefical to individuals because it reduces some or all of these adverse effects, a truly comprehensive measure of benefits should capture all of these effects

Measures based solely on decreases in medical costs or lost wages are inadequate because they omit major categories of beneficial effects.

5.1.2 Defining and Measuring Changes in Health

● Health has many dimensions, and environmental changes can affect people's health in a variety of ways, ranging from changes in the frequency of mild illness or irritating symptoms to increases in the risk of contracting a serious or fatal disease. This chapter follows the conventional economic practice in distinguishing between mortality and morbidity effects, where in the former case the primary endpoint of concern is death, while in the latter case, the focus is on nonfatal illness or a set of symptoms. This section describes the major categories of health effects and how they typically are measured in empirical economic research.

1. Mortality

● For mortality, the measurement of a change in health is the change in the probability of dying, or more specifically, the change in the conditional probability of dying at each age, for an identified group of individuals at risk. The conditional probability of dying at age t is the probability that one dies before his $t + 1$st birthday, given he is alive on his tth birthday. Age-specific mortality rates provide empirical estimates of the conditional probability of death.

● A number of environmental contaminants ingested through various routes are known to cause or are suspected of causing increases in the incidence of fatal diseases such as cancer. One problem in valuing changes in risk of death due to exposure to environmental carcinogens is that there is typically a lag between exposure to the substance and the production of cancerous cells. Because the individual is safe from cancer during this latency period, the benefits of reduced exposure do not occur until the end of the latency period.

2. Morbidity

● Morbidity is defined by the U.S. Public Health Service as "a departure from a state of physical or mental well-being, resulting from disease or injury, of which the affected individual is aware." The last phrase in the definition is the key to answering an important question in air pollution control policy: What constitutes an adverse health effect from an economic perspective ?

● From an economic perspective, the answer to this question depends on whether the changes are perceived by the individual and whether the individual reveals or expresses a willingness to pay to avoid the effect.
● From the viewpoint of valuation, an important distinction to make concerning the health outcome that is affected by pollution is whether it occurs often enough and to a sufficient percentage of the population that it may be viewed as certain from the viewpoint of a single individual, or whether it is rare enough that its occurrence to an individual must be viewed as uncertain.

5.1.3 Methods Used to Value Health and Welfare Effects

● Methods for obtaining monetary values for improvements in health can broadly be categorized as those that rely either on observed behavior and choices (revealed preferences) or on responses to hypothetical situations posed to individuals (contingent valuation). The first category includes all of those techniques that rely on demand and cost functions, market prices, and observed behavior and choices. The second category includes asking people directly to state their willingness to pay or accept compensation for a postulated change, how their behavior would change, or how they would rank alternative situations involving different combinations of health and income or consumption.
● Benefit transfer suggests the possibility that some results of valuation study in other countries can be adopted for the valuation in country under consideration, given proper adjustments. Benefit transfer can be easily accepted when the population at risk and the sample population are considered to be close to identical (e.g., within one country). Problems arise when the population at risk and the sample population for whom WTP is known do not have similar characteristics and their preferences are not identical. However, various approximations can be made for such a transfer.

1. Methods of Valuing Reduced Mortality
● Two alternative approaches to defining a measure of the value of lifesaving activities.
● The first approach is based on measurements of the economic productivity of the individual whose life is at risk. This is often referred to as the human capital approach because it uses an individuals discounted lifetime earnings as its measure of value.

● The second approach is to use some indicator of the individuals willingness to pay to reduce his risk of death as the measure of value.
● The benefits of risk reductions are usually measured using the concept of the value of a statistical life (VSL) estimates are derived from aggregated estimates of individual values for small changes n mortality risks.
● This approach avoids the issue of valuing life, per se, by recognizing that what people actually buy and sell through their choices and trade-offs is not life versus death, but small changes in the probability of dying.
● In this approach, the economic value is derived by focusing on choices ex ante; that is, before the uncertainty about whether or not one will die is resolved.

■ The Human Capital Measure of Value
● This approach is based on measurements of the economic productivity of the individual whose life is at risk.
● The human capital measure is based on two assumptions: that the value of an individual is what he produces and that productivity is accurately measured by earnings.
● The human capital approach calculates the value of preventing the death of an individual who is presently of age j as the discounted present value of that individual's earnings over the remainder of his expected life.
● The change in expected lifetime earnings is a lower bound to willingness to pay to reduce risk of death.
● Lave and Seskin(1971, 1977)
● The most important criticism of the human capital approach is that it is inconsistent with the fundamental premise of welfare economics; namely, that it is each individual's own preferences that should count for establishing the economic values used in benefit-cost analysis.
● Furthermore, both theoretical reasoning and empirical evidence suggest that human capital measures are poor approximations of the desired willingness-to-pay measures of value for small changes in the risk of death.

■ Compensating Wage Studies
● An alternative approach is to infer the value of a statistical life from wage premia that workers receive to compensate them for risk of accidental death.
● To estimate the risk premium, which is the partial derivative of the market wage function with respect to risk of death, requires having data on wages, job attributes, and worker attributes. These data are used to estimate an hedonic

wage function, an equilibrium relationship between the wage, job characteristics, and variables affecting worker productivity.

■ The Willingness-to-Pay Approach

● In keeping with the assumption that individual's preferences provide a valid basis for making judgements concerning changes in their economic welfare, increases in longevity or reductions in the probability of death due to accident or illness should be valued according to what an individual is willing to pay to achieve them. This presupposes that individuals treat longevity more or less like any other good rather than as a hierarchical value.

● The most important conclusion to be drawn from the review of theorectical models of individual choice and willingness to pay is that the value each person attaches to a small reduction in his probability of dying is likely to differ because of differences in underlying preferences, age, wealth, number of dependents, degree of aversion to risk, and level of risk to which he is currently exposed.

● A second conclusion is that in the case of multiple risks of death, where the individual can "purchase" reductions in one component of risk can usually be taken as a close approximation of the individual's willingness to pay for reductions in other components of risk.

● U.S. EPA identified 26 policy-relevant risk VSL studies as part of an extensive assessment titled ***The Benefits and Costs of the Clean Air Act, 1970 to 1990***(EPA, 1997). Five of the 26 studies are contingent valuation studies; the rest are compensating wage(wage-risk) studies. To allow for probabilistic modeling of mortality risk reduction benefits, the analysts reviewed a number of common distributions to determine which best fit the distribution of mean values form the studies. A Weibull distribution was selected with a central tendency(or mean) of $ 5.8 million(in 1997 dollars).

2. Methods of Valuing Reduced Morbidity

● There are three techniques for valuing reduced morbidity

● The first, the cost of illness(COI) approach, uses data on lost earnings and medical expenditures to infer a lower bound to willingness to pay for reduced air pollution.

● The second technique, the averting behavior method, infers peoples willingness to pay to reduce ambient pollution levels from the amounts of money they spend to avoid exposure to air pollution (for example, by installing air filters) or to mitigate its effects (for example, by taking an antihistamine to reduce nasal discharge).

● The third technique for valuing reduced morbidity is the contingent valuation method, involves asking people what they would pay to reduce the number of symptom or restricted-activity days they experience.

■ Cost of Illness(COI)

● The value of work and leisure time lost due to illness plus any change in averting and mitigating expenditures constitute a lower bound to willingness to pay for reduced exposure to pollution.

● If these costs of illness are to constitute a lower bound to individual WTP, then the relevant prices are those that the individual faces. This measure is referred to as the ***private cost of illness.***

● Since the rest of society's WTP to reduce health risks must be added to the sum of individual WTPs if individuals do not face the full social cost of medical care or lost productivity, it is also of interest to value lost time plus averting and mitigating expenditures at their true social cost. This is termed the ***social cost of illness***.

■ Averting Behavior Method

● To implement the averting behavior approach requires having data in the following five categories for a cross-section of individuals:

1. Frequency, duration, and severity of pollution-related symptoms.
2. Ambient pollution levels to which the individual is exposed.
3. Actions which the individual takes to avoid or mitigate the effects of air pollution.
4. Costs of avoidance and mitigating activities.
5. Other variables affecting health outcomes (age, general health status, presence of chronic conditions, and so on.)

● These data are used to estimate health production and input demand functions, which, in turn, are used to calculate willingness to pay for a marginal change in ambient pollution.

● Gerking and Stanley(1986), Dickie et al.(1986), Chestnut et al.(1988b)

■ Contingent Valuation Method

● The contingent valuation method involves asking people either what they would be willing to pay to reduce pollution or what value they place on reducing symptoms, and then multiplying this answer by the reduction in symptoms corresponding to a change in pollution. pay to reduce the number of symptom or restricted-activity days they experience.

- Loehman et al.(1979), Rowe and Chestnut(1985), Tolley, Babcock, et al.(1986), Dickie et al.(1987), and Chestnut et al.(1988b).

5.2 Benefit Transfer

5.2.1 Introduction

● To estimate the health benefits of a reduction in ambient air pollution, four components were determined: (1) the quantitative relationship between ambient concentrations and the health response or concentration-response functions; (2) the size and identification of susceptible populations, (3) the projected change (between BAU and reduction scenarios) in air pollution concentrations under consideration, and (4) the economic value of the reduction in health effects incidence.

● Firstly, Epidemiologic study provides the basis for the concentration-response relationships between ambient PM10 and several adverse health outcomes used in this analysis including: premature mortality, asthma, and acute respiratory diseases. The relative risks of premature mortality, asthma, and acute respiratory diseases which are suggested in the analysis of health effect are utilized.

● Secondly, the susceptible populations of our research are given in Table 1. Population for individual grid (total grid amounts to 156 covering ICAP area) is calculated as follows:

1. population data in 1995 for Seoul, Incheon, and Kyonggi(A1) are projected for 2000, 2010, and 2020 based population projection data and the populations of total 76 administrative units belonging to the three A1 in 1996 have been selected as a base year population
2. then for the projection of the 76 unit, projection rates of A1 have been made to individual administrative unit, respectively ,
3. using GIS projected population is derived for individual grid,
4. age and sex ratios of Seoul in 1995 are applied to total 76 administrative units.

Table 5.1: Population Projections (people)

Year / Area	1995	2000	2010	2020
Seoul	10,342,224	9,981,649	9,625,060	9,409,018
Incheon	2,333,769	2,559,424	2,886,504	3,114,402
Kyonggi	7,737,864	9,364,923	11,727,264	13,188,852
Total	20,413,857	21,905,996	24,238,828	25,712,272

5.2.2 Quantification of Health Effects(Mortality)

● Thirdly, the projected changes of 156 grids between BAU and GHG reduction scenarios in annual average PM10 concentrations are estimated using data from air quality modeling. Equation [1] is used as the basis for calculating the numbers of cases of premature mortality.

● Occurrence reduction in annual mortality in each grid

$$= (RR-1) \times B_a \times PM_a \times POP, \qquad [1]$$

where

RR: relative risk

B_a : baseline annual mortality, and

PM_a : change in annual average PM10 concentration

POP : population.

● In order to calculate an estimate of the change in the number of premature

Scenario	Deaths by	2000	2010	2020
Reduction Scenario 1	Cardiovascular Disease	6.22	55.46	83.37
	Respiratory Disease	0.71	6.36	9.56
Reduction Scenario 2	Cardiovascular Disease	22.27	29.16	36.01
	Respiratory Disease	2.55	3.34	4.13
Reduction Scenario 3	Cardiovascular Disease	44.55	58.32	72.01
	Respiratory Disease	5.11	6.69	8.26
Reduction Scenario 4	Cardiovascular Disease	66.82	87.48	108.02
	Respiratory Disease	7.66	10.03	12.39

deaths expected as a result of a change in PM10 in a given location, a baseline mortality rate must be used. For this assessment, the estimates are made in terms of annual cases of premature deaths reduced, so we use national annual average mortality rates as each baseline. Annual occurrences reduction in annual mortality are given in Table 5.2.

Table 5.2 : Annual occurrence reduction in premature death

5.2.3 Transferred Monetary Value of Statistical Life

● Finally, the economic value of the reduction in health effects incidence.

● The valuation of these full impacts is usually referred to as the maximum willingness to pay (WTP) to prevent the health effects. The basic analytical approaches used in welfare economics to estimate WTP are based on situations in which individuals are observed making tradeoffs between health effects (measured as incidence or risk) and some financial benefit, such as income.

● Reductions in risk of death are arguably the most important societal benefit underlying many environmental programs. In two recent analyses of the benefits of U.S. air quality legislation, The Benefits and Costs of the Clean Air Act, 1970 to 1990(U.S. EPA, 1997) and The Benefits and Costs of the Clean Air Act, 1990 to 2010(U.S. EPA, 1999), more than 80% of monetized benefits were attributed to reductions in premature mortality.

● Individual WTPs for small reductions in mortality risk are summed over enough individuals to infer the value of a statistical life saved.

● There are two sources of empirical estimates of individuals willingness to pay(WTP) for mortality risk reductions: revealed preference studies, based on compensating wage data or consumer behavior, and stated preference studies, including those employing contingent valuation methods.

● Benefit transfer suggests the possibility that some results of valuation study in other countries can be adopted for the valuation in country under consideration, given proper adjustments. Benefit transfer can be easily accepted when the population at risk and the sample population are considered to be close to identical (e.g., within one country). Problems arise when the population at risk and the sample population for whom WTP is known do not have similar characteristics and their preferences are not identical. However, various approximations can be made for such a transfer.

● A simple adjustment method for transferring the monetary values of health effects from United States to Korea is proposed, applying the following relationship:

$$VSL(Korea) = VSL(US)*R_{adj} \qquad [2]$$

	Monetary Values in the U.S. or Canada	Adjusted 1 (million won)	Adjusted 2 (million won)	Non Adjusted (million)	Average (million won)
Low	1,300,000 (1999 C $)	246.1	429.5	925.1	
Central	3,800,000 (1999 C $)	779.2	1,360.0	2,929.6	
High	4,800,000 (1990 US $)	1,288.7	1,901.7	5,066.6	
Average		771.3	1,230.4	2,973.8	1,658.5

where VSL(Korea) and VSL(US) are the value of statistical life in Korea and the United States, respectively, and R_{adj} is an adjustment parameter.

- The simplest adjustment ratio corrects for income differentiation between the two countries. Thus, the transferring ratio(Adjusted 1) is the ratio between average incomes of the two countries. Another ratio of per capita income adjusted by parity of purchasing power(PPP)(Adjusted 2) can be recommended.
- The adjustment ratios are used to extrapolate values of health endpoints from Krupnick(2000) to this Korea case study. And we adopt VSL in U.S. EPA(1997, 1999)The transferred unit values of VSL are given in Table 5.3.

Table 5.3 : Transferred monetary values of VSL(value of statistical life)

5.2.4 Benefits of Premature Mortality Risk Reduction

● The estimated benefits of premature mortality risk reduction due to GHG mitigation scenarios in Korea are calculated by using the unit value of VSL and excess occurrence of premature deaths. These estimated benefits are given Table 5.4.

Table 5.4: Estimated annual benefits of mortality avoided(Benefit transfer)(1999 million won)

Adjusting Method	Scenario	2000	2010	2020
Adjusted 1	Scenario 1	5,345.2	47,682.6	71,678.1
	Scenario 2	19,144.0	25,067.7	30,960.5
	Scenario 3	38,303.4	50,143.1	61,913.3
	Scenario 4	57,447.4	75,510.7	92,873.8
Adjusted 2	Scenario 1	8,526.6	76,062.7	114,340.1
	Scenario 2	30,538.3	39,987.7	49,387.8
	Scenario 3	61,101.2	79,987.6	98,763.4
	Scenario 4	91,639.4	119,975.3	148,151.2
NonAdjusted	Scenario 1	20,608.4	183,839.8	276,354.4
	Scenario 2	73,809.5	96,648.2	119,368.0
	Scenario 3	147,678.5	193326.2	238,706.2
	Scenario 4	221,488.0	289,974.0	358,074.2
Average	Scenario 1	11,493.4	102,528.3	154,124.2
	Scenario 2	41,163.9	53,901.2	66,572.1
	Scenario 3	82,361.0	107,819.0	133,127.6
	Scenario 4	123,524.9	161,720.1	199,699.7

5.3 Contingent Valuation Method[1]

5.3.1 Introduction

● Much of the justification for environmental rulemaking rests on estimates of the benefits to society of reduced mortality rates. Reductions in risk of death are arguably the most important benefit underlying many of the United States Environmental Protection Agency's (U.S. EPA) legislative mandates, including the Safe Drinking Water Act, the Resource Conservation and Recovery Act and the Clean Air Act. For example, in two recent analyses of the benefits of U.S. air quality legislation, ***The Benefits and Cost of the Clean Air Act***, 1970-1990 (U.S. EPA, 1997) and ***The Benefits and Cost of the Clean Air Act,*** 1990-2010 (U.S. EPA, 1999), over 80 percent of monetized benefits were attributed to reductions in premature mortality. These benefits are equally important in environmental cost-benefit analyses performed in Canada(Environment Canada, 1999).

● There are two sources of empirical estimates of individuals willingness to pay (WTP) for mortality risk reductions: revealed preference studies, based on compensating wage data or consumer behavior, and stated preference studies, including those employing contingent valuation methods. From the perspective of valuing lives saved by environmental programs both estimation techniquesas applied to dateshare a common shortcoming. They focus on measuring the value that prime-aged adults place on reducing their risk of dying, whereas the majority of statistical lives saved by environmental programs, according to epidemiological studies, appear to be the lives of older people and people with chronically impaired health. It has been conjectured that older people should be willing to pay less for a reduction in their risk of dying than younger people on the grounds that they have fewer expected life years remaining. Theory, however, cannot predict exactly how WTP varies with age, and, to our knowledge, few empirical studies have been conducted that include subjects over the age of 65. Likewise, there are no studies that examine the impact of health status on WTP for mortality risk changes.

● The goal of this research is to estimate what older people are willing to pay to reduce their risk of dying, and to examine the impact of current health status on WTP. We accomplish this through a contingent valuation survey that

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[1] As we used the modified version of Canada survey, the most contents in this chapter are cited from Krupnick et al.(2000).

is administered to persons 40 to 79 years old. Targeting this age range allows us to examine the impact of age on WTP, thus providing an empirical answer to the above speculations, and allows us to compare our WTP estimates with those from previous studies. We measure health status in two ways. Respondents are asked whether they have ever been diagnosed as having one of several chronic heart or lung diseases, or cancer. To further capture the severity of the disease (or other chronic health conditions) we ask respondents to complete a detailed health questionnaire, Standard Form 36 (Ware et al., 1997), which has been shown to correlate well with severity of various chronic illnesses (Bousquet et al., 1994).

● The survey uses audio and visual aids to communicate both baseline risk of death and risk changes. Respondents are given experience with graphical representations of risks of death (depicted by colored squares on a rectangular grid) and are tested for comprehension of probabilities before being asked WTP questions.

5.3.2 The Value of Reductions in Mortality Risks

1. The Nature of Mortality Risk Reductions from Environmental Programs

● Life saving benefits from environmental regulations have been quantified for the conventional air pollutants, especially particulate matter, and for carcinogens. These studies suggest that life-saving benefits are concentrated among persons 65 years of age and older and may disproportionately benefit people with pre-existing chronic conditions. Other health and safety regulations, such as those intended to reduce foodborne pathogens, also disproportionately benefit older persons and persons in compromised health.

● Epidemiological evidence for the link between older people and air pollution comes from two directions. First, epidemiological studies typically assume that the effect of a change in pollution concentrations is proportional to baseline mortality rates. This assumption is implicit in time-series models in which deaths on day t are assumed to be an exponential function of air pollution on day $t-s$, weather and other variables. It is also embodied in the prospective cohort study of Pope et al. (1995), which assumes that the impact of air pollution is proportional to the probability of dying at each age (given that one survives to that age). Since death rates are higher for older persons, this implies that the benefits of reducing exposure to air pollution accrue primarily to older people. Based on Pope et al. (1995), the EPA (1997) estimates that three-quarters of the statistical lives saved by the Clean Air Act in 1990 as a result of reducing particulate matter are persons 65 years of age and older. Second, epidemiological studies have found larger changes in mortality rates for people over 64 than for younger people (Schwartz 1991, 1993).

● Reducing exposure to pollution may also reduce risk of cancer. Cancer is the health endpoint most often quantified in connection with hazardous waste sites, pesticide regulations and drinking water standards. Although the toxicological studies that are used to quantify cancer risks provide only an estimate of lifetime cancer risk, rather than age-specific risk estimates, it is reasonable to assume that the age distribution of deaths from environmentally induced cancers follows the same pattern as cancer mortality rates from all causes. Since cancer mortality rates are concentrated among individuals aged 65 and over, the statistical lives saved by reducing exposure to carcinogens will be concentrated among people in the same age group. In 1996, 71 percent of all cancer deaths in the U.S. were concentrated among residents aged 65 years and over (US. Census Bureau, 1999).

● Epidemiological studies also suggest that persons with chronic heart or lung conditions are likely to benefit disproportionately from improvements in air quality. For example, Schwartz (1991), Schwartz and Dockery (1989), and Pope et al. (1995) find that changes in particulate concentrations have a larger impact on deaths due to cardiovascular disease and chronic obstructive lung disease than on all deaths. This has caused some observers to suggest that the value of lives saved by air pollution should reflect the compromised health of the beneficiaries (EOP Group, Inc., 1997). It is not, however, clear that people with chronic heart and lung disease would pay less than healthier individuals to reduce their risk of dying.

2. Current Approaches to Valuing Mortality Risk Reductions

● In benefit-cost analyses of health and safety regulations, including environmental regulations, it is standard practice to ignore the health status of people whose lives are extended by the regulation. The age of persons saved is sometimes incorporated by converting the value of a statistical life from a labor market study (or other source) into a value per life-year saved. To illustrate this calculation, suppose that the value of a statistical life based on compensating wage differentials is $5 million, and that the average age of people receiving this compensation is 40. If remaining life expectancy at age 40 is 35 years and the interest rate is zero, then the value per life year saved is approximately $140,000. If, however, the interest rate is 5 percent, then discounted remaining life expectancy is only 16 years, and the value per life-year saved rises to approximately $300,000. The value of a life-year can then be multiplied by discounted remaining life expectancy to value the statistical lives of persons of different ages. This procedure is, however, ad hoc. It assumes that the value per life-year saved is independent of age, and it is sensitive to the rate used to discount the value of future life-years, which is usually assumed by the researcher rather than estimated on the basis of actual behavior. Moore and Viscusi (1988) have used labor market data to infer the rate at which workers discount future utility of consumption; however, their models make very specific functional form assumptions in order to infer a discount rate from a single cross section of data.

- Evidence from contingent valuation studies (Jones-Lee et al., 1985) suggests that willingness to pay is not proportional to remaining life expectancy; however, policymakers may be reluctant to rely on such studies unless it can be demonstrated that they pass tests of internal and external validity. One measure of the success of a contingent valuation survey is that, when different groups of respondents are asked to value risk changes of different magnitudes, WTP increases with the size of the risk change. An external scope test is passed when the mean WTP of respondents faced with the larger risk change is significantly greater than the mean WTP of the respondents faced with the smaller risk change. An internal scope test is passed when a respondents WTP increases with the size of the risk reduction. In the context of valuing risk changes, however, a more stringent criterion can be applied. If respondents maximize expected utility or, more generally, if their utility function is linear in probabilities, WTP for small risk changes should increase in proportion to the size of the risk change.
- As a recent literature review by Hammitt and Graham (1999) demonstrates, few contingent valuation studies of mortality risks pass either internal or external scope tests. In some cases (e.g., Jones-Lee et al., 1985; Smith and Desvousges, 1987) WTP fails to increase at all with the size of the risk change. Only three contingent valuation studies designed to value mortality risks pass external scope tests. All of these studies were conducted in the context of traffic safety and two involved extremely small samples ($N < 110$). None of these studies focused on valuing mortality risk reductions among older people and none examined the impact of health status on WTP for risk reductions.

5.3.3 Valuing Mortality Risks Among Older Persons

1. Goals of the Survey

● The goal of our survey is to estimate what older people would pay for a reduction in their risk of dying and to examine the impact of health status on WTP. We target a population ranging in age from 40 (the mean age of workers in compensating wage studies) to 79 years and collect extensive information on health status. We ask respondents to value annual risk reductions on the order of 10^{-4} . Risk changes valued in labor market studies are on the order of 1 in 10,000 per year. A risk change of this order of magnitude could also be delivered by an environmental program (e.g., air pollution control). For instance, the Pope et al. study (1995) predicts that a 10 □/m^3 change in PM10 results in an average risk change of 2.4 in 10,000, whereas studies based on time series generally predict that the same change in pollution levels results in a 0.8 in 10,000 risk change.

● For use in benefit-cost analyses, it is important that risk reductions be a private good; that is, that we estimate each respondents WTP to reduce his or her own risk of dying. For this reason, we have chosen an abstract product (not covered by health insurance) as the mechanism by which risk reductions are delivered. In practice, most environmental programs reduce mortality risks for all persons in an exposed population: In other words, risk reductions are a public good. Johansson (1994) and Jones-Lee (1991) have shown, however, that when people exhibit pure altruism, maximization of net social benefits calls for equating the sum of individuals' marginal WTP to reduce risks to themselves to the marginal cost of the risk reductions. Therefore, the appropriate measure of benefits is the sum of private WTP for reductions in risk.

2. Avoiding Past Pitfalls

● The failure of many contingent valuation studies to pass tests of internal and external validity may be traced to three types of problems:

1. Respondents may not understand the risk changes they are asked to value.
2. Respondents may not believe that the risk changes (or baseline risks) apply to themselves.
3. Respondents may lack experience in trading money for quantitative risk changes or lack the realization that they engage in this activity.

● Our approach to dealing with each problem is described below.

- Communication of Risk Changes. Our survey relies on a graph containing 1,000 squares to communicate probability of dying. White squares denote chances of surviving, red squares represent chances of dying. Reductions in the risk of dying are represented by changing red squares to blue.
- Because we value annual risk changes on the order of 10^{-4} , the graph represents the chances of dying (surviving) over a 10-year period with risks on the order of 10^{-3}. The use of a 10-year period is motivated by two considerations. When respondents are told their baseline risk of dying over the next 12 months, they often believe that the risks do not apply to them. In focus groups, respondents more readily accepted baseline risks over longer periods. Secondly, the use of a 10-year period makes it possible to represent risks using 1,000 squares. In our questionnaire development, we found that respondents regarded grids with more squares (e.g., 10,000 or 100,000) confusing and tended to dismiss such small risk changes as insignificant.
- Understanding of Risk Changes. Each respondent goes through the survey on a computer screen, at his own pace. We encourage respondents to think about changes in mortality risks by showing them side-by-side depictions of the risks with and without the product, and by asking them questions to test their understanding of how risks(and risk changes) are represented. If the respondent answers a question incorrectly, he or she is provided additional educational information and is asked an additional, similar question.
- Experience Trading Quantitative Risk Changes. Although most respondents engage in activities or purchase goods to reduce their risk of dying, they often fail to associate quantitative risk reductions with these activities. We acquaint respondents with the quantitative risk reductions associated with medical tests and products with which the respondent may be familiar (e.g., mammograms, colon cancer screening tests, and medicine to reduce blood pressure) prior to asking what he or she would pay for a product that will reduce risk of dying. In doing so, we keep the cost information provided to the respondent qualitative in nature (e.g., expensive, moderate, and inexpensive).
- Communication of Payments. Tests in focus groups and one-on-one interviews suggested that payments for risk reductions should be made annually, over a 10-year period. We use graphs to convey the timing of the payments and the relationship between the timing of payments and risk reductions. This relationship is especially important when eliciting WTP today for a future risk reduction.

3. Survey Protocols

● The survey instrument used in this project was developed over several years. The development effort included extensive one-on-one interviews in the United States, pretests in the United States and Japan, and several focus groups in Hamilton, Ontario, including one at a senior citizen recreation center, followed by another pretest.
● Korean survey was administered to around 1,000 subjects in Seoul, in 2000. Research 21, a survey research firm, administered the survey over a two-month period. Our target population consisted of persons between 40 and 79 years of age.
● The survey was administered on a computer with a simplified keypad, which was color-coded and especially labelled for use with the survey (e.g., Press the BLUE key to see the next screen.). Respondents moved through the survey at their own pace. Words on each screen appeared in large font and were read to the respondent by a voice-over.

4. Description of the Questionnaire

● The questionnaire is divided into five parts. Part I elicits personal information, including health information about the respondent and his or her immediate family.The questionnaire is divided into five parts. Part I elicits personal information, including health information about the respondent and his or her immediate family.
● Part II introduces the subject to simple probability concepts through coin tosses and roulette wheels. The probabilities of dying and surviving over 10-year periods are then depicted using a 1,000-square grid. The respondent goes through simple exercises to become acquainted with our method of representing the probability of dying. The respondent is then shown two 25 by 40 grids: one for person 1, with red squares (representing death), and one for person 2, with 10 red squares (see Figure 5.1). The respondent is asked to indicate which person faces the higher risk. If the respondent picks person 1, he or she is provided with additional information about probabilities and is asked again. The respondent is then asked which person he or she would rather be. Individuals responding Person 2 (the person with the higher risk) are asked a followup question to verify this answer and are given the opportunity to change their answer if they wish. The baseline risk of death for a person of the respondents age and gender is then presented numerically and graphically.
● Part III presents the leading causes of death for someone of the respondents

age and gender. Common risk-mitigating behaviors are listed, together with the quantitative risk reductions they achieve and a qualitative estimate of the costs associated with them (inexpensive, moderate, and expensive). The purpose of this section is twofold. We wish, first, to acquaint the respondent with the magnitude of risk changes delivered by common risk-reducing actions and products (cancer screening tests, medication to reduce high blood pressure) and, second, to remind the respondent that such actions have a cost, whether out-of-pocket or not.

Table 5.5 : Survey design

Group of respondents	Initial Risk Reduction Valued	Second Risk Reduction Valued	Future Risk Reduction Valued
Wave 1(N = 484)	5 in 1,000	1 in 1,000	5 in 1,000
Wave 2(N = 513)	1 in 1,000	5 in 1,000	5 in 1,000

● Part IV elicits WTP for risk reductions of a given magnitude, occurring at a specified time, using dichotomous choice methods. (Table 5 summarizes our survey design.) In one sub-sample (Wave 1), respondents are first asked if they are willing to pay for a product that, when used and paid for over the next 10 years, will reduce baseline risk by 5 in 1,000 over the 10-year period (WTP5); that is, by 5 in 10,000 annually. In the second WTP question, risks are reduced by 1 in 1,000 (WTP1); that is, by 1 in 10,000 annually. In a second subsample (Wave 2), respondents are given the 1 in 1,000 risk change question first. Baseline risk is age- and gender-specific, and increases with age and for males. The baseline risks are shown as red squares on the 1,000-square grid. The red squares are first randomly scattered over the grid, and then grouped together. The risk reductions delivered by the products are shown by changing the appropriate number of squares from red to blue.

● After the first two questions, respondents in both subsamples under age 60 years are asked their WTP over the next 10 years for a 5 in 1,000 risk reduction over 10 years beginning at age 70 years (WTP70)(Table 5.6). This question serves two purposes. First, it tests whether respondents are willing to pay anything today for a future risk reduction what one would like to measure to value reduced exposure to a pollutant with a latency period. Second, it provides a test of internal consistency of responses because WTP today for a future risk change should be less than WTP today for an immediate risk change. This question is preceded by a question that asks the respondent to estimate his or her chances of surviving to age 70.

Table 5.6 : Bid structure in the mortality risk survey(2000 Korean won)

Group of respondents	Initial payment question	Follow-up question (if "yes")	Follow-up question (if "no")
□	40,000	90,000	20,000
□	90,000	300,000	40,000
□	300,000	450,000	90,000
□	450,000	600,000	300,000

● All WTP dichotomous choice questions answered by No-No or Yes-Yes responses were followed by a question asking how much the respondent is willing to pay. With bids secured, respondents were then asked, on a 1 to 7 scale, their degree of certainty about their responses.
● Part V asks an extensive series of debriefing questions, followed by some final socio-demographic questions (e.g., education and household income). The debriefing questions are used to identify respondents who had trouble comprehending the survey or did not accept the risk reduction being valued.
● The 36-question quality of life survey (Standard Form-36, abbreviated SF-36), which is used routinely in the medical community to gauge physical functionality and mental and emotional health states (Ware et al. 1997). The 36 health questions supplement those posed at the beginning of the interview and can be used to construct eight indices commonly used in the health literature.

5.3.4 Results

1. WTP and VSL Estimates: Current and Future Risk Reductions

● Since we have three rounds of payment questions, we can form three different sets of estimates for mean WTP. All sets of estimates recode not sure responses as no responses.

● The first set of estimates utilizes only the responses to the initial payment questions, and is thus safe from undesirable response effects sometimes observed in the presence of follow-up questions (Herriges and Shogren, 1996; Alberini, Kanninen and Carson, 1997).

Table 5.7 : Mean WTPs for current risk and future risk reductions and implied value of statistical life, both waves

Type of Risk Reduction	Risk Reduction	Single bound Model (Weibull distribution)	
		Mean WTP (won)	VSL (million won)
Current Risk	5 in 1,000	333,067 (203,702 – 544,588)[1)]	666.13 (407.40 – 1,089.17)[1)]
	1 in 1,000	133,297 (90,068 – 197,276)[1)]	1,332.97 (900.68 – 1,972.8)[1)]
	Average		999.56
Future Risk	5 in 1,000 (WTP70)	271,671 (179,013 – 412,349)[1)]	543.38 (358.03 – 824.69)[1)]

1) 95 % confidence interval

● As shown in Table 5.7, mean WTP for a 5 in 1,000 risk reduction ranges from 203,702 won to 544,588 won a year. The corresponding figures for the 1-in-

1,000 risk reduction are 90,068 won to 197,276 won per year. In the case of future risk reduction, the mean WTP for the risk reduction of 5 in 1,000 beginnign at age 70 is 271,671 and the 95% confidence interval ranges from 179,013 won to 412,349 won per year.

- The WTP figures can be used to compute the corresponding value of a statistical life (VSL). We computed VSL by dividing annual WTP by the size of the annual risk reduction (5 in 10,000 or 1 in 10,000). The respective VSLs of current risk reductions, also reported in Table 8, range from 407.40 million won to 1972.76 million won. The average VSL of current these results is 999.56 million won. The VSL from future risk reduction is 543.38 million won and the 95% confidence interval ranges from 358.03 million won to 824.69 million won.
- To summarize, the corresponding VSLs are generally lower than those used by those of Canada or U.S. in benefit-cost analyses.

2) Benefits of Mortality Risk Reduction due to GHG Mitigation

- The VSL based on future mortality risk reduction in Table 5.7, that is 543.4 million won(0.47 million $) is applied to estimate annual benefits of mortality avoided, because the VSL inferred from future mortality risk reduction is more appropriate for health effects of our GHG mitigation scenarios(Table 5.8).

Table 5.8 : Estimated annual benefits of mortality avoided(CVM)

(1999 million $)

Scenario \ Year	2000	2010	2020
Reduction scenario 1	3.29	29.33	44.09
Reduction scenario 2	11.77	15.42	19.04
Reduction scenario 3	23.56	30.84	38.08
Reduction scenario 4	35.33	46.26	57.12

5.4 Cost of Illness

5.4.1 Introduction

● Conservative estimates of the benefits of improving air quality can be obtained by focusing on the cost of illness, that is the sum of medical expenditures and lost earnings attributable to the illness associated with pollution. In some cases, one can obtain estimates of the averting expenditures incurred by the individual to control exposure to pollution and hence illness.

● It is widely recognized that the cost of illness and averting expenditure provide only a lower bound for the correct measure of willingness to pay (Harrington and Portney 1987).

5.4.2 A Structural Model of Illness

● Suppose that the health outcome of interest is the number of hours $\boldsymbol{S}$ during a year or a month that a person spends ill with some respiratory ailment. The health production function relates time spent ill to exposure to pollution, $\boldsymbol{E}$, and to activities that mitigate the effects of exposure, $\boldsymbol{M}$. Mitigating activities include taking antihistamines or visiting a doctor, and have a unit cost of $\boldsymbol{p_M}$, which includes time as well as out-of-pocket costs. Pollution exposure is a function of ambient pollution and activities $\boldsymbol{A}$ termed averting or avoidance activities, that affect exposure given ambient pollution levels; that is, $\boldsymbol{E = E(A, P)}$. Let $\boldsymbol{p_A}$ denotes the unit cost of $\boldsymbol{A}$. The health production function may be written

$$\boldsymbol{S = S[E(A,P),M]} \qquad [4]$$

● Time spent ill directly affects the individual's utility by producing discomfort; it indirectly affects it by reducing the amount of time (and possibly money) available for leisure activities and consumption. Formally, $\boldsymbol{S}$ enters the utility function, together with all other goods $\boldsymbol{X}$ and leisure time $\boldsymbol{L}$.

$$\boldsymbol{U = U(X, L, S)} \qquad [5]$$

● S also enters the budget constraint by reducing the amount of time spent at work, and hence, the amount of income earned. The individual's budget constraint says that nonwage income I plus earnings must equal total

$$I + w(T - L - S) = p_X X + p_A A + p_M M \qquad [6]$$

expenditure. Formally,

where w is the wage rate and ***T - L - S*** is the time spent at work(***T*** is total time).

- The health production model assumes that the individual allocates his time between work and leisure activities and his income between defensive (averting and mitigating) expenditures and expenditures on other goods to maximize utility. The problem for the individual is to choose the mitigating and averting activities ***M*** and ***A***, the expenditures on all other goods ***X***, and the leisure time ***L*** that will maximize function [5] subject to [4] and [6].
- An individual's willingness to pay for a small reduction in ambient pollution ***P*** is defined as the largest amount of money that can be taken away from him without reducing his utility. Formally, economists define the pseudoexpenditure function as the minimum value of expenditure minus the wage income necessary to keep utility at U^0, or

where ***m*** is a Lagrangian multiplier. Applying the envelope theorem to [7] and substituting from the first-order conditions for utility maximization, willingness to pay for a marginal

$$E = \min[p_X X + p_A A + p_M M - w(T - L - S) + m[U^0 - U[X, L, S(A, P, M)]]] \quad [7]$$

change in ***P***, $\partial E/\partial P$, is given by

- Willingness to pay is given by the reduction in sick time associated with the

$$\begin{aligned} WTP &= -(\partial S/\partial P)p_M/(\partial S/\partial M) = p_M(\partial M/\partial P) && [8a] \\ &= -(\partial S/\partial P)p_A/(\partial S/\partial A) = p_A(\partial A/\partial P) && [8b] \\ &= (\partial S/\partial P)WTP_S && [8c] \end{aligned}$$

reduction in pollution, $\partial S/\partial P$, times the marginal cost of sick time. The latter is given by the cost of an additional mitigating input p_M divided by the reduction in sick time that input produces $-\partial S/\partial M$, or alternatively, by the cost of averting behavior p_A divided by the reduction in sick time that averting behavior produces $-\partial S/\partial A$.

- In the health production model, in which pollution affects utility only through health, this amount of money is the reduction in the cost of achieving the optimal level of health made possible by the decrease in pollution.
- According to Harrington and Portney(1987), WTP can be written as the sum of the value of lost time $w(\partial S/\partial P)$ and the disutility of the change in illness $(dS/dP)(\partial U/\partial S)/\lambda$ plus the observed changes in averting and mitigating expenditures, $p_M(\partial M^*/\partial P)$ and $p_A(\partial A^*/\partial P)$:

$$WTP = w\frac{dS}{dP} = p_M \frac{\partial M^*}{\partial P} = p_A \frac{\partial A^*}{\partial P} - \frac{\partial U/\partial S}{\lambda}\frac{dS}{dP} \quad [9]$$

where λ, the marginal utility of income, converts the disutility of illness $\partial U/\partial S$ into dollars, and where $M^* = M^*(I, w, p_X, p_A, p_M, P)$ and $A^* = A^*(I, w, p_X, p_A, p_M, P)$ are the demand functions for ***M*** and ***A*** to a change in pollution. WTP is a function of the total derivative of illness with respect to pollution, dS/dP, which incorporates the effect of pollution on averting behavior and averting behavior on illness. To compute dS/dP, it is not necessary to estimate a health production function; rather it is possible to estimate ***a dose-response function***, which is a reduced-form relationship between illness, ambient pollution, and variables that affect averting and mitigating behavior. In the health production framework, a dose-response fucntion is obtained by substituting the demand functions for ***M*** and ***A*** into the health production function.

● As a practical matter, the first three terms in [9] can be approximated after the fact by using the observed changes in illness and averting and mitigating expenditures. In this way, equation [9] can be used to derive a lower bound to individual WTP. Because the last term in the equation is negative ($\partial U/\partial S < 0$), the first two terms - the value of lost time plus the change in averting and mitigating expenditures - give a lower bound to WTP. These terms are referred to as the ***private cost of illness***, or the cost borne by an individual of mitigating and averting expenditure and lost time.

● In practice, the cost of these items to an individual may differ from their cost to society due to medical insurance and paid sick leave. Therefore, the social cost of mitigating and averting expenditures plus lost time will be referred to as the ***social cost of illness***.

● In the health literature, the expression cost of illness typically refers only to the social cost of lost earnings plus the recuperative (mitigating) medical expenditures associated with illness. This expression therefore ignores two components of our social cost of illness - the social value of averting expenditures and the cost of leisure time that results from illness.

5.4.3 Results

1. Data

● 1995 National Health Interview Survey : The Health Interview Survey, which also incorporated the health behavior survey, was aimed at estimation of the national prevalence of selected diseases and risk factors and included a set of questions on topics such as morbidity, limitation of activity, medical utilization and health behaviors asked by interviews through personal household interviews. A stratified multistage probability sampling design was used in this survey. A total number of 6,791 Korean households with 22,450 household members took part in this survey.
● 1995 Occupational Wage Survey Data : wage data of 39,891 workers

2. Quantification of Health Effects(Morbidity)

● The projected changes of 156 grids between BAU and GHG reduction scenarios in annual average PM10 concentrations are estimated using data from air quality modeling. Equation [10] is used as the basis for calculating the numbers of cases of morbidity(asthma and acute respiratory disease)
● Occurrence reduction in annual morbidity in each grid

$$= (RR-1) \times B_a \times PM_a \times POP, \qquad [10]$$

where
RR: relative risk
B_a : baseline annual morbidity, and
PM_a : change in annual average PM10 concentration
POP : population.

● In order to calculate an estimate of the change in the number of asthma and acute respiratory disease occurrences expected as a result of a change in PM10 in a given location, a baseline mortality rate must be used. For this assessment, the estimates are made in terms of annual cases of premature deaths reduced, so we use national annual average morbidity rates as each baseline. Excess occurrences in annual morbidity are given in Table 5.9

Table 5.9 : Annual occurrences of asthma and acute respiratory disease avoided

Scenario	Illness of	2000	2010	2020
Reduction Scenario 1	Asthma	472	4207	6324
	Acute Respiratory Disease	10	86	129
Reduction Scenario 2	Asthma	1690	2212	2732
	Acute Respiratory Disease	34	45	56
Reduction Scenario 3	Asthma	3379	4425	5463
	Acute Respiratory Disease	69	90	111
Reduction Scenario 4	Asthma	5069	6637	8195
	Acute Respiratory Disease	103	135	167

3) Estimation of Wage per Hour

- The wage per hour of respondent with occupation is estimated through three assumption using the wage function 1 (Table 5.10) which was estimated from [1995 occupational wage survey data]
- The wage per hour of respondent without occupation is estimated using wage function 2(Table 5.10) which was estimated from [1995 occupational wage survey data]

Table 5.10 : Wage functions estimated from 1995 wage survey data

Variable \ Function		Wage function 1		Wage function 2	
variable	Definition Of variable	coefficient	t-value	coefficient	t-value
CONST	Constant	-7991.93	-38.7	-7197.00	-33.4
SEX	Sex (female = 0, male =	798.37	21.0	607.67	15.5
MAR	No marriage = 0, Marriage = 1	670.83	14.8	622.25	12.8
AGE	Age	331.95	29.9	373.59	31.8
AGES	Age^2	-2.64	-19.3	-3.03	-21.0
MID	Graduated From middle school	909.96	12.5	1282.03	16.5
HIGH	Graduated From high school	2362.19	32.9	3480.20	46.9
COLL	Graduated from college	2209.97	24.7	4268.26	49.0
UNIV	Graduated from University	4270.95	49.6	6911.36	89.9
OC1	Occupation1[1)] =1 Else = 0	8195.25	69.4		
OC2	Occupation2[1)] =1 Else = 0	4376.00	50.7		
OC3	Occupation3[1)] =1 Else = 0	4022.55	48.6		
OC4	Occupation4[1)] =1 else = 0	3290.55	43.7		
OC5	Occupation5[1)] =1 else = 0	2421.00	25.6		
OC6	Occupation6[1)] =1 else = 0	775.82	1.2		
OC7	Occupation7[1)] =1 else = 0	2217.00	30.1		
OC8	Occupation8[1)] =1 else = 0	2258.99	32.3		
R-square		0.5044		0.4366	
Adj R-square		0.5042		0.4365	

1) occupation 1: legislators, senior officials and managers, occupation 2:

professionals, occupation 3: technicians and associate professional, occupation 4: clerks, occupation 5: service workers and shop and sales workers, occupation 6: skilled agriculture and fishery workers, occupation 7: craftmen and related trade assemblers, occupation 8: plant and machine operator and occupations, occupation 9: laborers

5.4.4 Total Medical Cost of Respiratory Disease

● Total medical costs of outpatient and inpatient was calculated by equations [11], [12].

● Total medical cost of outpatient = personal expenses for treatment + expenses from insurance + traffic expenses + {(number of visit × required time for visit × 2) + waiting time for treatment} * (wage per hour) [11]

● Total medical cost of inpatient = personal expenses for hospital treatment + expenses from insurance + expenses for come-and-go + expenses for nursing + rewards or supplementary expenses +{(required time for visit × 2) + days of hospital treatment × 8} × (wage per hour) [12]

● The costs of admission and outpatient visit are calculated by using data from the National Health Insurance data(NHIC) and 1995 National Health Interview Survey. In order to get the mean costs of asthma and respiratory disease, the prevalence rates of each diseases are utilized as weight factors(Table 5.11).

Table 5.11 : Unit values of morbidity

	Cost of Adm.(KW)	Cost of OPD.(KW)	Mean Cost (KW)	Mean Cost (US $)	Prevalence rate (spell based)
Asthma	913,534	40,157	70,973	62.0	Adm:OPD= 203 : 5,359
Respiratory Disease	1,040,488	33,959	63,845	55.7	Adm:OPD= 196 : 6,405

Note: Adm.: admission OPD.: outpatient

1) Benefits of Morbidity Reduction due to GHG Mitigation

The annual benefits of asthma and other respiratory diseases avoided due to GHG mitigation scenarios are presented in Table 5.12

(1999 million $)

Scenario \ Year	2000	2010	2020
Reduction scenario 1	0.03	0.27	0.40
Reduction scenario 2	0.11	0.14	0.17
Reduction scenario 3	0.21	0.28	0.34
Reduction scenario 4	0.32	0.42	0.52

Table 5.12 : Estimated annual benefits of morbidity avoided(COI)

5.5 Total Benefits of Health Effect due to GHG Mitigation

As for benefit estimation, only morbidity and mortality were calculated in connection with PM_{10}. Cost of illness figures were employed for economic valuation of diseases while a range of values of statistical life was used to calculate the value of the avoided premature deaths(Table 5.13). As for the values of the avoided cases of asthma and other respiratory diseases COI estimates were appplied(Table 5.14). All numbers are in 1999 present values with annual discount of 7.5 percent and with converted as 1US$=1,145.4 Korean Won (KW). Key results of the aggreagte values of mortality and morbidity include :

- The economic value(inferred from CVM of future mortality risk reduction) of the deaths avoided from the climate change mitigation scenarios ranges from 3.32 million (2000, scenario 1) to 57.64 million (2020, scenario 4) US$/yr.
- The economic value of the cases of asthma and other respiratory diseases avoided for the climate change mitigation scenarios range from 0.03(2000, scenario 1) million to 0.52 million(2020, scenario 4) US$/yr.
- The economic benefits per GHG emission avoided range $6.21(2000, scenario 1 to $14.4(2010, scenario 1) for the climate change scenarios(Table 5.15).
- The cumulative value of these avoided health effects is estimated to range from 342.16(scenario 2) to 1,026.57(scenario 4) million US$(Table 5.16).

Table 5.13 : Values of statistical life

		VSL (M KW)	VSL (M US $)	Reference
Human Capital Approach[2]		283.3	0.25	Average remaining expected life time between 40 and 79: 27.5 years Per capita GDP : 10.3 (MKW)
Transferred Value		1,658.5	1.45	range of values : 246.1 – 5,066.6 (M KW)
CVM	Current Risk	999.6	0.87	range of values : 407.4 – 1,972.8 (M KW)
	Future Risk	543.4	0.47	range of values : 358.0 – 824.7 (M KW)

Table 5.14 : Estimated annual health benefits of mortality(CVM) and morbidity avoided

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2 The value of life based on human capital approach is calculated by the average remaining expected life time of target people(between 40 and 79 years old persons) and the population of each age in Seoul.

(99 million US $)	Benefits from decreases of	2000	2010	2020
Scenario 1	Asthma and respiratory disease	0.03	0.27	0.40
	Premature deaths	3.29	29.33	29.59
	Total benefit	3.32	29.60	29.59
Scenario 2	Asthma and respiratory disease	0.11	0.14	0.17
	Premature deaths	11.77	15.42	19.04
	Total benefit	11.88	15.56	19.21
Scenario 3	Asthma and respiratory disease	0.21	0.28	0.34
	Premature deaths	23.56	30.84	38.08
	Total benefit	23.77	31.12	38.42
Scenario 4	Asthma and respiratory disease	0.32	0.42	0.52
	Premature deaths	35.33	46.26	57.12
	Total benefit	35.65	46.68	57.64

Table 5.15 Economic benefit per GHG emission avoided

$/ton of carbon avoided	2000	2010	2020
Scenario 1	6.2	14.4	10.4
Scenario 2,3,4	7.5	6.9	6.8

Table 5.16 Cumulative results 2000 to 2020 of total excess occurrence of mortality and morbidity avoided and the corresponding benefits

Scenario			Cumulative Decreases from 2000 to 2020 (occurrence)	Value (M US$)	Total Value
Scenario 1	Mortality	Cardiovascular Disease	1,102.81	523.17	588.44

		Respiratory Disease	126.45	59.99	
	Morbidity	Asthma	83,660	5.18	
		Respiratory Disease	1,701	0.09	
Scenario 2	Mortality	Cardiovascular Disease	641.30	304.23	342.16
		Respiratory Disease	73.48	34.86	
	Morbidity	Asthma	48,652	3.01	
		Respiratory Disease	990	0.06	
Scenario 3	Mortality	Cardiovascular Disease	1,2 82.60	608.47	684.41
		Respiratory Disease	147.13	69.80	
	Morbidity	Asthma	97,305	6.03	
		Respiratory Disease	1,979	0.11	
Scenario 4	Mortality	Cardiovascular Disease	1,923.90	912.70	1,026.57
		Respiratory Disease	220.61	104.66	
	Morbidity	Asthma	145,957	9.04	
		Respiratory Disease	2,969	0.17	

CHAPTER 6: CONCLUSIONS AND IMPLICATIONS FOR POLICY

The Korea ICAP work applies a bottom-up impact analysis approach to evaluate the ancillary benefits resulting from greenhouse gas mitigation polices and measures. This work initially has focused on the impact of these greenhouse gas mitigation measures on PM10 levels in the Seoul Metropolitan area and the corresponding impact on premature mortality and morbidity of asthma and respiratory diseases in 1995 through 2020. The greenhouse gas scenarios considered in this preliminary analysis focus primarily on energy efficiency and use of compressed natural gas for vehicles. More aggressive greenhouse gas reduction scenarios that include fuel substitution outside of the transportation sector would likely generate greater air pollution health benefits.

The results reveal that modest greenhouse gas reduction scenarios (5-15% reductions in 2020) can result in significant air pollution health benefits through reductions in PM10 concentrations. For instance, these greenhouse gas reduction measures for Korea's energy sector could avoid 40 to 120 premature deaths/yr. and 2,800 to 8,300 cases/yr. of asthma and other respiratory diseases in the Seoul Metropolitan Area in 2020. The cumulative value of these avoided health effects is estimated to range from 7 to 103 million US$/yr (in 1999 dollars with annual discounting rate 7.5%). This is equivalent to a benefit of $10 to $42 per ton of carbon emissions reduced in 2020 for the climate change scenarios.

Policy Implications

A review meeting for the ICAP-Korea project was held on 16 October 2000. This meeting was attended by the Korean ICAP study team lead by KEI, Korean policy makers from Ministry of Environment and the Korean legislature, Korean technical experts, and technical experts from the USA. The objectives of the meeting were to present the analytical methodology and the outcome of the project to Korean policy makers and technical experts and to obtain feedback on the usefulness of the project approach and results for enhancing effective policy making in Korea in the areas of GHG mitigation and air quality management.

The ICAP-Korea assessment found that the ancillary benefits of implementing GHG mitigation measures in Seoul Metro. Korea between 2000 and 2020 would, on average, result in human health benefits of reduced air pollution of $US10-42/ton C mitigated, a significant figure when considering the costs of potential GHG mitigation measures. Policy makers agreed that the ICAP approach and the results of this project were useful in informing policy makers and the public of the co-benefit impacts of policy decisions and assisting with the development of cost-effective integrated strategies to address both local air quality issues and GHG mitigation concerns simultaneously.

Study limitations that effect magnitude of results;
The average ancillary health benefits of $US10-42/ ton C were viewed as conservative due to several limitations of the current studies analytical approach and methodology which tended to lead to underestimates of the total benefits which could be realized. The meeting recognized these study limitations and concluded that if these limitations could be successfully addressed in future work, the expected ancillary benefits of the GHG mitigation scenarios would likely increase. The discussion of the key limitations identified by the policy makers and experts and their effect on the assessment outcome is summarized below.

Mitigation scenarios:
The meeting noted that the GHG mitigation scenarios assumed a modest level of implementation of effective GHG mitigation measures and that these measures were not specifically targeted toward "integrated strategies" which would be most effective in simultaneously reducing GHG emissions and emissions of air pollutants. A greater focus in the mitigation scenarios on harmonized strategies that target both GHG and air pollution emissions from specific sectors and fuel types would likely have resulted in greater emission reductions of both types of pollutants, and hence greater health benefits.

Assessment considered a limited set of key air pollutants:
The only air pollutant considered under the assessment methodology was directly emitted PM10, which Korean researchers estimate make up only about 50% of total air pollution health effects in Seoul. Other pollutants which are have been determined to have important impacts on human health include fine particulate matter (PM2.5 and secondary particulate matter such as sulfates and nitrates), SO2, NOx, and O3. Atmospheric concentrations of these other pollutants would also be expected to be reduced as a result of implementation of the GHG mitigation strategies, along side PM10. Thus, the meeting

recognized that consideration of a wider range of air pollutants would allow the project to quantify an increasingly larger set of ancillary health benefits resulting from implementation of GHG mitigation measures.

Health effects estimation includes some known uncertainties.
For social impact estimation, mortality should be estimated as a probability of death among total population. In this study and similar studies else, health effect was analyzed as short-term premature deaths probably from the already diseased pools. This discrepancy is most important source of overestimation, considering the larger proportions that mortality occupies in total impact/benefits (more than 80%).

This study also has some important sources of underestimation:
Besides the fact that we did not consider the "main effect" from the beginning (direct health effect from GHG, i.e., heat wave, extreme weathers and newly emerging infection), we limited pollutants to PM10. This restriction ruled out the ozone and SO2 effects, which in Korea had shown stronger adverse health effects. Particularly, ozone has been observed to adversely affect mortality and respiratory diseases by the factor of 3-4 compared with PM10. To top on this, there has been strong evidence that ozone modifies the effect of heat wave effect on mortality. This restriction of pollutants may be the largest source of underestimation.

Many health outcome cells are still left empty, not included in calculating benefits. Ischemic heart diseases, congestive heart failure and lung cancer may be the most probable health effects to be included in next step. And there are important but often neglected source of underestimation from using annual average value in pollutant level projection. We believe that strong adverse health effect may be caused in the day of extremely high pollution levels. Small increase in the average pollution level almost always parallels wider fluctuation of pollution level. In this study we only considered change in annual average level, which dampened actual daily health effects. As a result, the meeting concluded that the assessment, by associating health effects with daily average PM10 concentrations, underestimated the health impacts resulting from increased PM10 concentrations and hence the ancillary benefits of reducing these concentrations were also underestimated.

Relevance and usefulness of the ICAP approach and results for policy making:
There was an overwhelming consensus that the approach and results of this project were very useful for policy making at both local levels (on air quality

management) and national levels (on GHG mitigation). Policymakers noted that the project demonstrated the potential for real, positive economic and social ancillary benefits from mitigation scenarios and commended the project efforts activities to provide these estimates. An important next step in this process would be to more widely disseminate the outcome and results of this project to achieve greater recognition and understanding of the results in the policy making community and the general public.

Representatives from the Ministry of the Environment (MOE) noted that while in general in Korea, policy makers place greater value on actions to improve local air quality than on actions to mitigate GHG emissions, the approach followed in this project could be used to develop cost-effective integrated strategies to address both types of concerns simultaneously.

The representative from Congress pointed out that the Korean government already expressed a keen interest in climate change issues and lawmakers are very interested in the issue of ancillary benefits of climate change mitigation actions. Under consideration is establishment of a special committee on climate change in congress to investigate policy matters related to climate change issues in greater detail. However, the problem of awareness extends beyond the policymakers to the general population who view climate change as a complicated, difficult and potentially costly problem. Thus, one benefit of this project and it's results would be to assist with educating the general public about the potential economic and social benefits of taking action on climate change issues in a way that allows them to better relate to these issues on a personal level and comprehend the costs and benefits of policy decisions.

The ICAP project affords the benefit of allowing the policy issues of climate change to be viewed in the context of sustainable development. Through linking strategies to address local air quality and improve human health with GHG emissions reductions, the relationship between sustainable development and climate change policy becomes more apparent. As those linkages are further developed, it becomes clear that practical measures to address climate change are also practical measures to help achieve sustainable development goals as well.

It was also pointed out that in Korea, as in the US and many other developed countries, pollution regulation has traditionally addressed one criteria pollutant at a time often resulting in a overall regulatory strategy which is not optimal nor cost effective. The ICAP project is useful for air pollution regulation in Korea as it aids policymakers in integrating the regulation of multiple pollutants simultaneously, resulting in more effective, and more cost-effective strategies.

The policy makers also noted that to be useful in practical application, the ICAP project should attempt to prioritize specific measures and strategies in terms of their benefit potential and cost effectiveness in achieving simultaneous GHG mitigation and human health improvement. To address this concern, ICAP would need to develop and analyze more specific mitigation measures and technologies related to specific sectors and fuel types to determine the overall impact and benefit ratio for these measures. In this way, the ICAP approach could more effectively communicate to policymakers and the general public the anticipated level of ancillary benefits of specific measures and build support for implementation of these measures.

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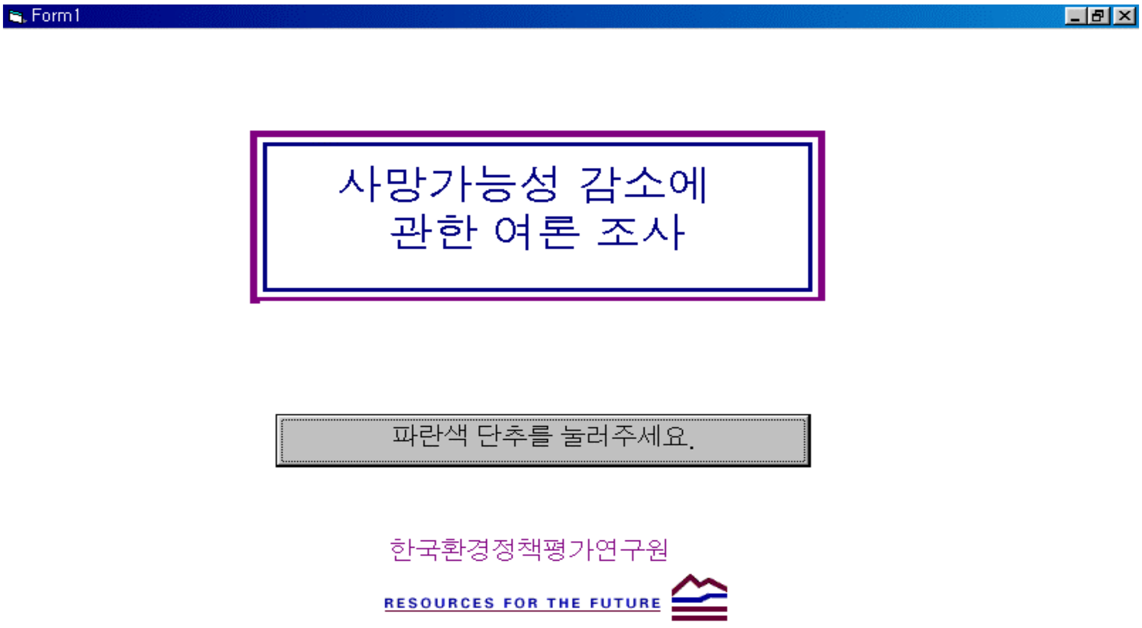
Appendix: Contents of Survey Questionnaire



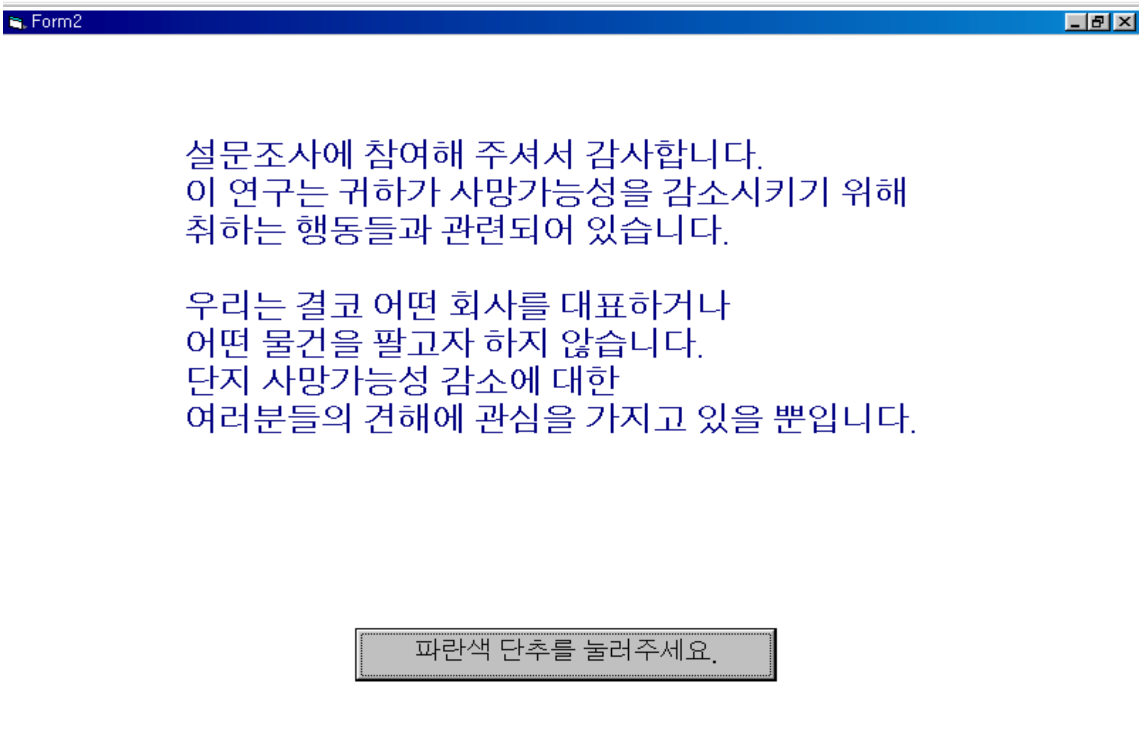
Form1

사망가능성 감소에
관한 여론 조사

파란색 단추를 눌러주세요.

한국환경정책평가연구원

RESOURCES FOR THE FUTURE

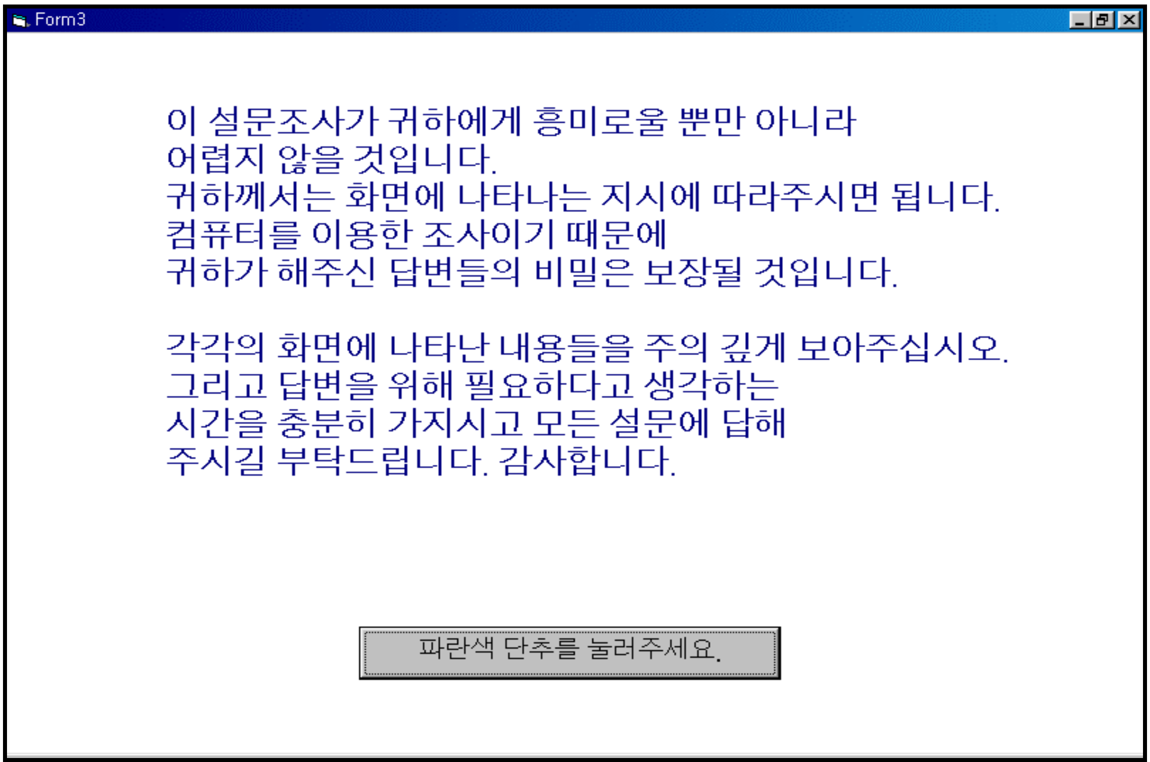


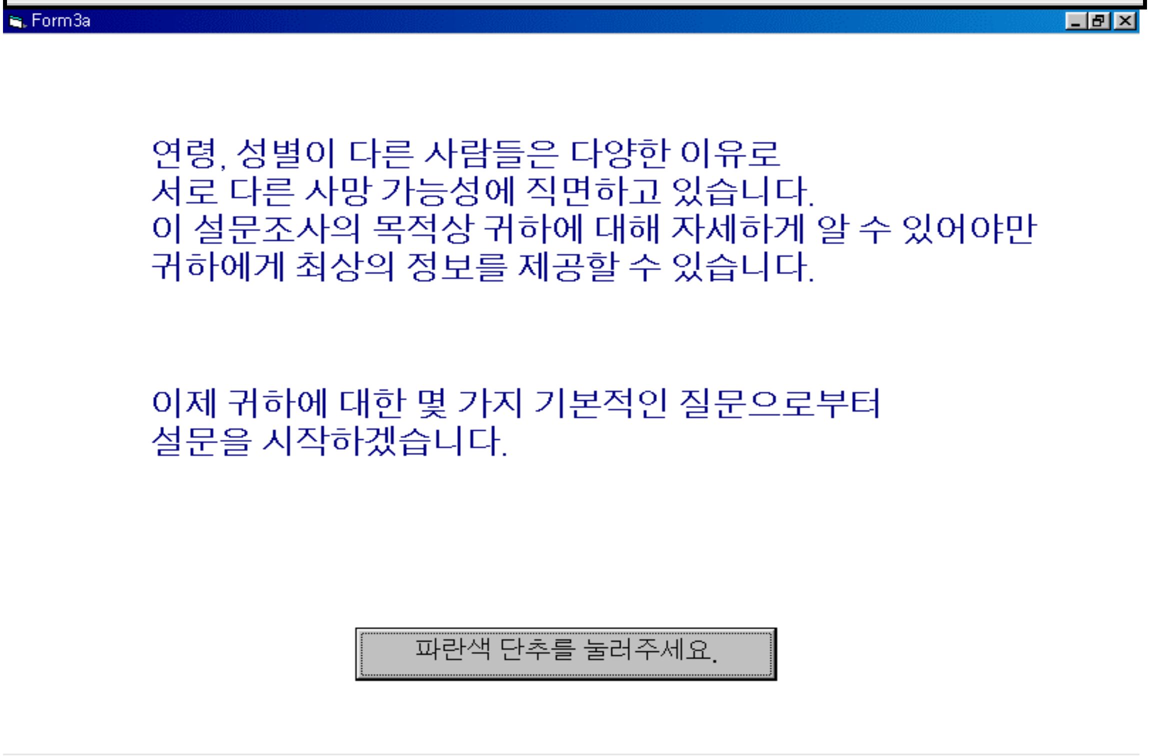
Form2

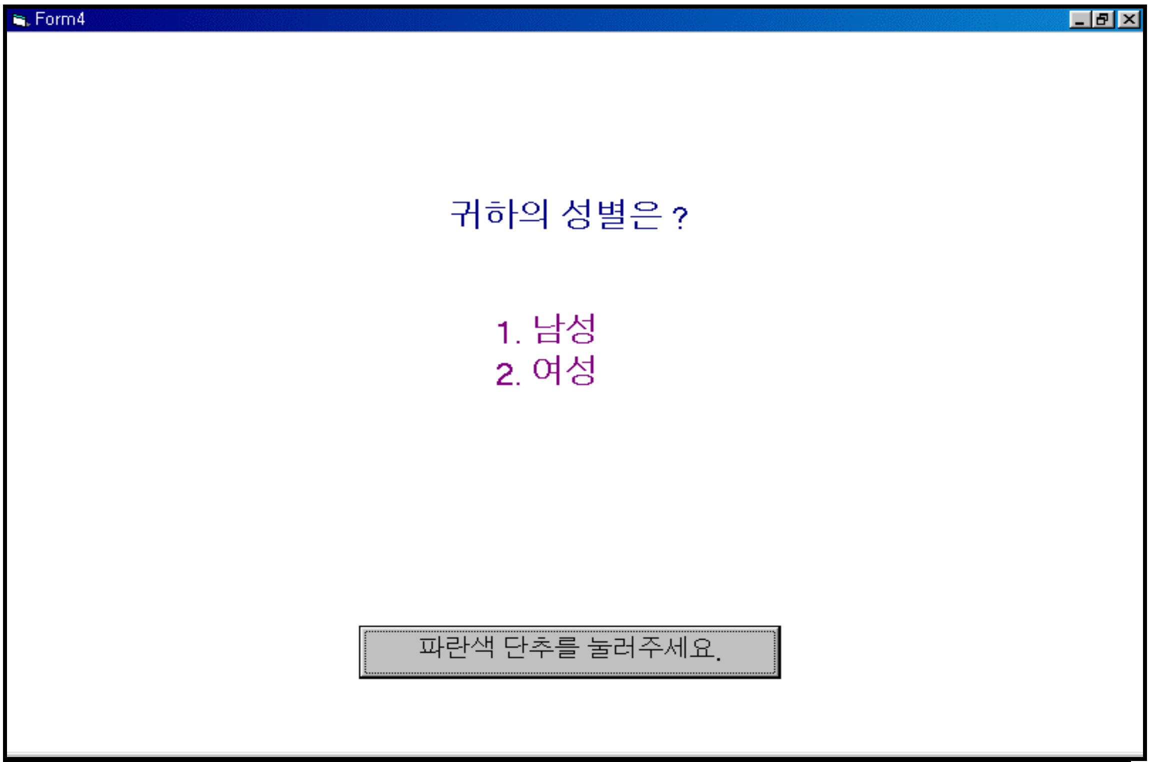
설문조사에 참여해 주셔서 감사합니다.
이 연구는 귀하가 사망가능성을 감소시키기 위해
취하는 행동들과 관련되어 있습니다.

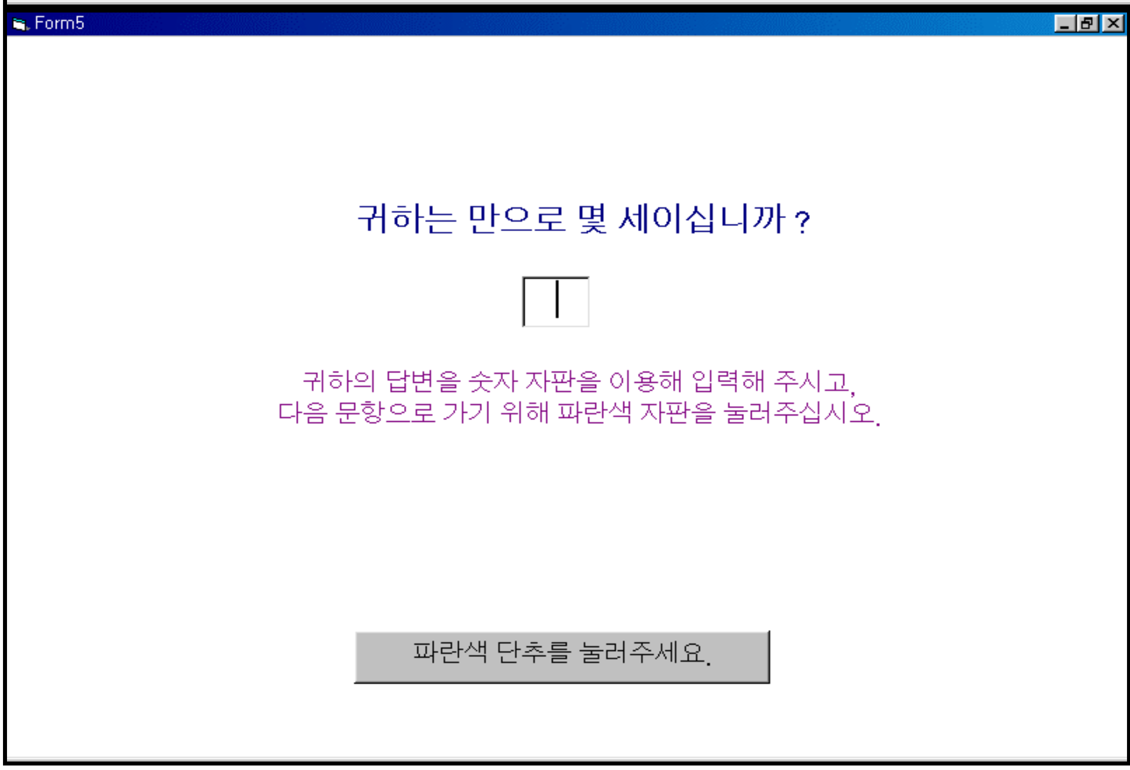
우리는 결코 어떤 회사를 대표하거나
어떤 물건을 팔고자 하지 않습니다.
단지 사망가능성 감소에 대한
여러분들의 견해에 관심을 가지고 있을 뿐입니다.

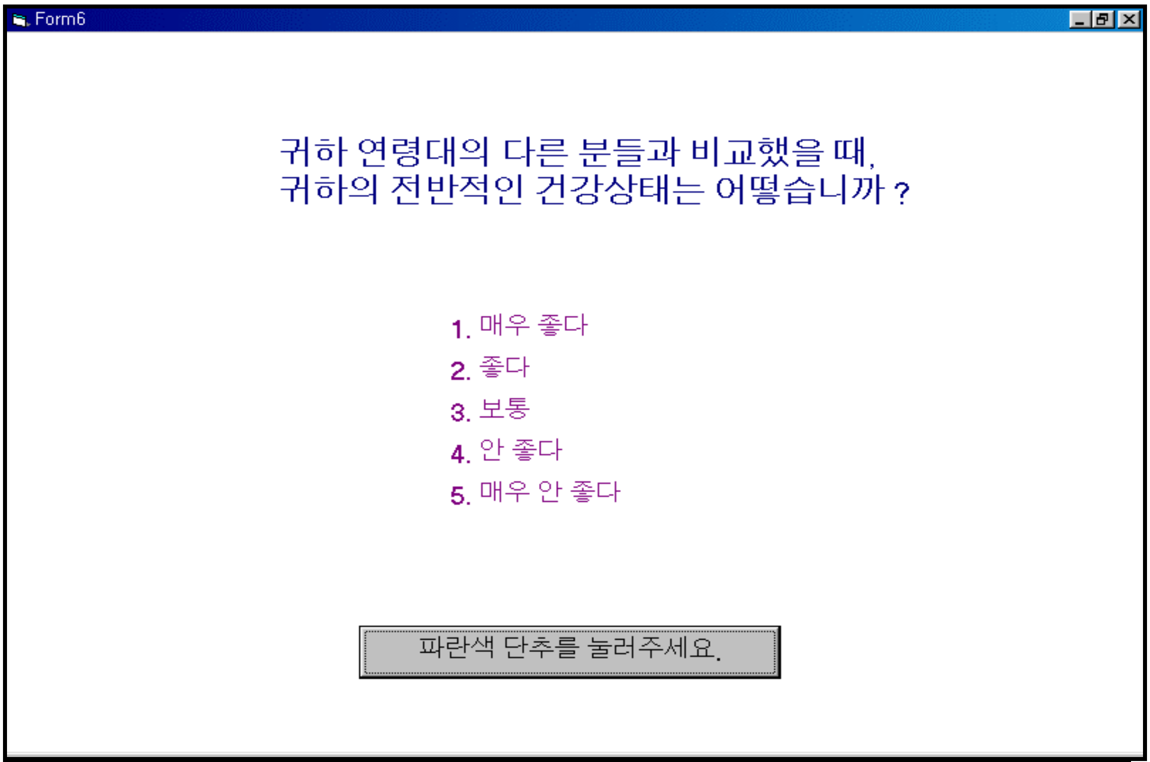
파란색 단추를 눌러주세요.

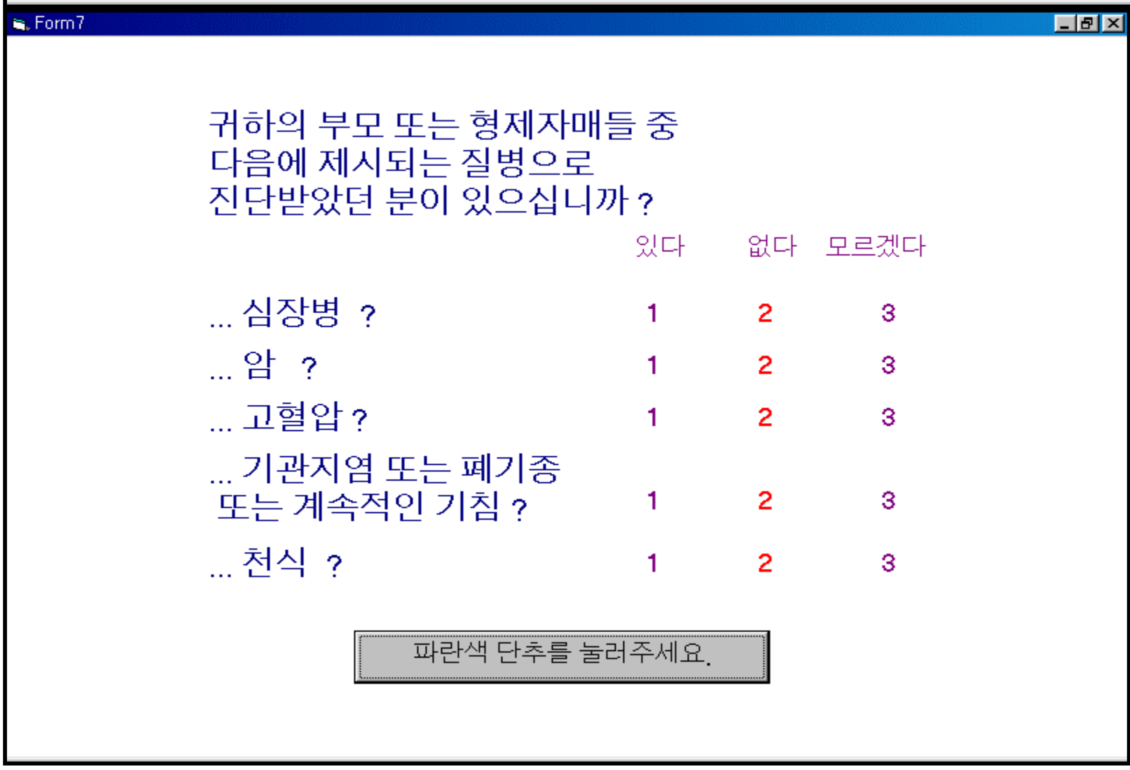

Form3
이 설문조사가 귀하에게 흥미로울 뿐만 아니라
어렵지 않을 것입니다.
귀하께서는 화면에 나타나는 지시에 따라주시면 됩니다.
컴퓨터를 이용한 조사이기 때문에
귀하가 해주신 답변들의 비밀은 보장될 것입니다.
각각의 화면에 나타난 내용들을 주의 깊게 보아주십시오.
그리고 답변을 위해 필요하다고 생각하는
시간을 충분히 가지시고 모든 설문에 답해
주시길 부탁드립니다. 감사합니다.
파란색 단추를 눌러주세요.


Form3a
연령, 성별이 다른 사람들은 다양한 이유로
서로 다른 사망 가능성에 직면하고 있습니다.
이 설문조사의 목적상 귀하에 대해 자세하게 알 수 있어야만
귀하에게 최상의 정보를 제공할 수 있습니다.
이제 귀하에 대한 몇 가지 기본적인 질문으로부터
설문을 시작하겠습니다.
파란색 단추를 눌러주세요.


Form4
귀하의 성별은 ?
1. 남성
2. 여성
파란색 단추를 눌러주세요.

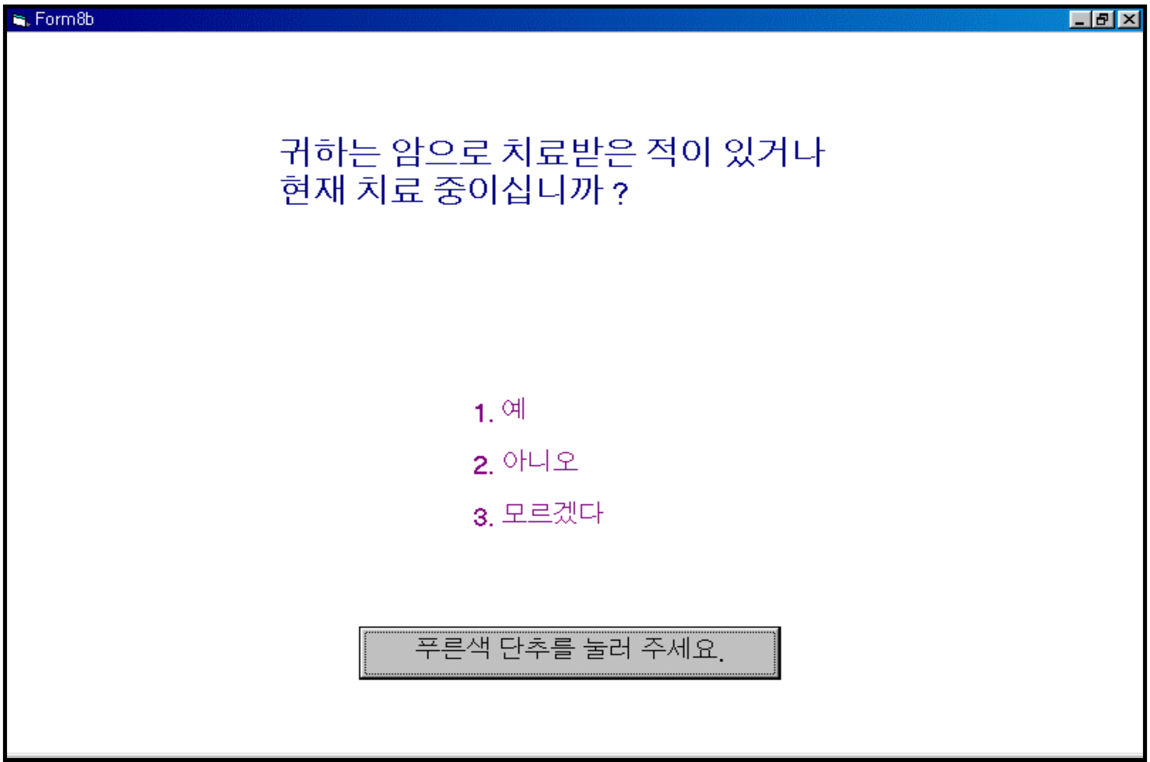

Form5
귀하는 만으로 몇 세이십니까 ?
귀하의 답변을 숫자 자판을 이용해 입력해 주시고,
다음 문항으로 가기 위해 파란색 자판을 눌러주십시오.
파란색 단추를 눌러주세요.

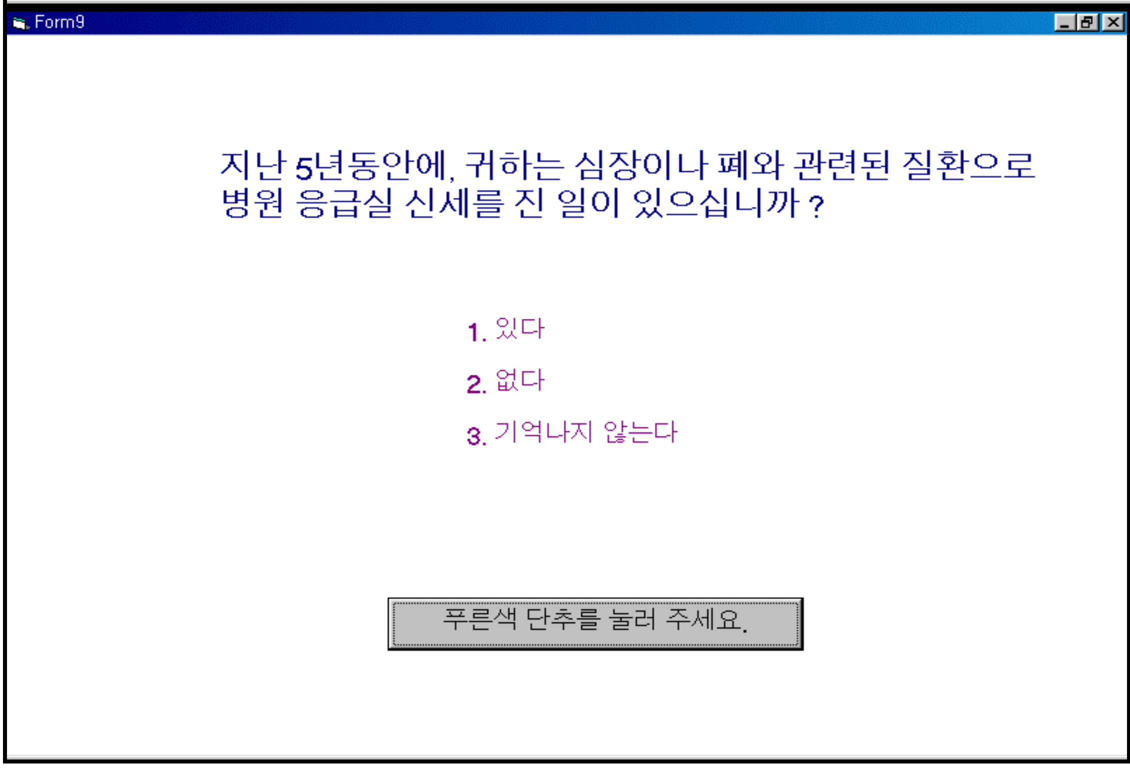

Form6
귀하 연령대의 다른 분들과 비교했을 때,
귀하의 전반적인 건강상태는 어떻습니까?
1. 매우 좋다
2. 좋다
3. 보통
4. 안 좋다
5. 매우 안 좋다
파란색 단추를 눌러주세요.

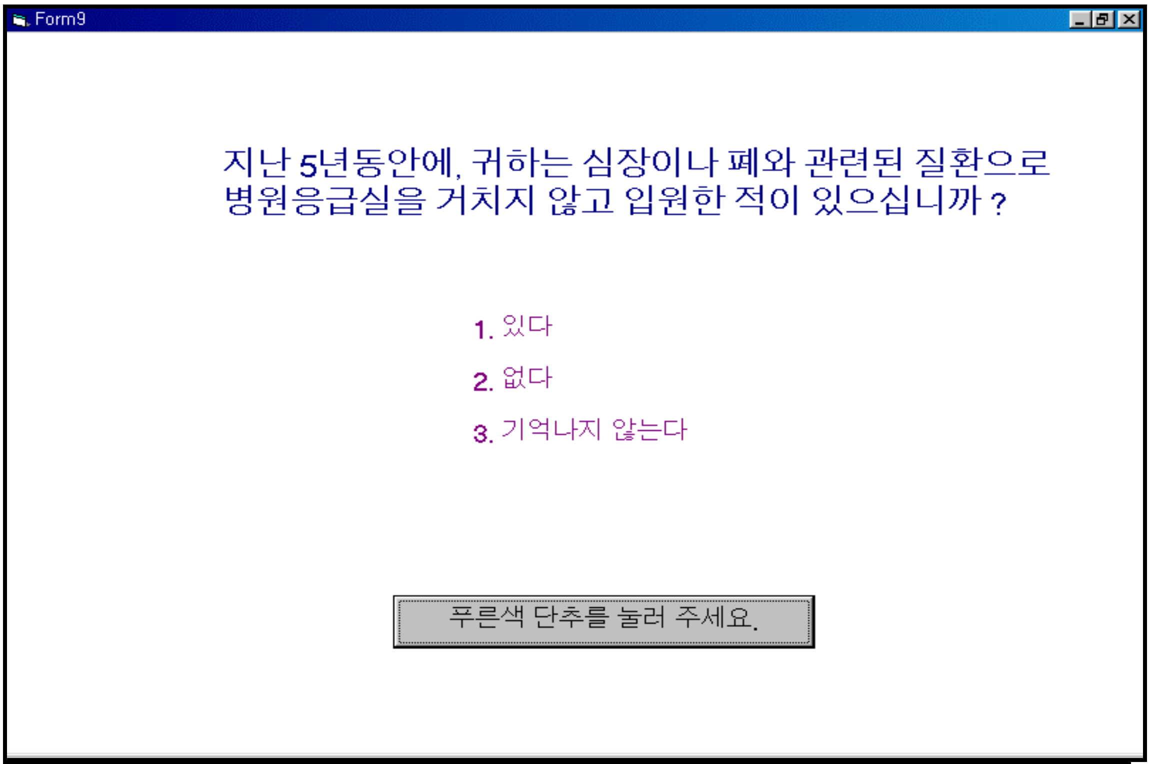

Form7
귀하의 부모 또는 형제자매들 중
다음에 제시되는 질병으로
진단받았던 분이 있으십니까?
있다 없다 모르겠다
... 심장병 ? 1 2 3
... 암 ? 1 2 3
... 고혈압? 1 2 3
... 기관지염 또는 폐기종
또는 계속적인 기침? 1 2 3
... 천식 ? 1 2 3
파란색 단추를 눌러주세요.

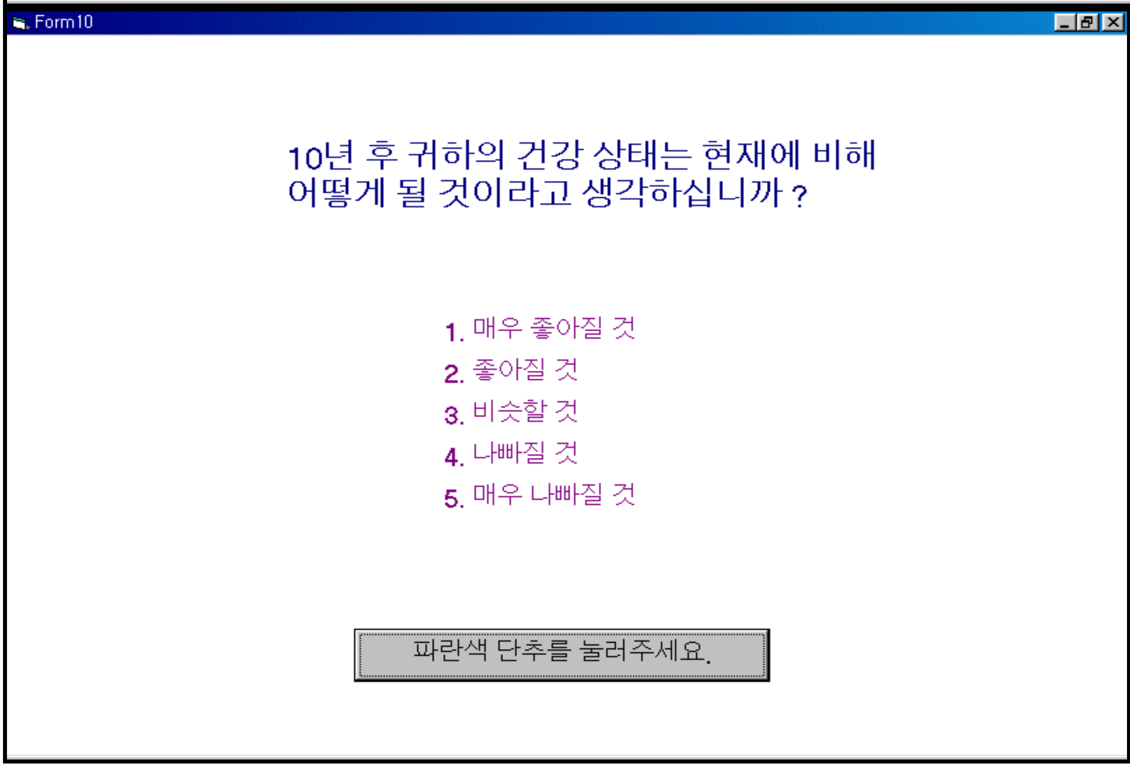

Form8
귀하는 다음에 제시되는 병으로
진단받은 적이 있으십니까 ?
있다 없다 모르겠다
... 고혈압 ? 1 2 3
... 관상동맥 심질환(일명 허혈성 심질환) 1 2 3
... 협심증 ? 1 2 3
... 심장마비(일명 심근경색증) ? 1 2 3
... 기타 심장병 ? 1 2 3
푸른색 단추를 눌러 주세요.

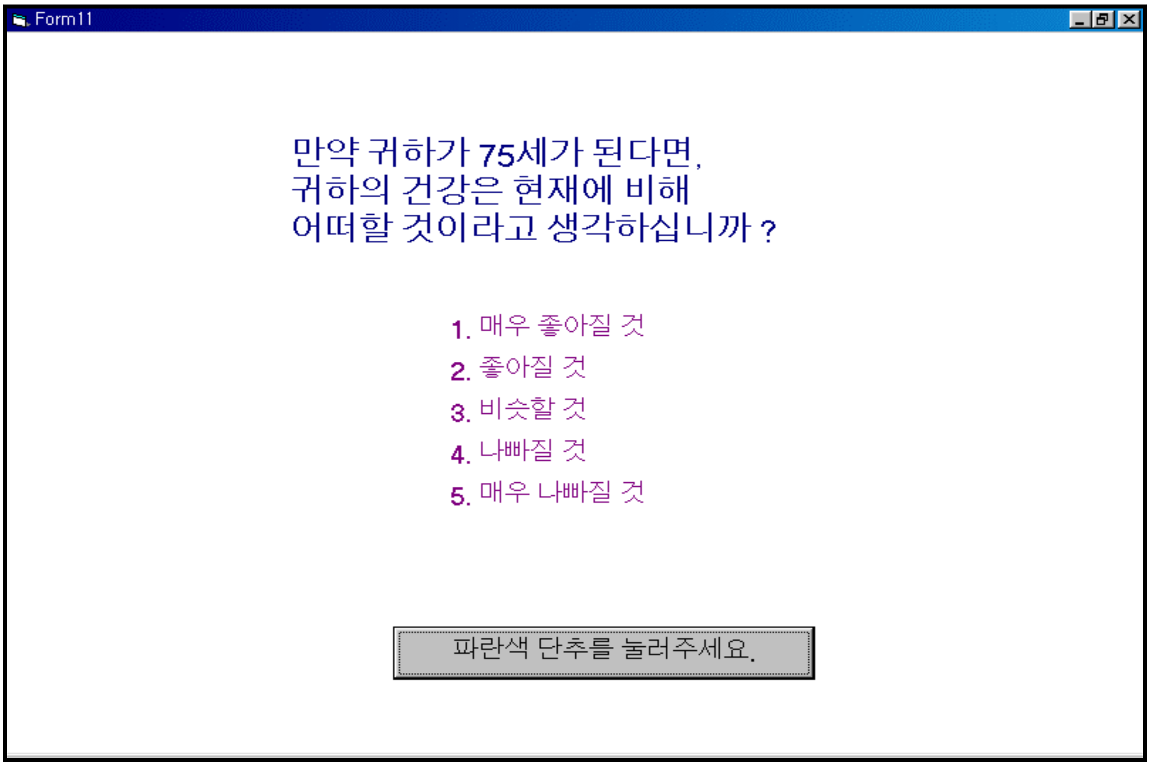

Form8a
귀하는 다음에 제시되는 병으로
진단받은 적이 있으십니까 ?
있다 없다 모르겠다
... 뇌졸증 ? 1 2 3
... 폐기종 ? 1 2 3
... 만성 기관지염 ? 1 2 3
... 천식 ? 1 2 3
... 암 또는 기타 악성 종양? 1 2 3
푸른색 단추를 눌러 주세요.

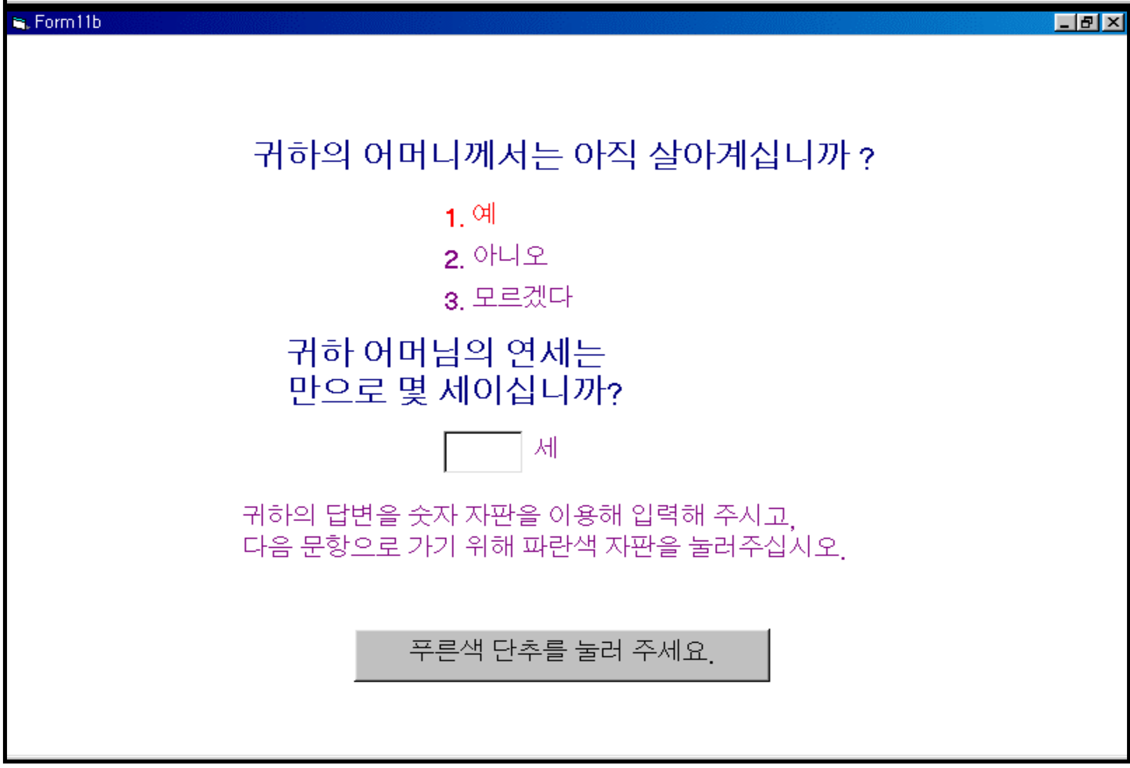

Form8b
귀하는 암으로 치료받은 적이 있거나
현재 치료 중이십니까 ?
1. 예
2. 아니오
3. 모르겠다
푸른색 단추를 눌러 주세요.

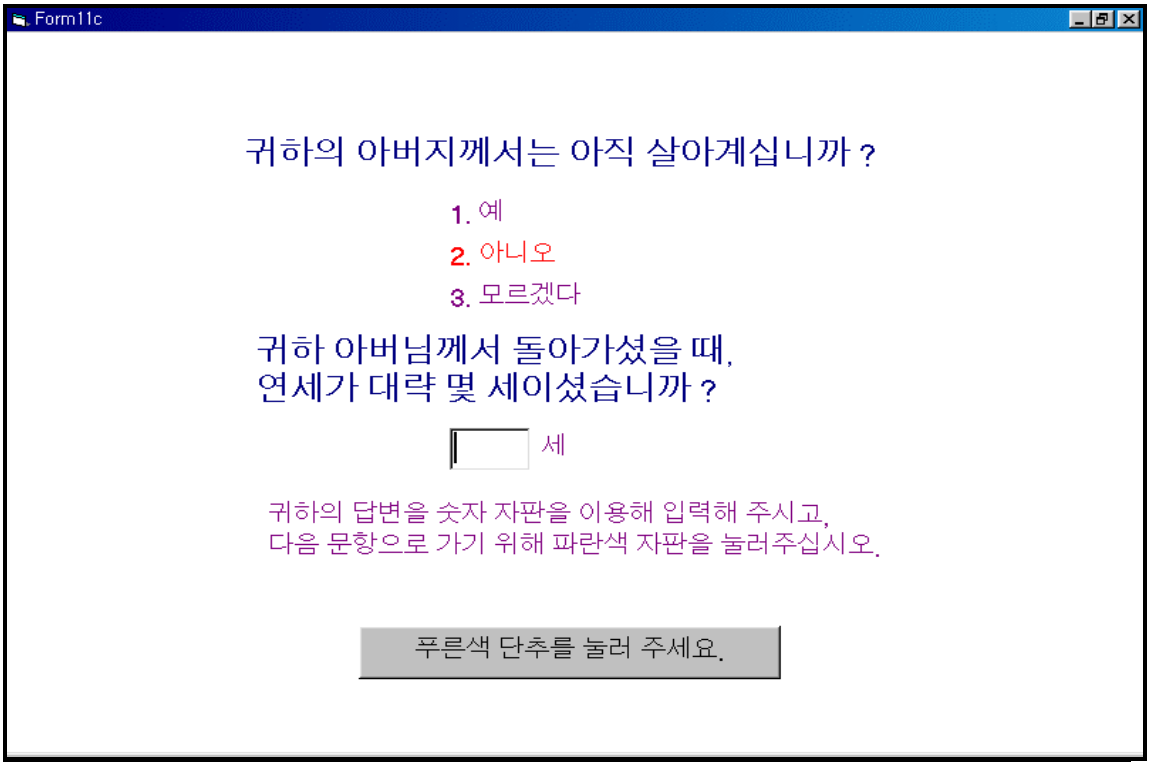

Form9
지난 5년동안에, 귀하는 심장이나 폐와 관련된 질환으로
병원 응급실 신세를 진 일이 있으십니까 ?
1. 있다
2. 없다
3. 기억나지 않는다
푸른색 단추를 눌러 주세요.

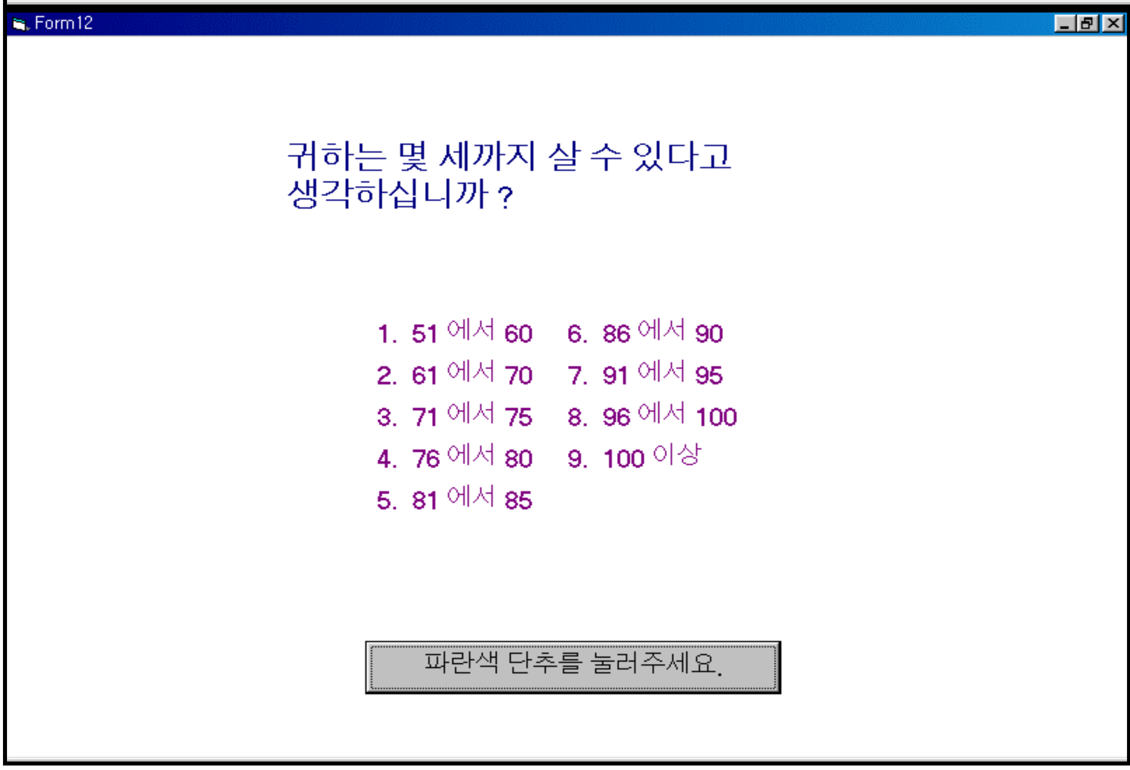

Form9
지난 5년동안에, 귀하는 심장이나 폐와 관련된 질환으로
병원응급실을 거치지 않고 입원한 적이 있으십니까 ?
1. 있다
2. 없다
3. 기억나지 않는다
푸른색 단추를 눌러 주세요.

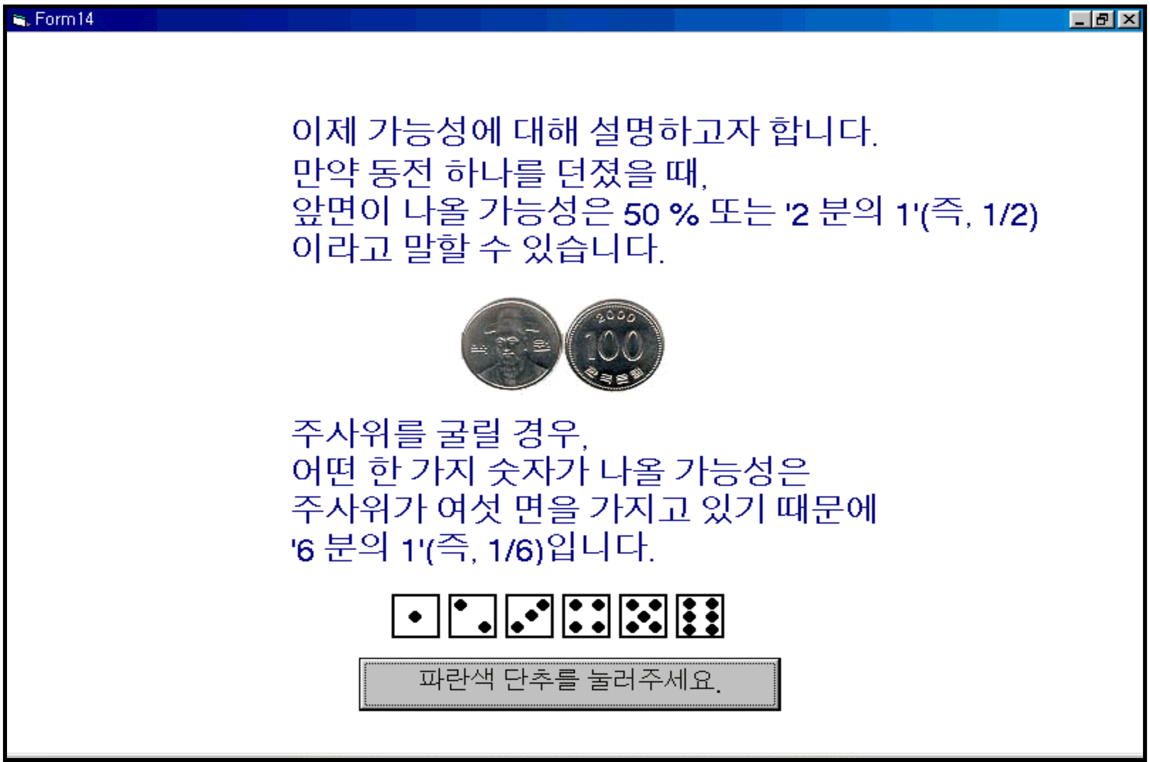

Form10
10년 후 귀하의 건강 상태는 현재에 비해
어떻게 될 것이라고 생각하십니까 ?
1. 매우 좋아질 것
2. 좋아질 것
3. 비슷할 것
4. 나빠질 것
5. 매우 나빠질 것
파란색 단추를 눌러주세요.

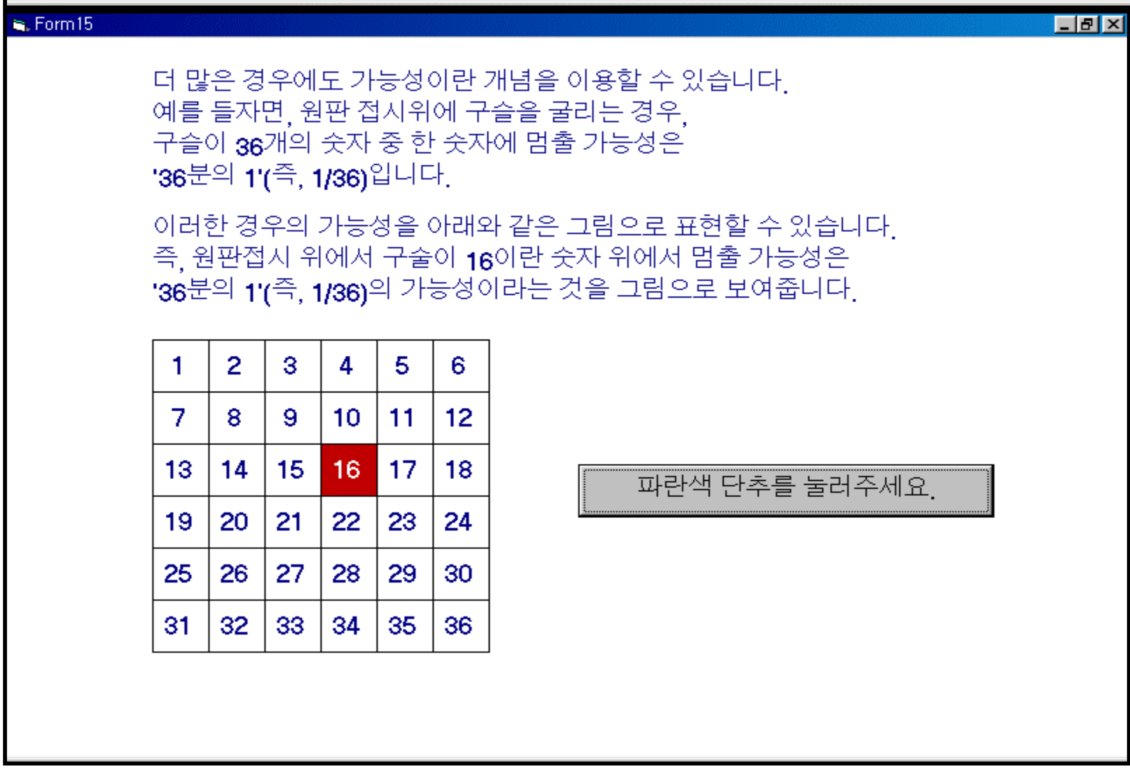

Form11
만약 귀하가 75세가 된다면,
귀하의 건강은 현재에 비해
어떠할 것이라고 생각하십니까 ?
1. 매우 좋아질 것
2. 좋아질 것
3. 비슷할 것
4. 나빠질 것
5. 매우 나빠질 것
파란색 단추를 눌러주세요.

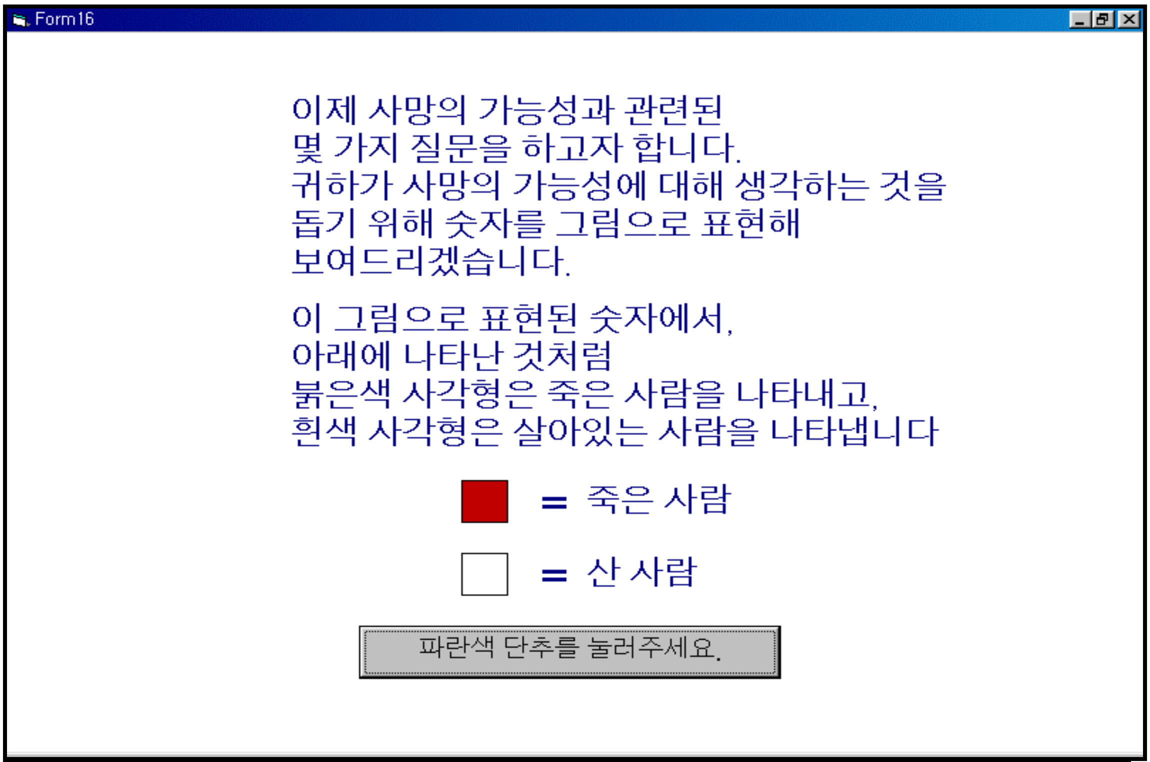

Form11b
귀하의 어머니께서는 아직 살아계십니까 ?
1. 예
2. 아니오
3. 모르겠다
귀하 어머님의 연세는
만으로 몇 세이십니까?
세
귀하의 답변을 숫자 자판을 이용해 입력해 주시고,
다음 문항으로 가기 위해 파란색 자판을 눌러주십시오.
푸른색 단추를 눌러 주세요.

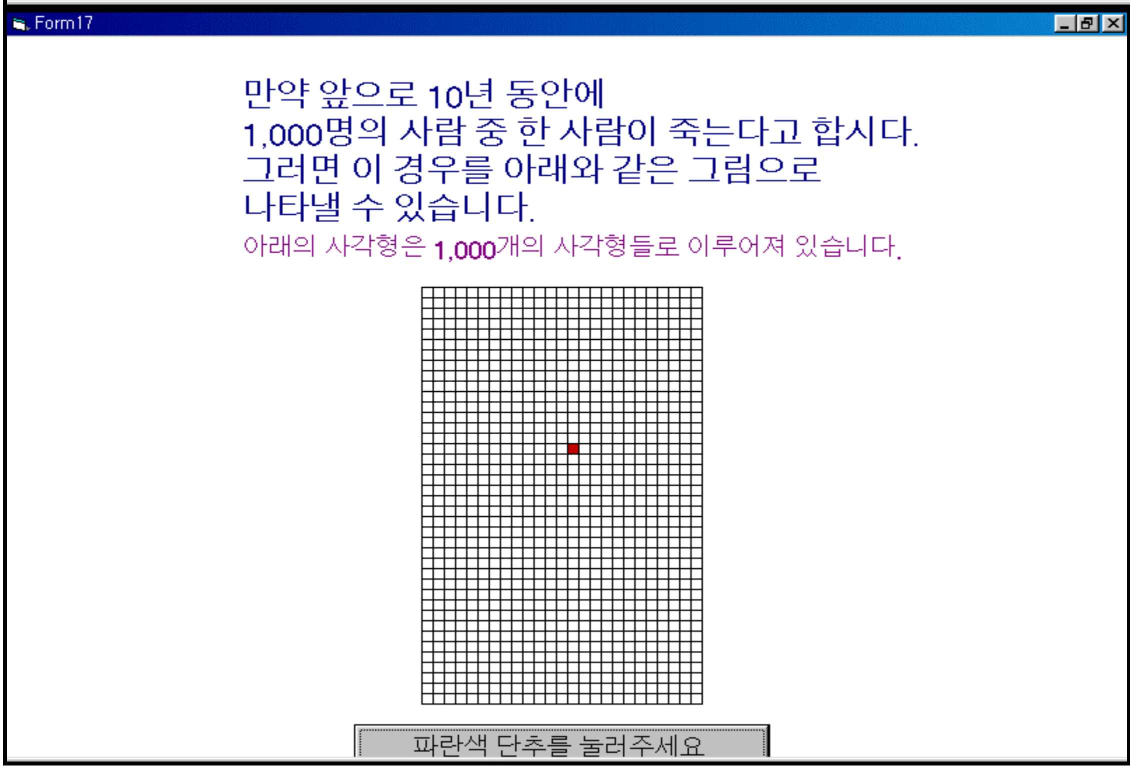

Form11c
귀하의 아버지께서는 아직 살아계십니까?
1. 예
2. 아니오
3. 모르겠다
귀하 아버님께서 돌아가셨을 때,
연세가 대략 몇 세이셨습니까?
세
귀하의 답변을 숫자 자판을 이용해 입력해 주시고,
다음 문항으로 가기 위해 파란색 자판을 눌러주십시오.
푸른색 단추를 눌러 주세요.

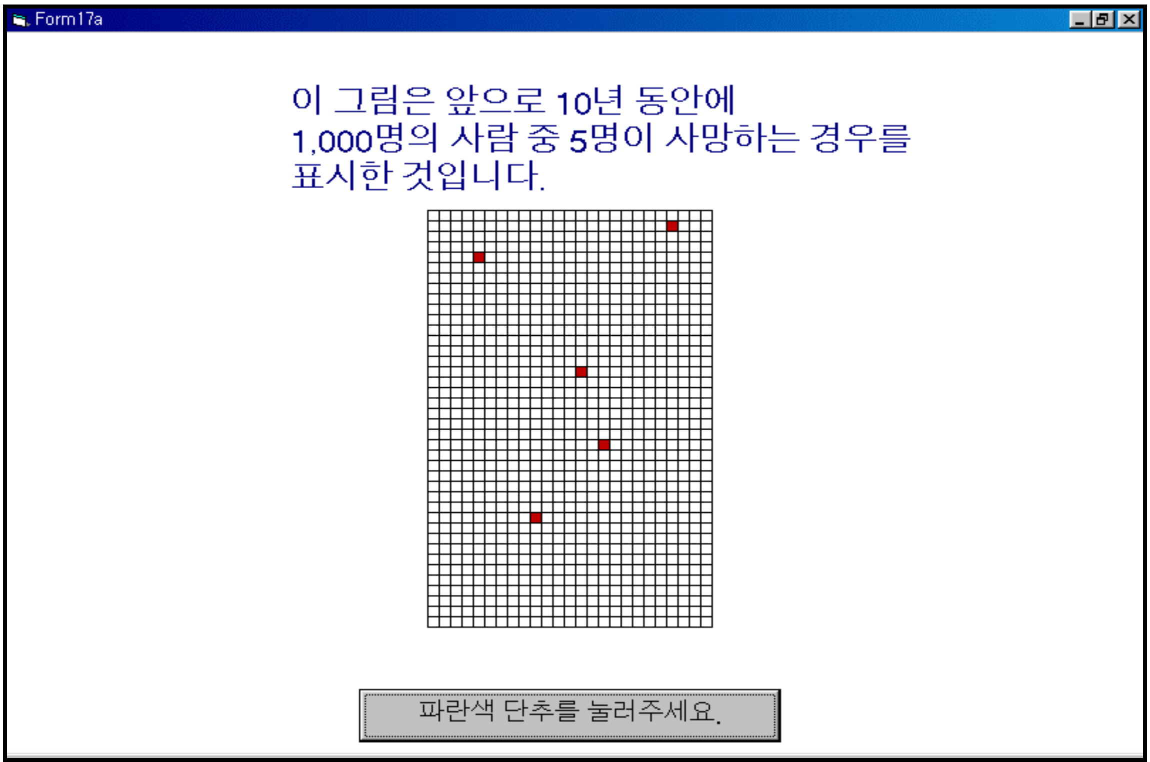

Form12
귀하는 몇 세까지 살 수 있다고
생각하십니까?
1. 51 에서 60
2. 61 에서 70
3. 71 에서 75
4. 76 에서 80
5. 81 에서 85
6. 86 에서 90
7. 91 에서 95
8. 96 에서 100
9. 100 이상
파란색 단추를 눌러주세요.

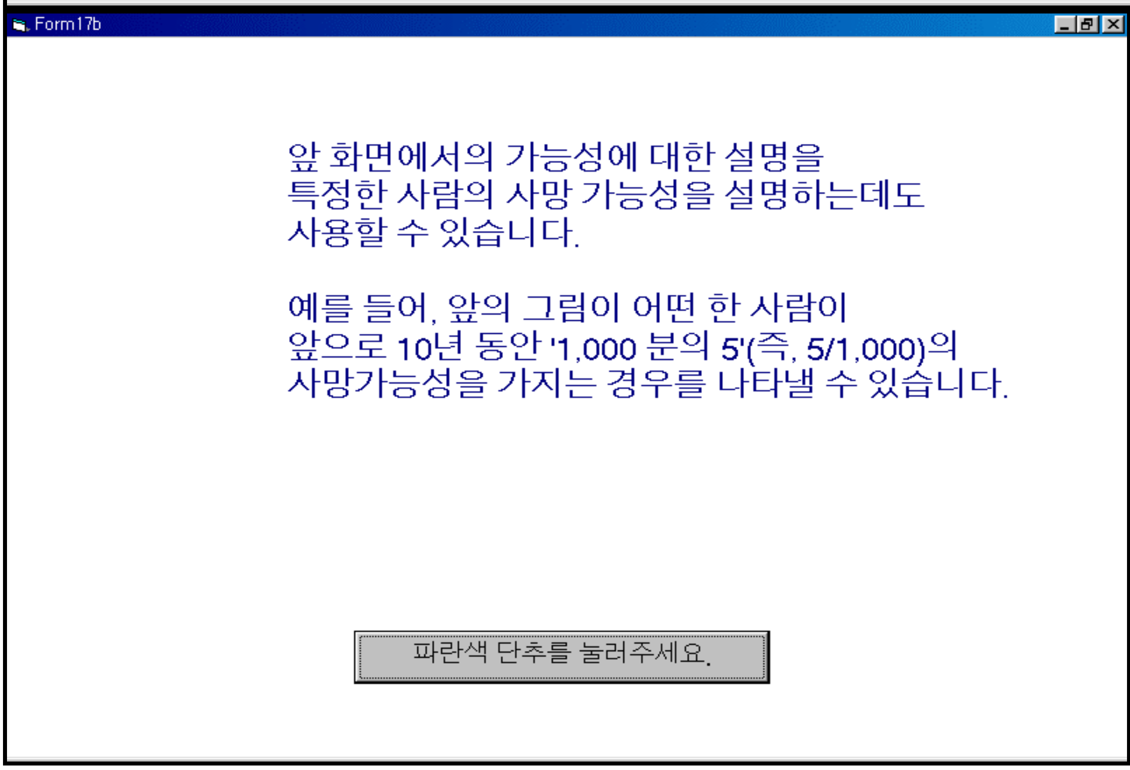

Form14
이제 가능성에 대해 설명하고자 합니다.
만약 동전 하나를 던졌을 때,
앞면이 나올 가능성은 50 % 또는 '2 분의 1'(즉, 1/2)
이라고 말할 수 있습니다.
주사위를 굴릴 경우,
어떤 한 가지 숫자가 나올 가능성은
주사위가 여섯 면을 가지고 있기 때문에
'6 분의 1'(즉, 1/6)입니다.
파란색 단추를 눌러주세요.

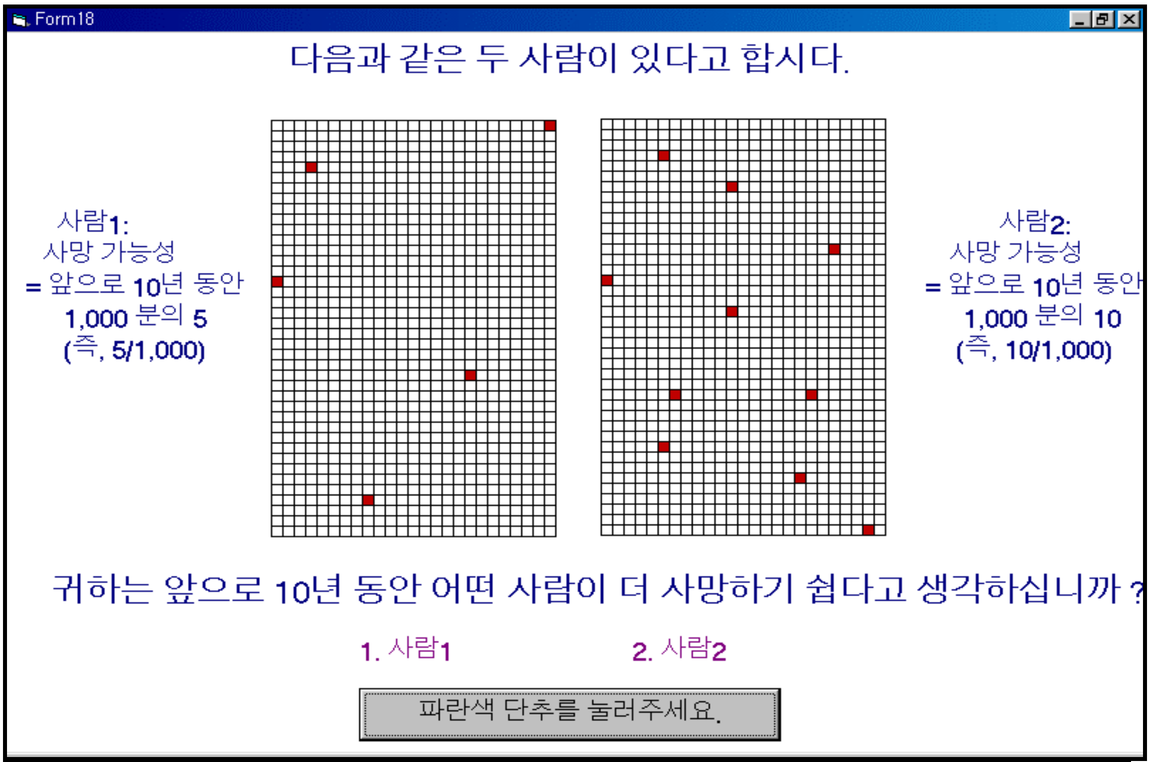

Form15
더 많은 경우에도 가능성이란 개념을 이용할 수 있습니다.
예를 들자면, 원판 접시위에 구슬을 굴리는 경우,
구슬이 36개의 숫자 중 한 숫자에 멈출 가능성은
'36분의 1'(즉, 1/36)입니다.
이러한 경우의 가능성을 아래와 같은 그림으로 표현할 수 있습니다.
즉, 원판접시 위에서 구슬이 16이란 숫자 위에서 멈출 가능성은
'36분의 1'(즉, 1/36)의 가능성이라는 것을 그림으로 보여줍니다.
1 2 3 4 5 6
7 8 9 10 11 12
13 14 15 16 17 18
19 20 21 22 23 24
25 26 27 28 29 30
31 32 33 34 35 36
파란색 단추를 눌러주세요.

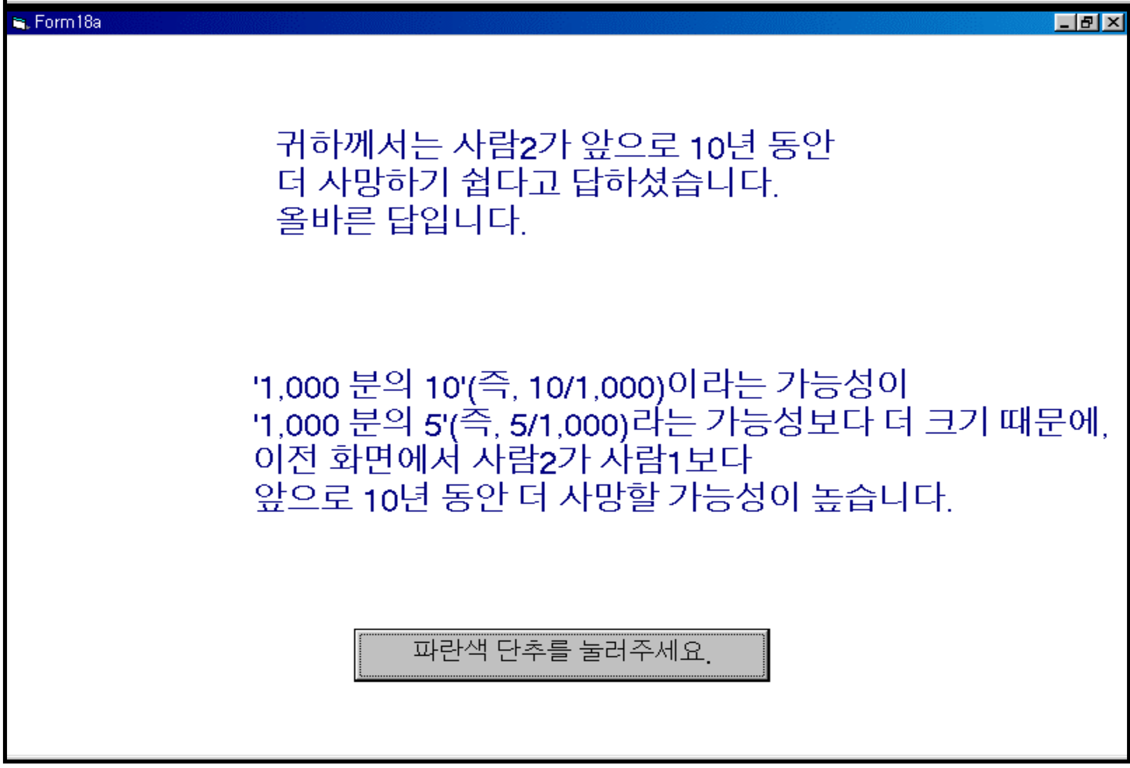

Form16
이제 사망의 가능성과 관련된
몇 가지 질문을 하고자 합니다.
귀하가 사망의 가능성에 대해 생각하는 것을
돕기 위해 숫자를 그림으로 표현해
보여드리겠습니다.
이 그림으로 표현된 숫자에서,
아래에 나타난 것처럼
붉은색 사각형은 죽은 사람을 나타내고,
흰색 사각형은 살아있는 사람을 나타냅니다
= 죽은 사람
= 산 사람
파란색 단추를 눌러주세요.

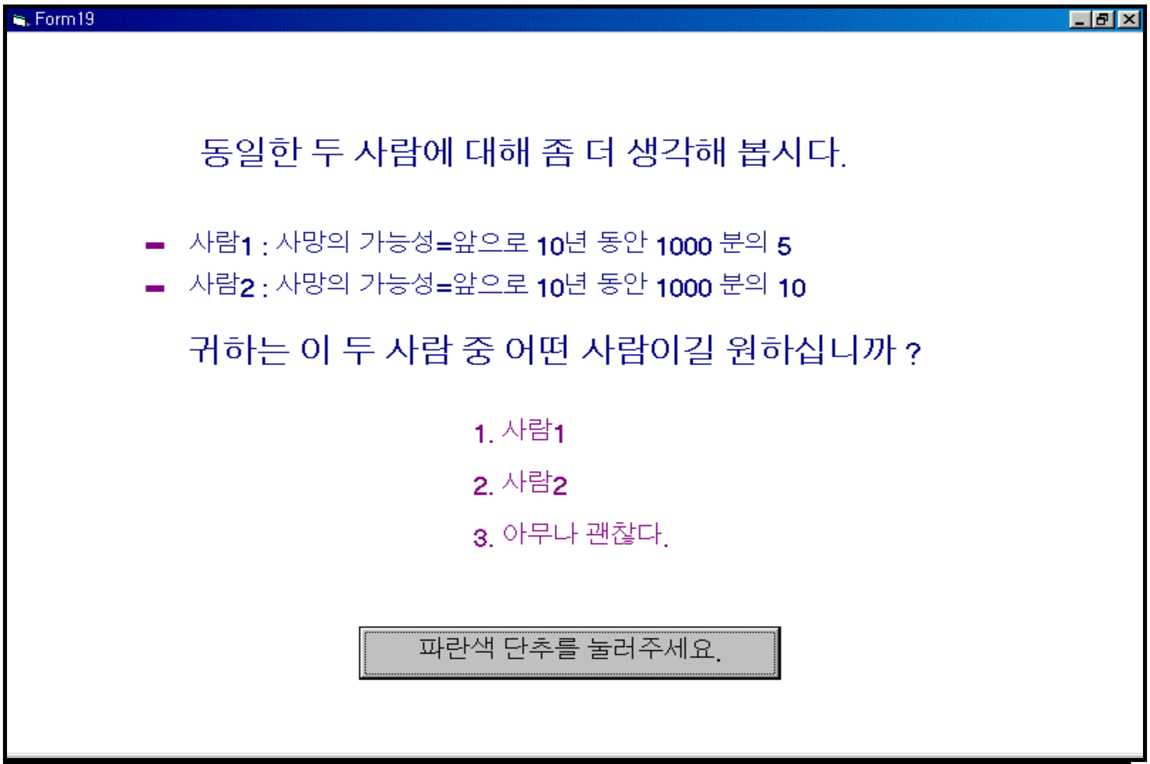

Form17
만약 앞으로 10년 동안에
1,000명의 사람 중 한 사람이 죽는다고 합시다.
그러면 이 경우를 아래와 같은 그림으로
나타낼 수 있습니다.
아래의 사각형은 1,000개의 사각형들로 이루어져 있습니다.
파란색 단추를 눌러주세요

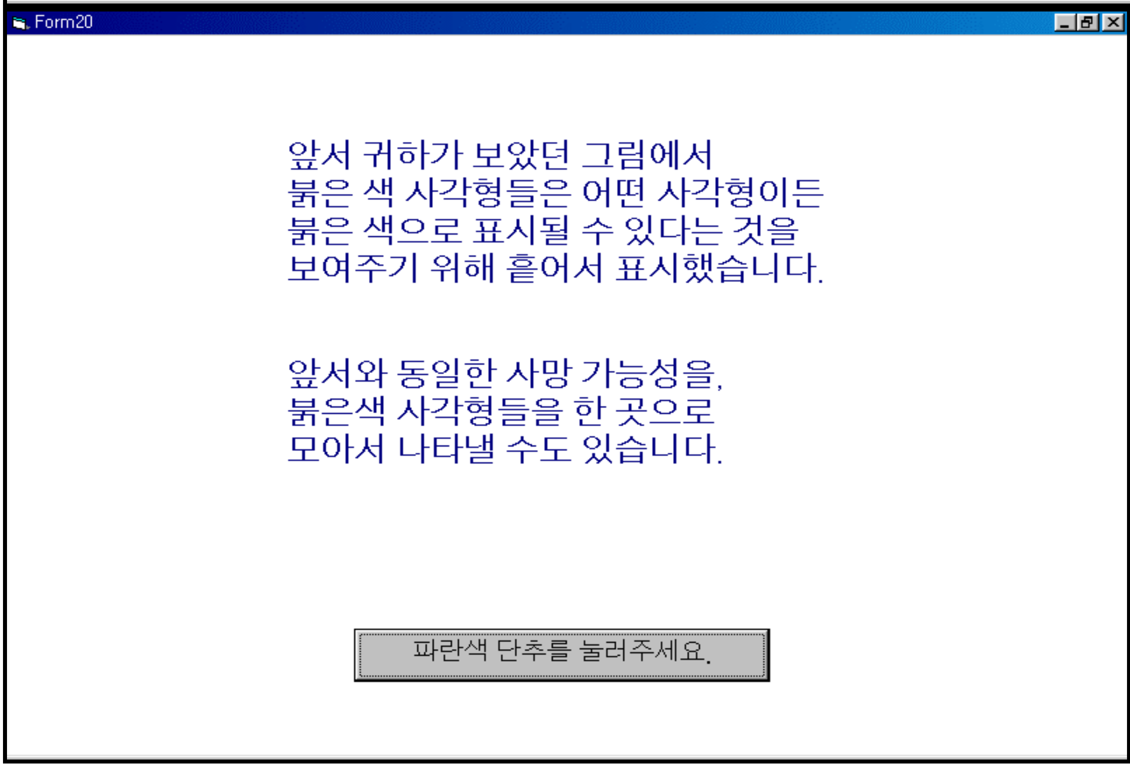

Form17a
이 그림은 앞으로 10년 동안에
1,000명의 사람 중 5명이 사망하는 경우를
표시한 것입니다.
파란색 단추를 눌러주세요.

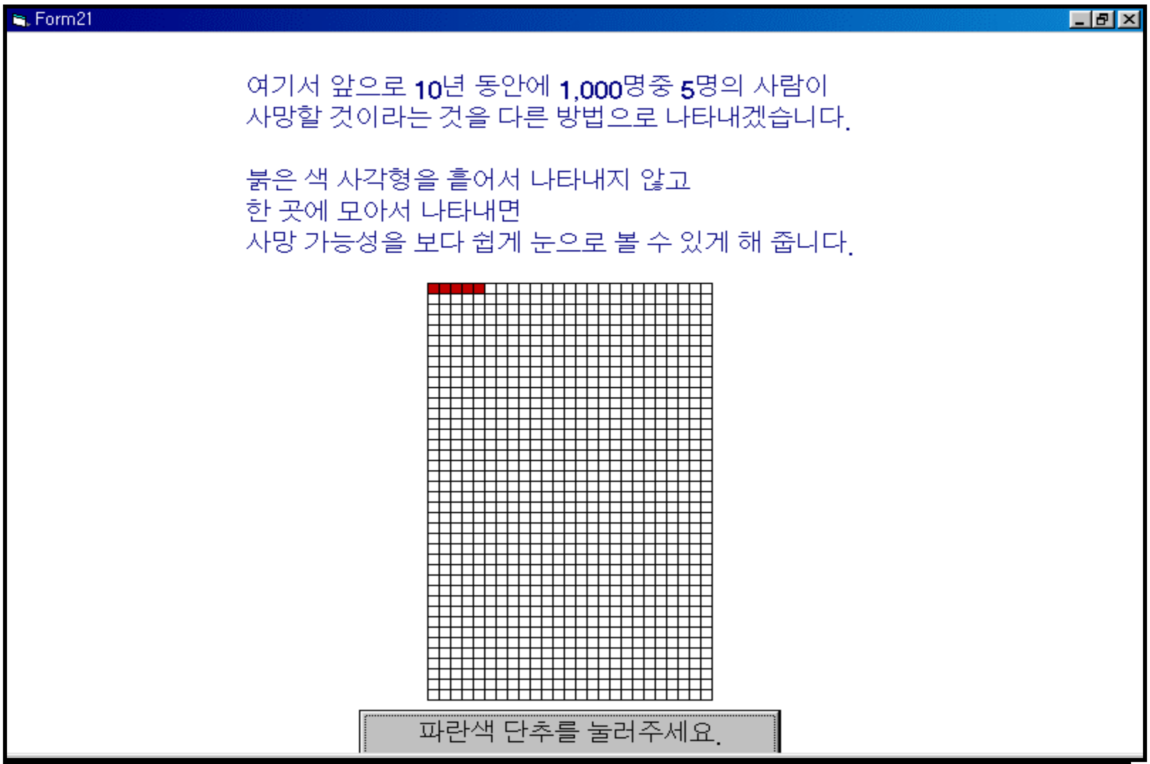

Form17b
앞 화면에서의 가능성에 대한 설명을
특정한 사람의 사망 가능성을 설명하는데도
사용할 수 있습니다.
예를 들어, 앞의 그림이 어떤 한 사람이
앞으로 10년 동안 '1,000 분의 5'(즉, 5/1,000)의
사망가능성을 가지는 경우를 나타낼 수 있습니다.
파란색 단추를 눌러주세요.

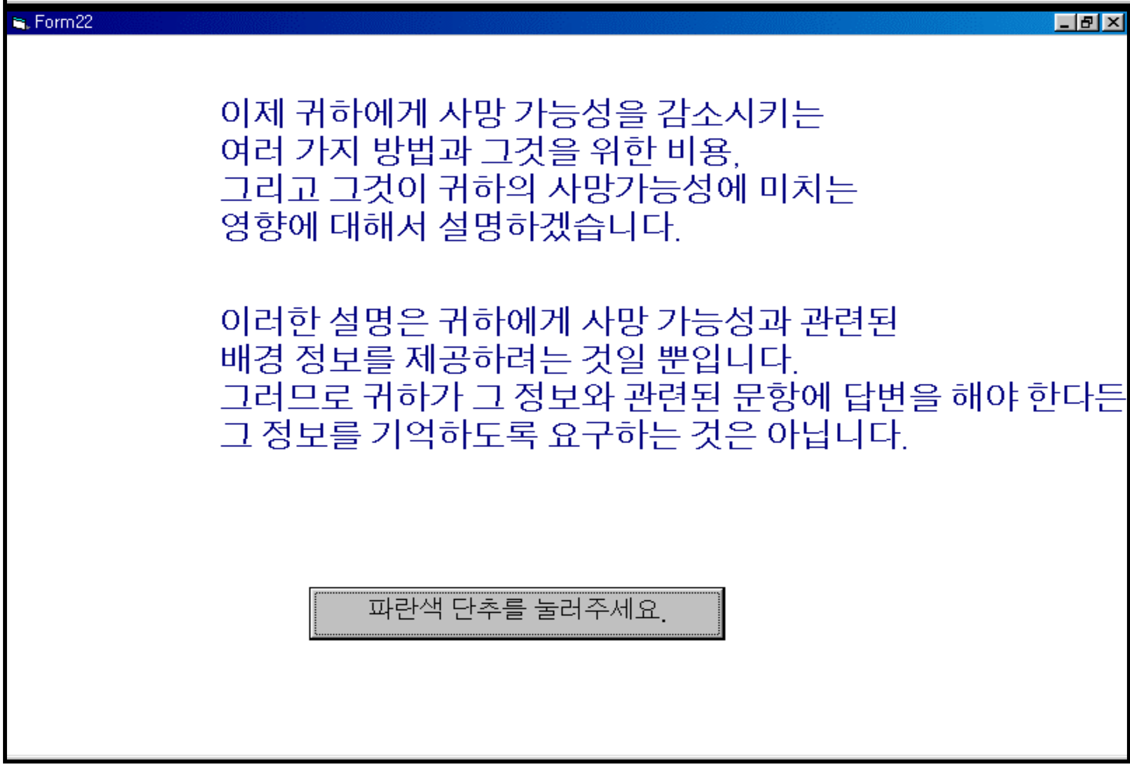

Form18
다음과 같은 두 사람이 있다고 합시다.
사람1:
사망 가능성
= 앞으로 10년 동안
1,000 분의 5
(즉, 5/1,000)
사람2:
사망 가능성
= 앞으로 10년 동안
1,000 분의 10
(즉, 10/1,000)
귀하는 앞으로 10년 동안 어떤 사람이 더 사망하기 쉽다고 생각하십니까?
1. 사람1
2. 사람2
파란색 단추를 눌러주세요.

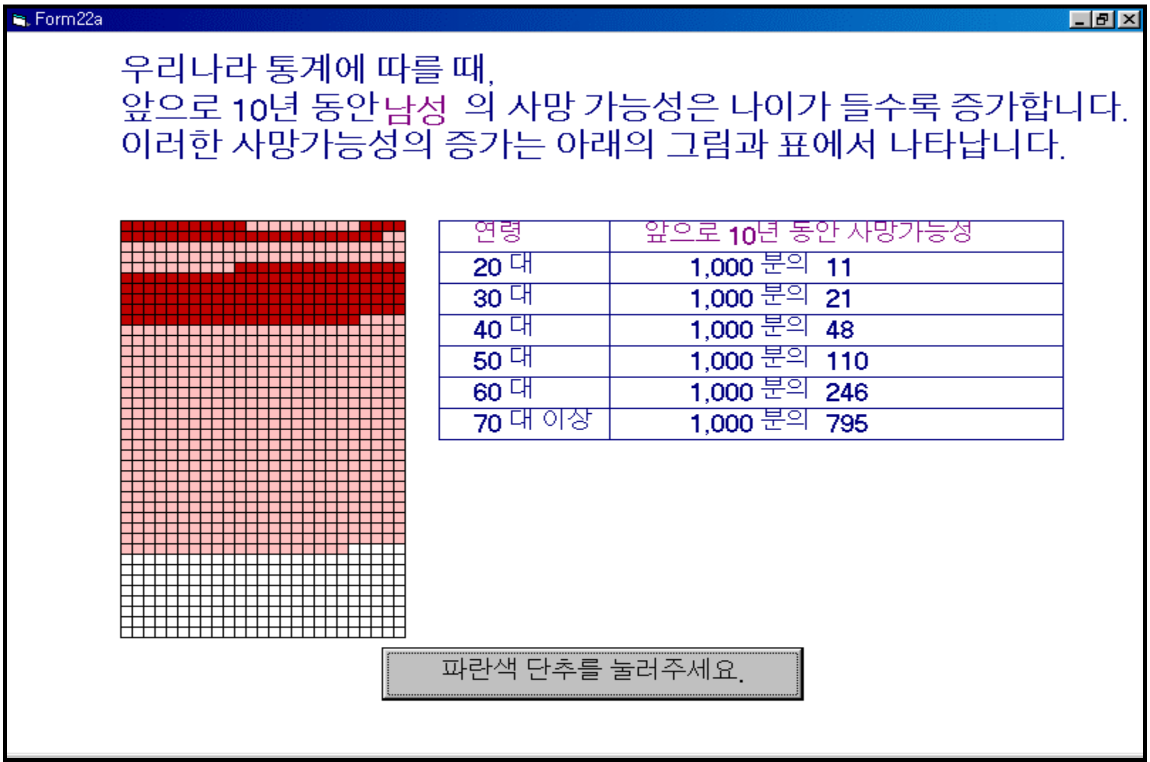

Form18a
귀하께서는 사람2가 앞으로 10년 동안
더 사망하기 쉽다고 답하셨습니다.
올바른 답입니다.
'1,000 분의 10'(즉, 10/1,000)이라는 가능성이
'1,000 분의 5'(즉, 5/1,000)라는 가능성보다 더 크기 때문에,
이전 화면에서 사람2가 사람1보다
앞으로 10년 동안 더 사망할 가능성이 높습니다.
파란색 단추를 눌러주세요.

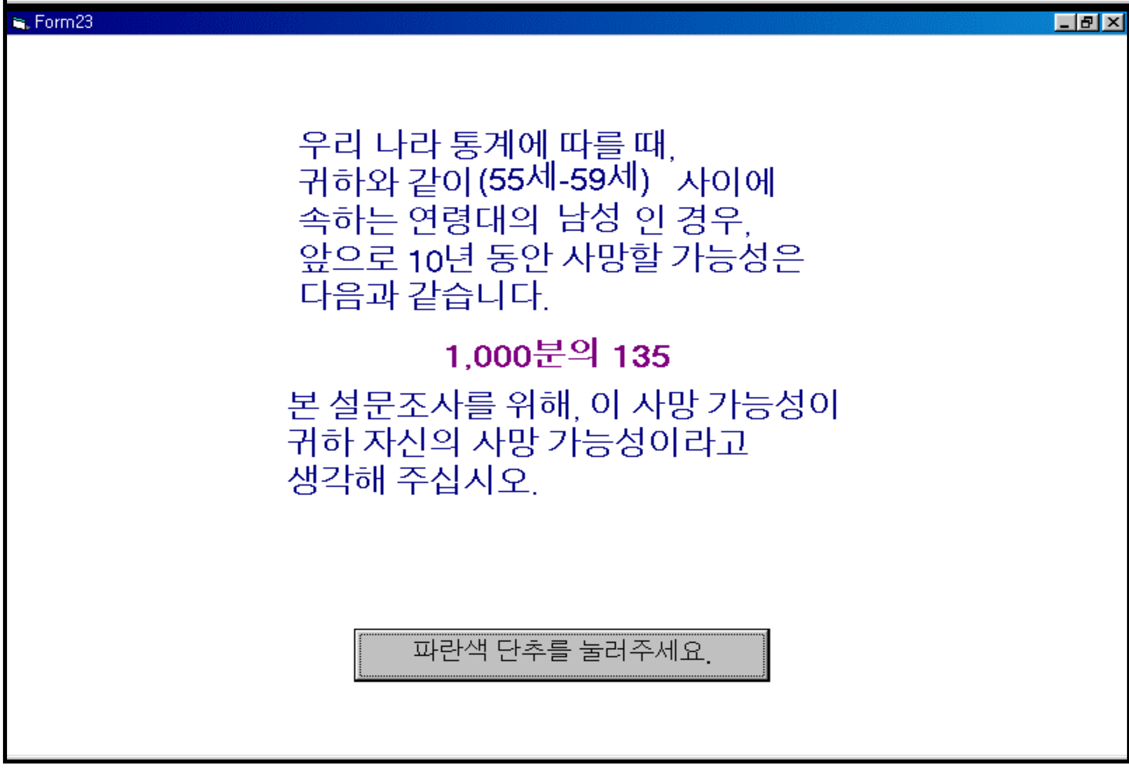

Form19
동일한 두 사람에 대해 좀 더 생각해 봅시다.
사람1 : 사망의 가능성=앞으로 10년 동안 1000 분의 5
사람2 : 사망의 가능성=앞으로 10년 동안 1000 분의 10
귀하는 이 두 사람 중 어떤 사람이길 원하십니까 ?
1. 사람1
2. 사람2
3. 아무나 괜찮다.
파란색 단추를 눌러주세요.

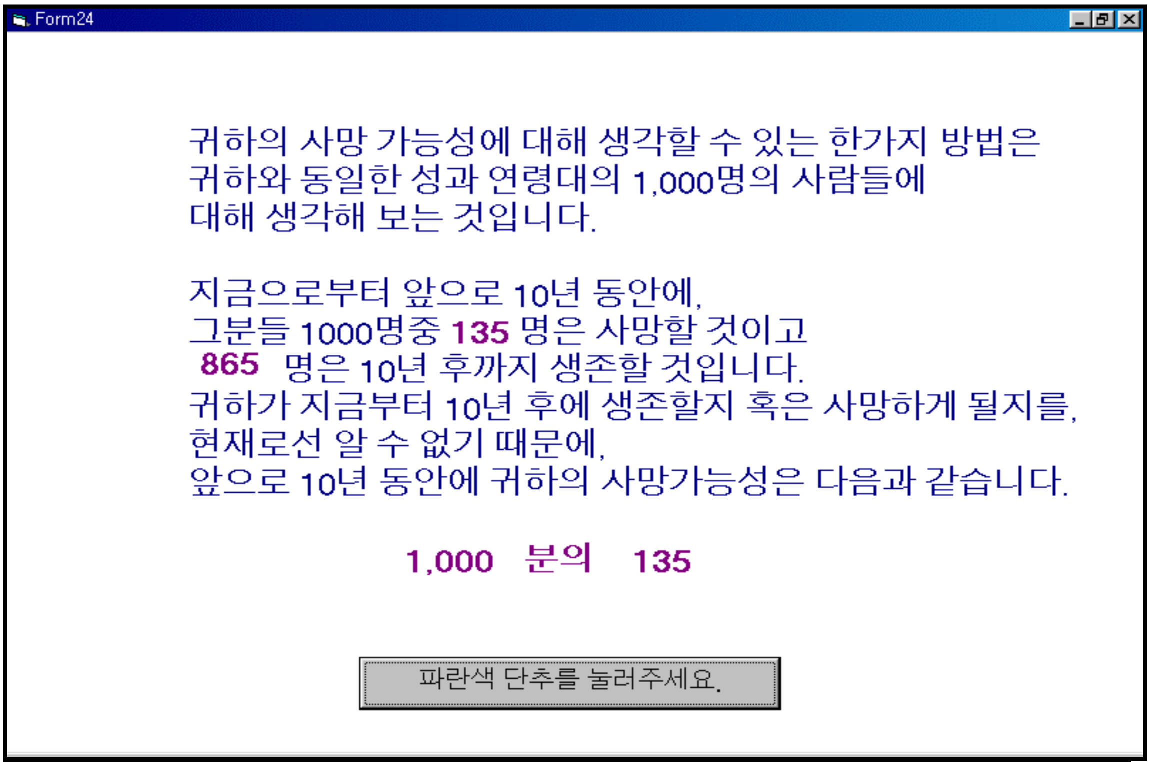

Form20
앞서 귀하가 보았던 그림에서
붉은 색 사각형들은 어떤 사각형이든
붉은 색으로 표시될 수 있다는 것을
보여주기 위해 흩어서 표시했습니다.
앞서와 동일한 사망 가능성을,
붉은색 사각형들을 한 곳으로
모아서 나타낼 수도 있습니다.
파란색 단추를 눌러주세요.

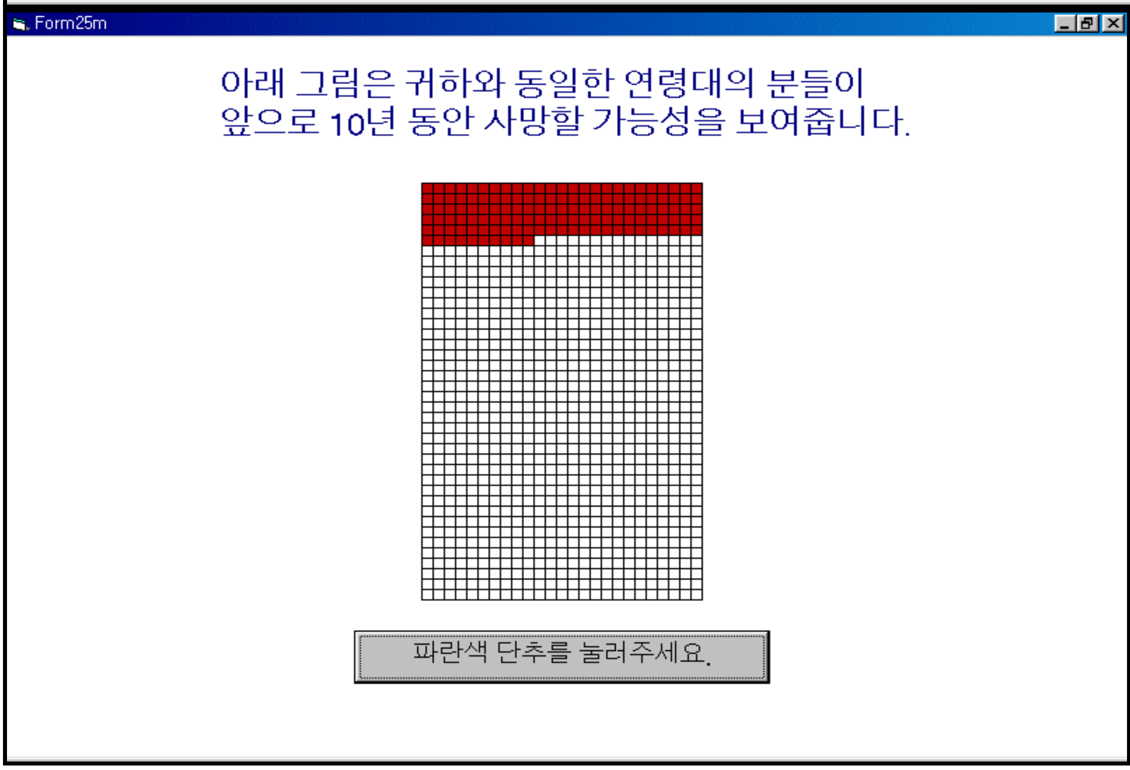

Form21
여기서 앞으로 10년 동안에 1,000명중 5명의 사람이
사망할 것이라는 것을 다른 방법으로 나타내겠습니다.
붉은 색 사각형을 흩어서 나타내지 않고
한 곳에 모아서 나타내면
사망 가능성을 보다 쉽게 눈으로 볼 수 있게 해 줍니다.
파란색 단추를 눌러주세요.

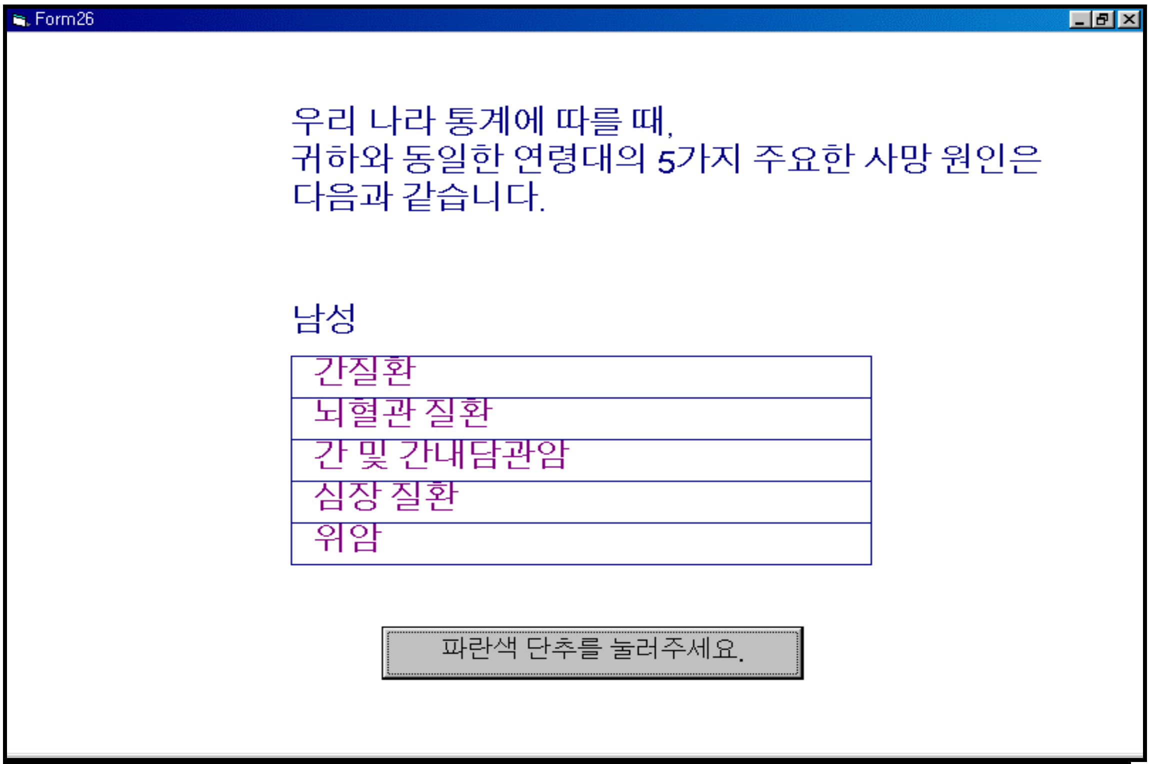

Form22
이제 귀하에게 사망 가능성을 감소시키는
여러 가지 방법과 그것을 위한 비용,
그리고 그것이 귀하의 사망가능성에 미치는
영향에 대해서 설명하겠습니다.
이러한 설명은 귀하에게 사망 가능성과 관련된
배경 정보를 제공하려는 것일 뿐입니다.
그러므로 귀하가 그 정보와 관련된 문항에 답변을 해야 한다든
그 정보를 기억하도록 요구하는 것은 아닙니다.
파란색 단추를 눌러주세요.

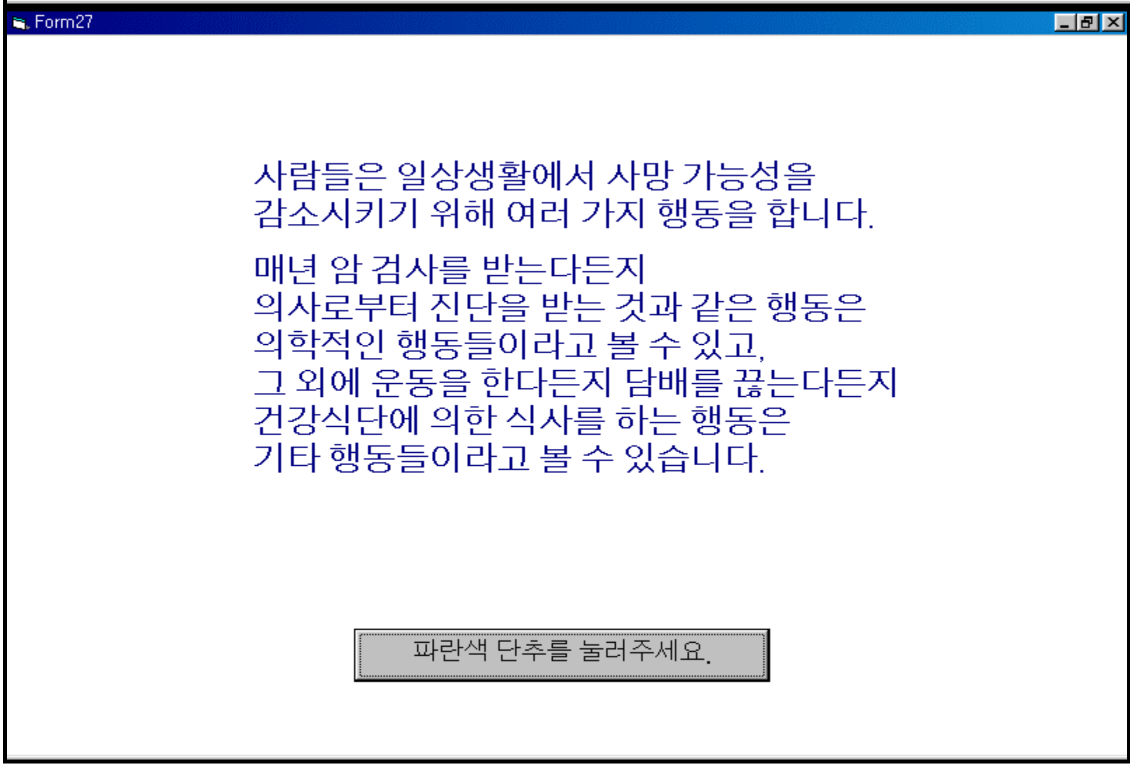

Form22a
우리나라 통계에 따르면 때,
앞으로 10년 동안 남성 의 사망 가능성은 나이가 들수록 증가합니다.
이러한 사망가능성의 증가는 아래의 그림과 표에서 나타납니다.
연령
앞으로 10년 동안 사망가능성
20 대
1,000 분의 11
30 대
1,000 분의 21
40 대
1,000 분의 48
50 대
1,000 분의 110
60 대
1,000 분의 246
70 대 이상
1,000 분의 795
파란색 단추를 눌러주세요.


Form23
우리 나라 통계에 따르면 때,
귀하와 같이 (55세-59세) 사이에
속하는 연령대의 남성 인 경우,
앞으로 10년 동안 사망할 가능성은
다음과 같습니다.
1,000분의 135
본 설문조사를 위해, 이 사망 가능성이
귀하 자신의 사망 가능성이라고
생각해 주십시오.
파란색 단추를 눌러주세요.


Form24
귀하의 사망 가능성에 대해 생각할 수 있는 한가지 방법은
귀하와 동일한 성과 연령대의 1,000명의 사람들에
대해 생각해 보는 것입니다.
지금으로부터 앞으로 10년 동안에,
그분들 1000명중 135 명은 사망할 것이고
865 명은 10년 후까지 생존할 것입니다.
귀하가 지금부터 10년 후에 생존할지 혹은 사망하게 될지를,
현재로선 알 수 없기 때문에,
앞으로 10년 동안에 귀하의 사망가능성은 다음과 같습니다.
1,000 분의 135
파란색 단추를 눌러주세요.


Form25m
아래 그림은 귀하와 동일한 연령대의 분들이
앞으로 10년 동안 사망할 가능성을 보여줍니다.
파란색 단추를 눌러주세요.


Form26
우리 나라 통계에 따를 때,
귀하와 동일한 연령대의 5가지 주요한 사망 원인은
다음과 같습니다.
남성
간질환
뇌혈관 질환
간 및 간내담관암
심장 질환
위암
파란색 단추를 눌러주세요.


Form27
사람들은 일상생활에서 사망 가능성을
감소시키기 위해 여러 가지 행동을 합니다.
매년 암 검사를 받는다든지
의사로부터 진단을 받는 것과 같은 행동은
의학적인 행동들이라고 볼 수 있고,
그 외에 운동을 한다든지 담배를 끊는다든지
건강식단에 의한 식사를 하는 행동은
기타 행동들이라고 볼 수 있습니다.
파란색 단추를 눌러주세요.

Form28m

남성들이 특정한 질환으로 사망할 가능성을 줄이기 위해 행하는 일반적인 의학적 행동 중 몇 가지 예를 소개하면 다음과 같습니다.

행동 및 조치의 종류		사망가능성을 감소시킬 수 있는 질병
의학적 행동 및 조치들	약물치료를 통한 콜레스테롤 조절	심장병
	위 내시경 검사	위암
	약물치료를 통한 고혈압 치료	심장병
	대장암 검사	대장암

파란색 단추를 눌러주세요.

Form29

사람들이 특정 질환으로 사망할 가능성을 감소시키기 위해 일반적으로 행하는 기타 행동의 몇 가지 예는 다음과 같습니다.

행동 및 조치의 종류		사망가능성을 감소시킬 수 있는 질병
기타 행동 및 조치들	운동	심장병
	식이요법을 통한 콜레스테롤 조절	심장병

파란색 단추를 눌러주세요.

Form30m

아래의 표에는 사람들의 사망 가능성을 감소시키고자 하는 행위들이
앞으로 10년 동안 그들의 사망 가능성을 얼마나 감소시키는지를 보여줍니다.

대상	향후 10년 동안 매년 취하는 행동 및 조치	향후 10년 동안 사망가능성을 감소시킬 수 있는 질병
고혈압을 갖고 있는 40세	고혈압을 조절하기 위한 약물치료	1000 분의 9
50세	매년 대장암 검사	1,000 분의 1
50세	매년 위 내시경 검사	1,000 분의 3
고혈압을 갖고 있는 60세	고혈압을 조절하기 위한 약물치료	1,000 분의 5

파란색 단추를 눌러주세요.

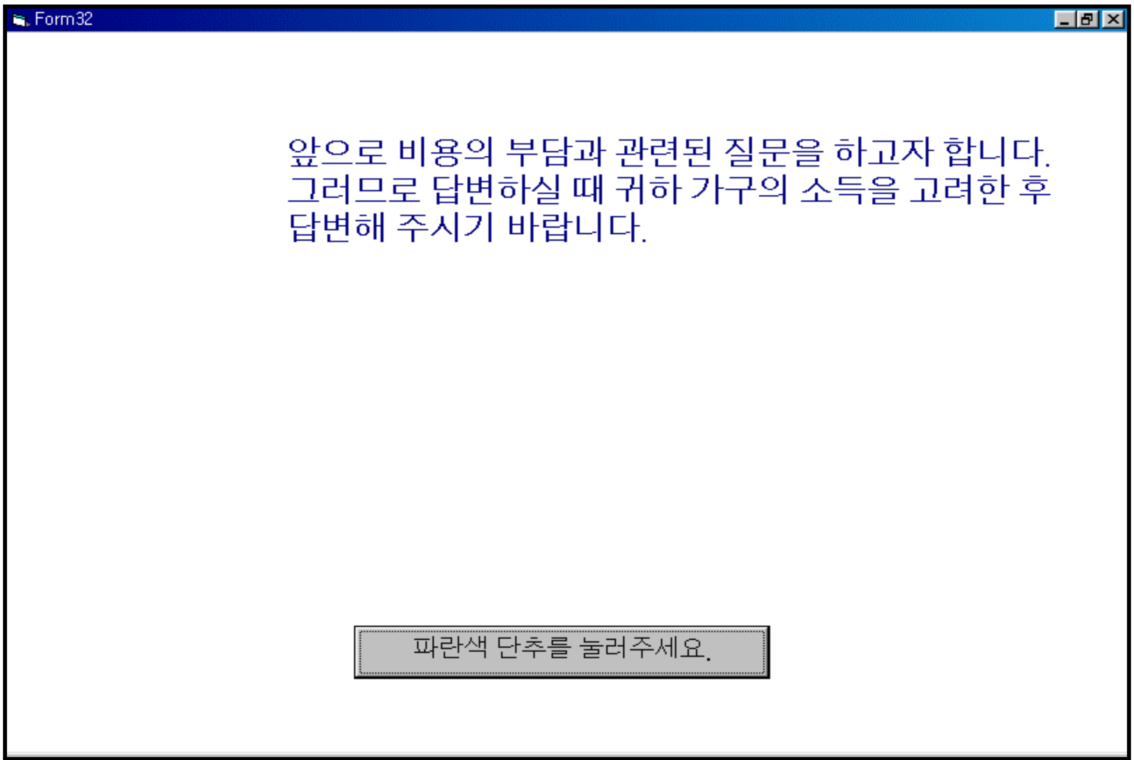
Form31m

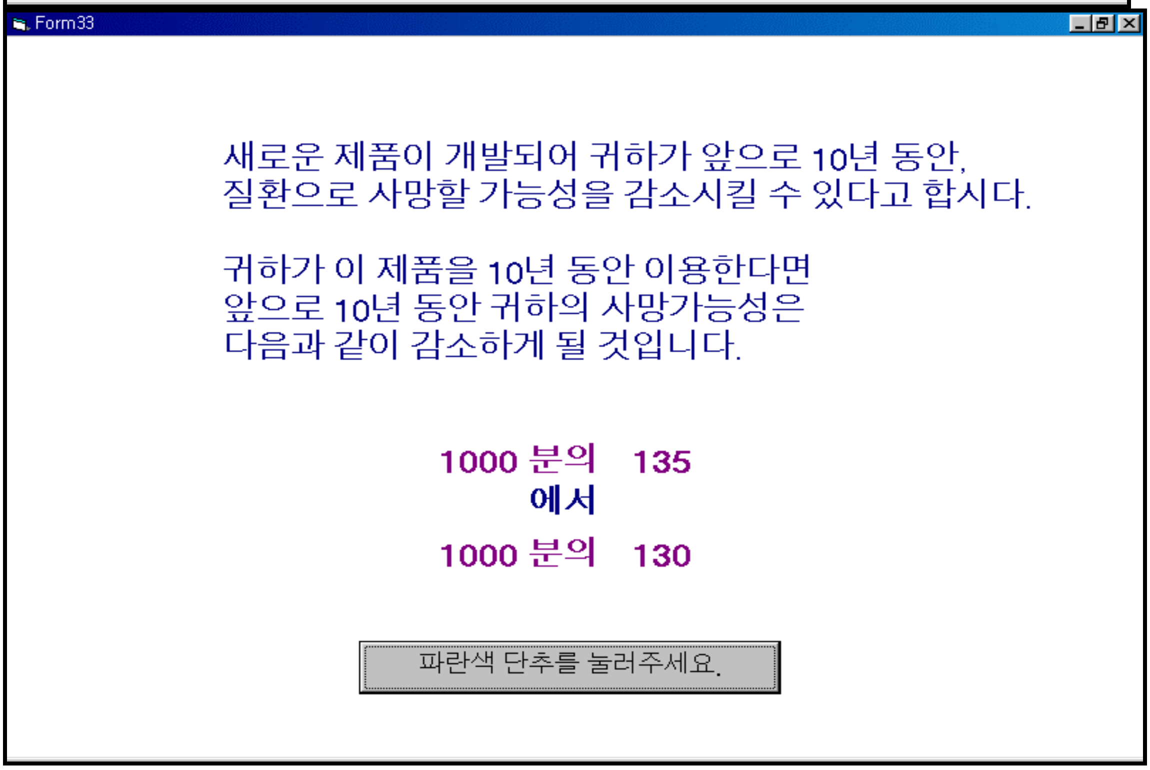
사람들이 그들의 사망 가능성을 줄이려고 하는 행위들의 비용은
어떤 행위를 하는가에 따라 달라집니다.

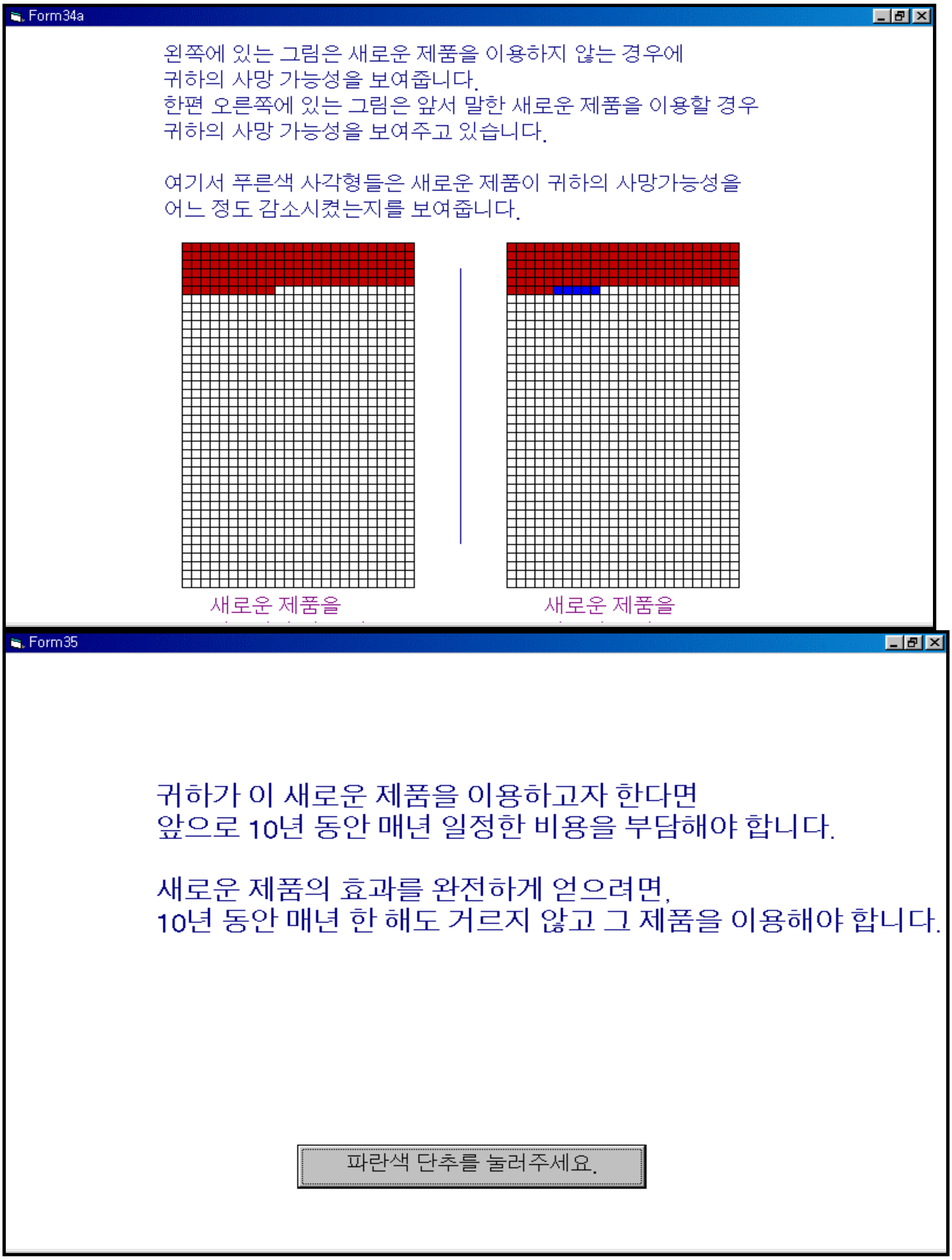
그러한 행동들의 비용도 의료보험에 의한 부담 정도 및
개인적으로 가입한 보험에 따라 본인이 부담하는 비용이 달라질 수 있습니다.
앞서 언급된 몇가지 행동들을 위한 연간 비용이 아래 표에 정리되어 있습니다.

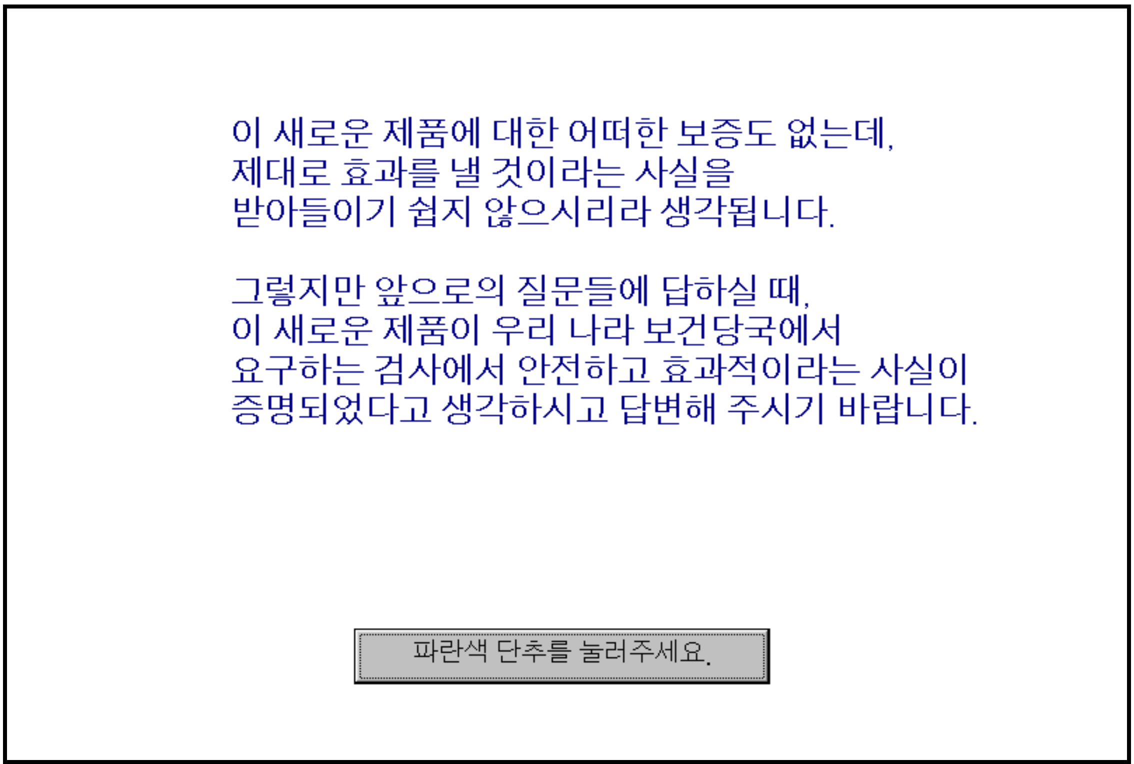
사망가능성을 감소시키기 위해 취하는 의학적 행동 및 조치	**비용 수준**
고혈압을 조절하기 위한 약물치료	가장 비쌈
위 내시경 검사	비쌈
대장암 검사	가장 저렴

파란색 단추를 눌러주세요.


Form32
앞으로 비용의 부담과 관련된 질문을 하고자 합니다.
그러므로 답변하실 때 귀하 가구의 소득을 고려한 후
답변해 주시기 바랍니다.
파란색 단추를 눌러주세요.


Form33
새로운 제품이 개발되어 귀하가 앞으로 10년 동안,
질환으로 사망할 가능성을 감소시킬 수 있다고 합시다.
귀하가 이 제품을 10년 동안 이용한다면
앞으로 10년 동안 귀하의 사망가능성은
다음과 같이 감소하게 될 것입니다.
1000 분의 135
에서
1000 분의 130
파란색 단추를 눌러주세요.

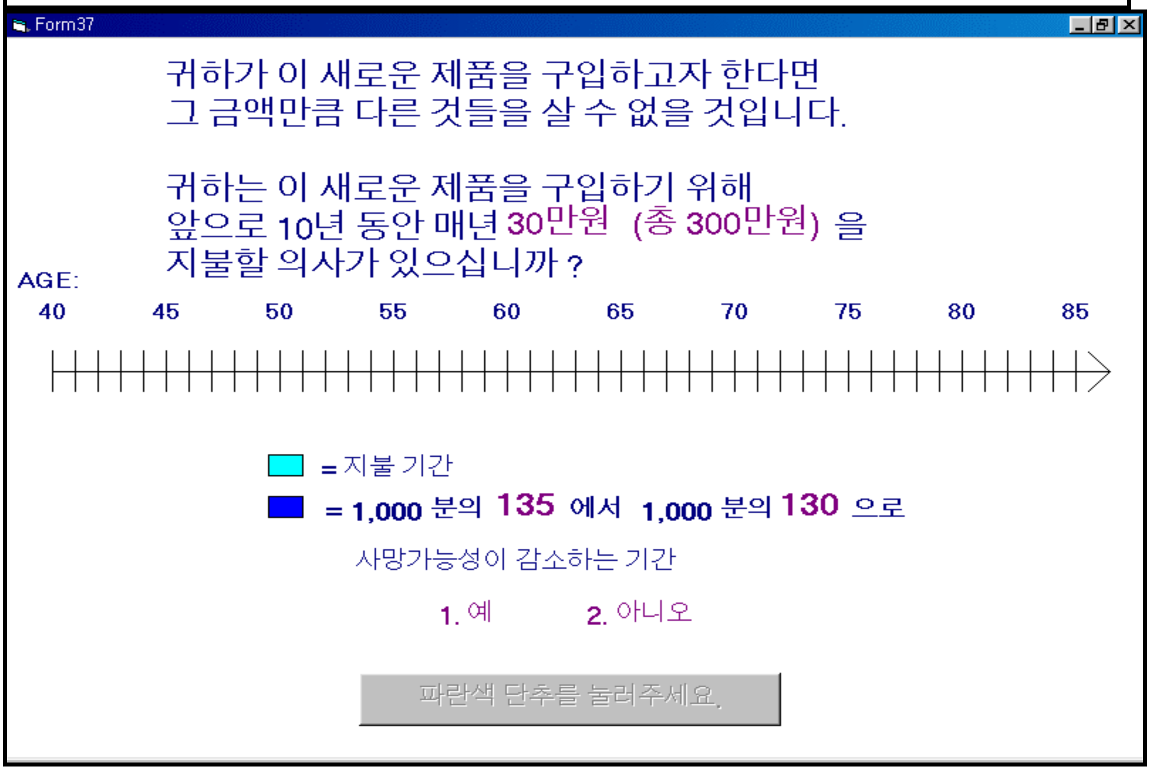

Form34a
왼쪽에 있는 그림은 새로운 제품을 이용하지 않는 경우에
귀하의 사망 가능성을 보여줍니다.
한편 오른쪽에 있는 그림은 앞서 말한 새로운 제품을 이용할 경우
귀하의 사망 가능성을 보여주고 있습니다.
여기서 푸른색 사각형들은 새로운 제품이 귀하의 사망가능성을
어느 정도 감소시켰는지를 보여줍니다.
새로운 제품을
새로운 제품을
Form35
귀하가 이 새로운 제품을 이용하고자 한다면
앞으로 10년 동안 매년 일정한 비용을 부담해야 합니다.
새로운 제품의 효과를 완전하게 얻으려면,
10년 동안 매년 한 해도 거르지 않고 그 제품을 이용해야 합니다.
파란색 단추를 눌러주세요.



이 새로운 제품에 대한 어떠한 보증도 없는데,
제대로 효과를 낼 것이라는 사실을
받아들이기 쉽지 않으시리라 생각됩니다.

그렇지만 앞으로의 질문들에 답하실 때,
이 새로운 제품이 우리 나라 보건당국에서
요구하는 검사에서 안전하고 효과적이라는 사실이
증명되었다고 생각하시고 답변해 주시기 바랍니다.

파란색 단추를 눌러주세요.



Form37

귀하가 이 새로운 제품을 구입하고자 한다면
그 금액만큼 다른 것들을 살 수 없을 것입니다.

귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 30만원 (총 300만원) 을
지불할 의사가 있으십니까 ?

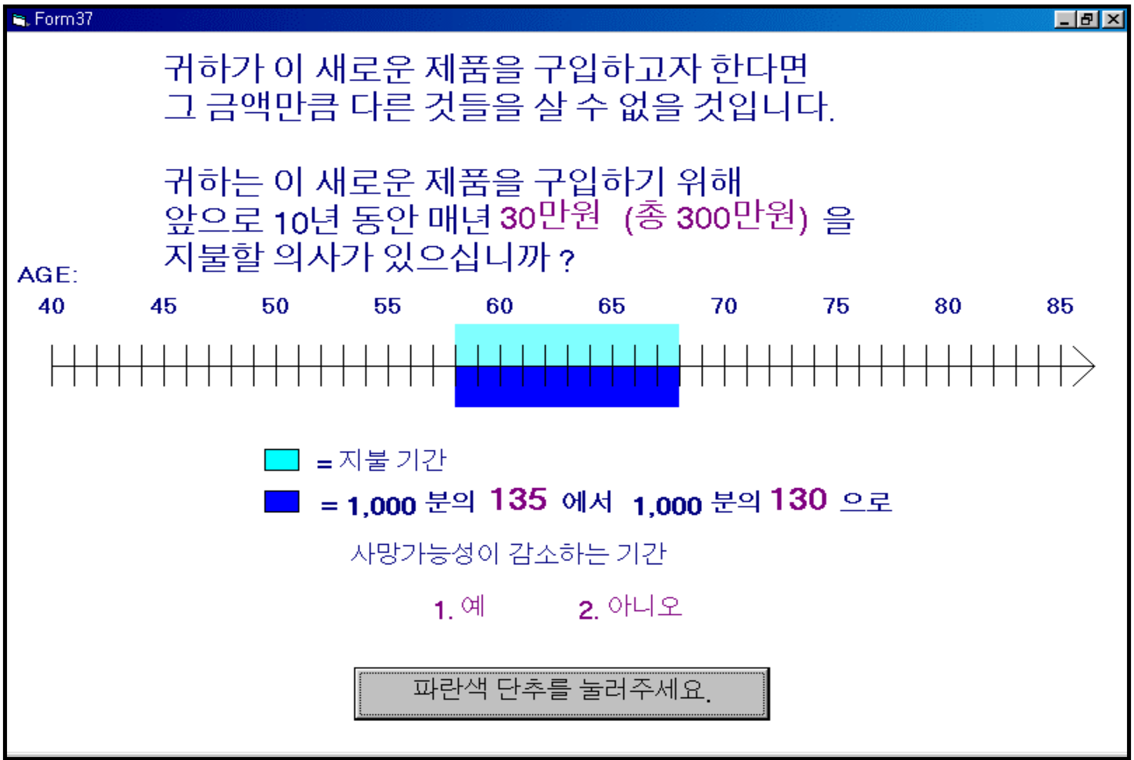
AGE: 40 45 50 55 60 65 70 75 80 85

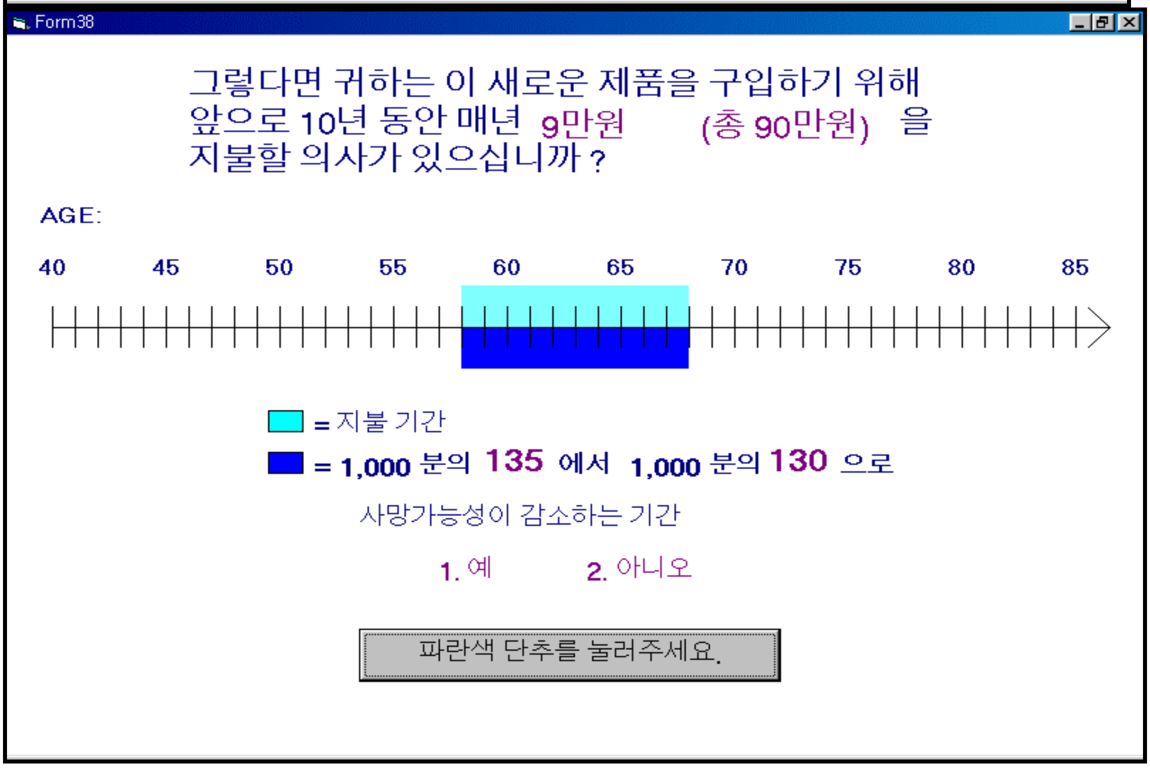
= 지불 기간

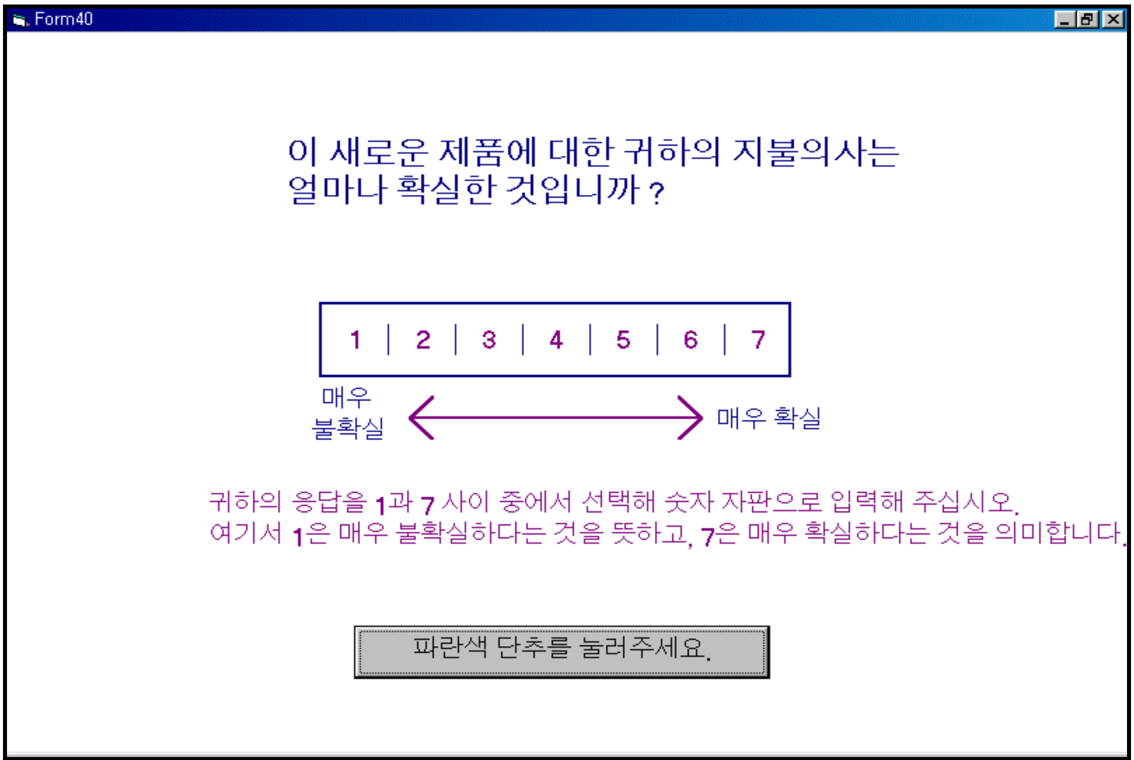
= 1,000 분의 135 에서 1,000 분의 130 으로
사망가능성이 감소하는 기간

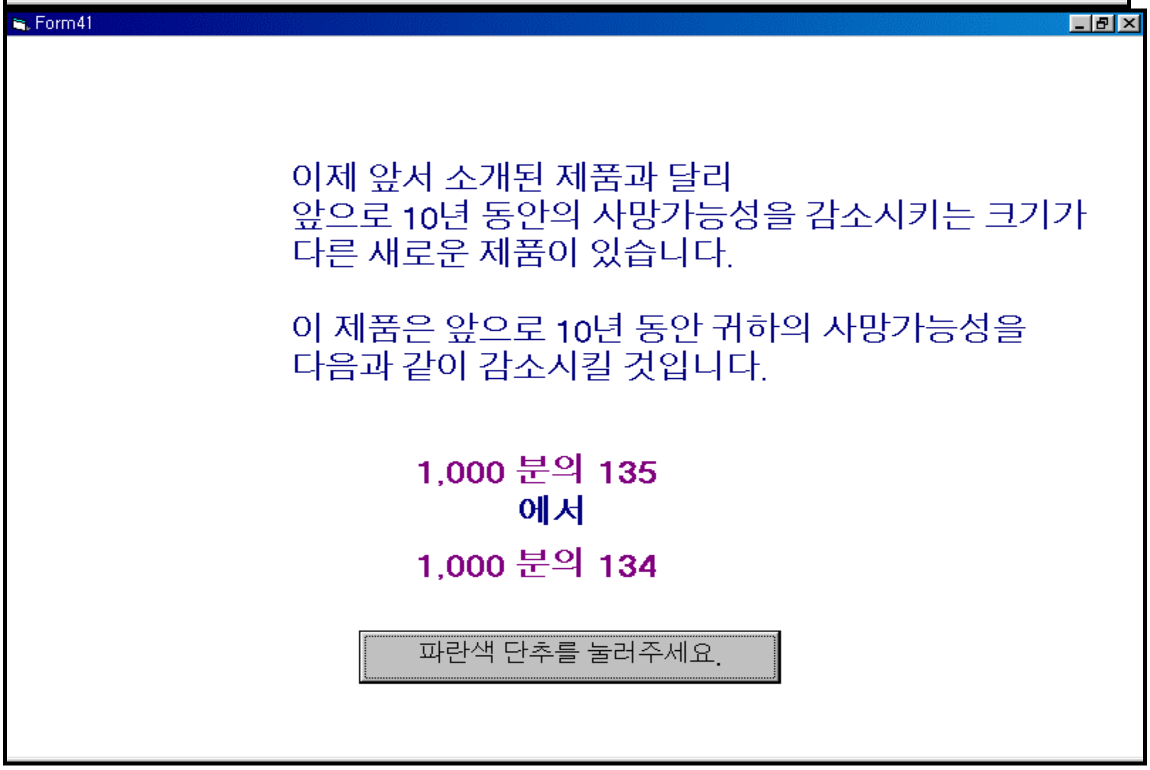
1. 예 2. 아니오

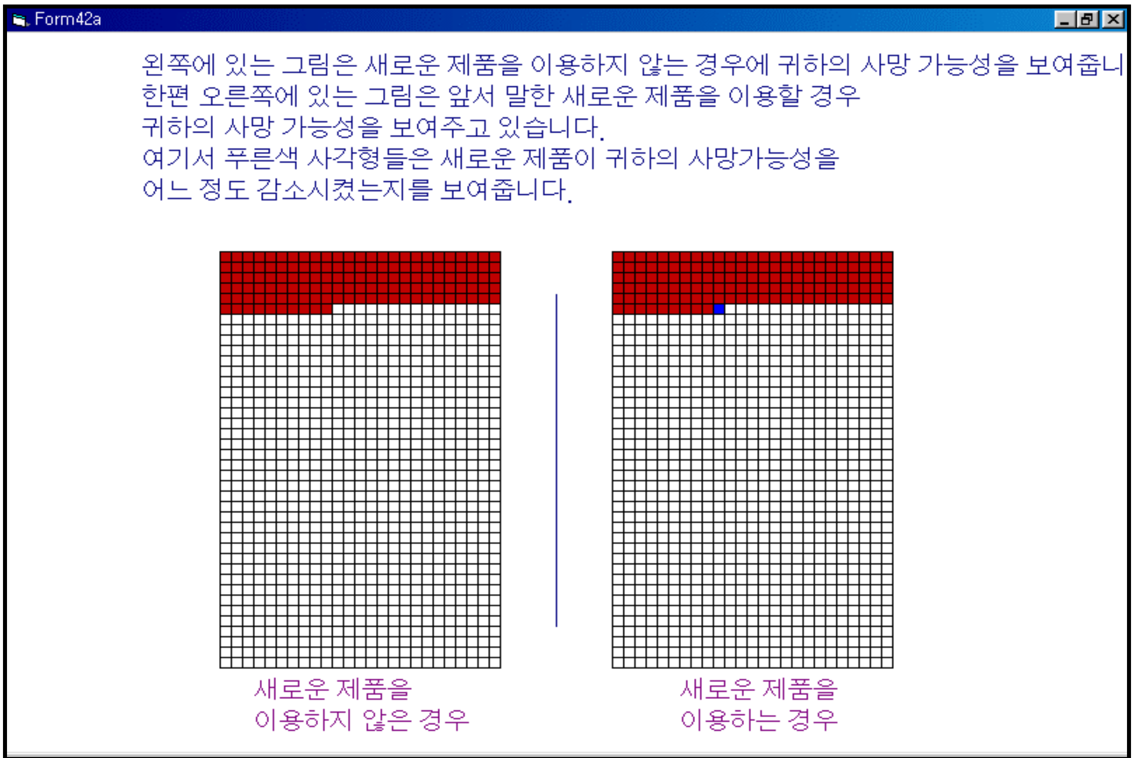
파란색 단추를 눌러주세요.

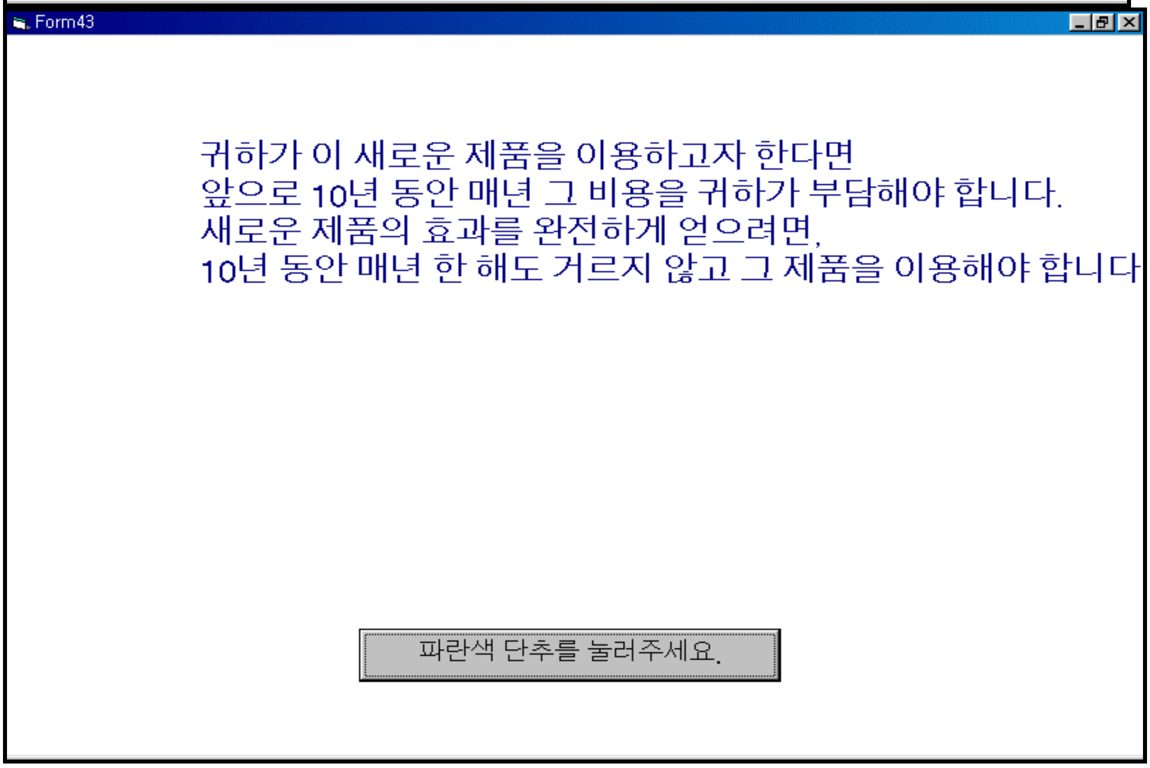

Form37
귀하가 이 새로운 제품을 구입하고자 한다면
그 금액만큼 다른 것들을 살 수 없을 것입니다.
귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 30만원 (총 300만원) 을
지불할 의사가 있으십니까 ?
AGE:
40 45 50 55 60 65 70 75 80 85
= 지불 기간
= 1,000 분의 135 에서 1,000 분의 130 으로
사망가능성이 감소하는 기간
1. 예
2. 아니오
파란색 단추를 눌러주세요.

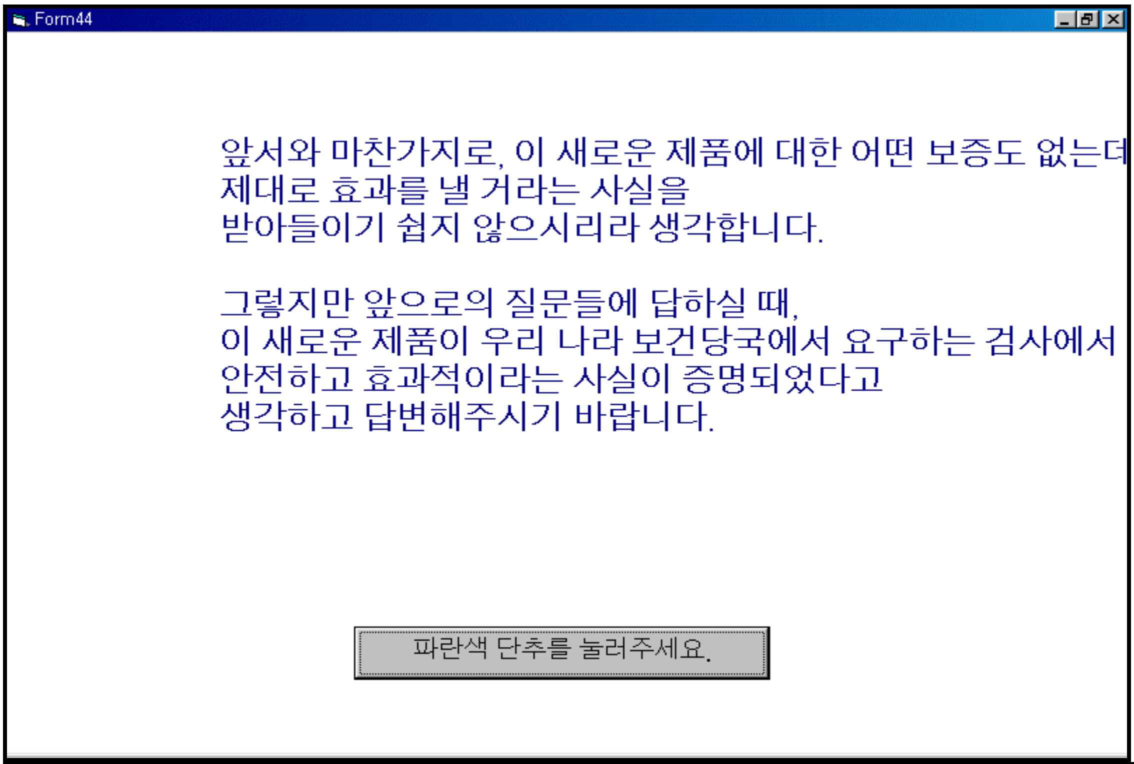

Form38
그렇다면 귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 9만원 (총 90만원) 을
지불할 의사가 있으십니까 ?
AGE:
40 45 50 55 60 65 70 75 80 85
= 지불 기간
= 1,000 분의 135 에서 1,000 분의 130 으로
사망가능성이 감소하는 기간
1. 예
2. 아니오
파란색 단추를 눌러주세요.


Form40
이 새로운 제품에 대한 귀하의 지불의사는
얼마나 확실한 것입니까 ?
1 | 2 | 3 | 4 | 5 | 6 | 7
매우
불확실
매우 확실
귀하의 응답을 1과 7 사이 중에서 선택해 숫자 자판으로 입력해 주십시오.
여기서 1은 매우 불확실하다는 것을 뜻하고, 7은 매우 확실하다는 것을 의미합니다.
파란색 단추를 눌러주세요.


Form41
이제 앞서 소개된 제품과 달리
앞으로 10년 동안의 사망가능성을 감소시키는 크기가
다른 새로운 제품이 있습니다.
이 제품은 앞으로 10년 동안 귀하의 사망가능성을
다음과 같이 감소시킬 것입니다.
1,000 분의 135
에서
1,000 분의 134
파란색 단추를 눌러주세요.


Form42a
왼쪽에 있는 그림은 새로운 제품을 이용하지 않는 경우에 귀하의 사망 가능성을 보여줍니
한편 오른쪽에 있는 그림은 앞서 말한 새로운 제품을 이용할 경우
귀하의 사망 가능성을 보여주고 있습니다.
여기서 푸른색 사각형들은 새로운 제품이 귀하의 사망가능성을
어느 정도 감소시켰는지를 보여줍니다.
새로운 제품을
이용하지 않은 경우
새로운 제품을
이용하는 경우


Form43
귀하가 이 새로운 제품을 이용하고자 한다면
앞으로 10년 동안 매년 그 비용을 귀하가 부담해야 합니다.
새로운 제품의 효과를 완전하게 얻으려면,
10년 동안 매년 한 해도 거르지 않고 그 제품을 이용해야 합니다
파란색 단추를 눌러주세요.

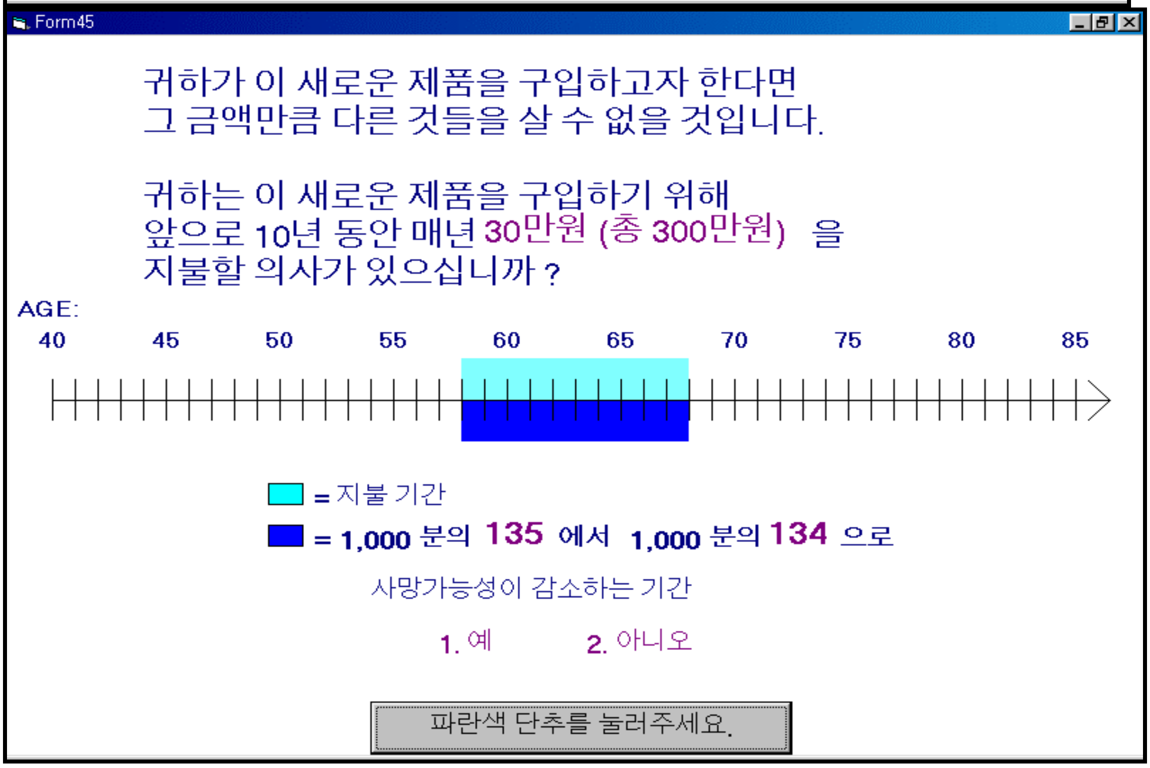


Form44

앞서와 마찬가지로, 이 새로운 제품에 대한 어떤 보증도 없는데
제대로 효과를 낼 거라는 사실을
받아들이기 쉽지 않으시리라 생각합니다.

그렇지만 앞으로의 질문들에 답하실 때,
이 새로운 제품이 우리 나라 보건당국에서 요구하는 검사에서
안전하고 효과적이라는 사실이 증명되었다고
생각하고 답변해주시기 바랍니다.

파란색 단추를 눌러주세요.



Form45

귀하가 이 새로운 제품을 구입하고자 한다면
그 금액만큼 다른 것들을 살 수 없을 것입니다.

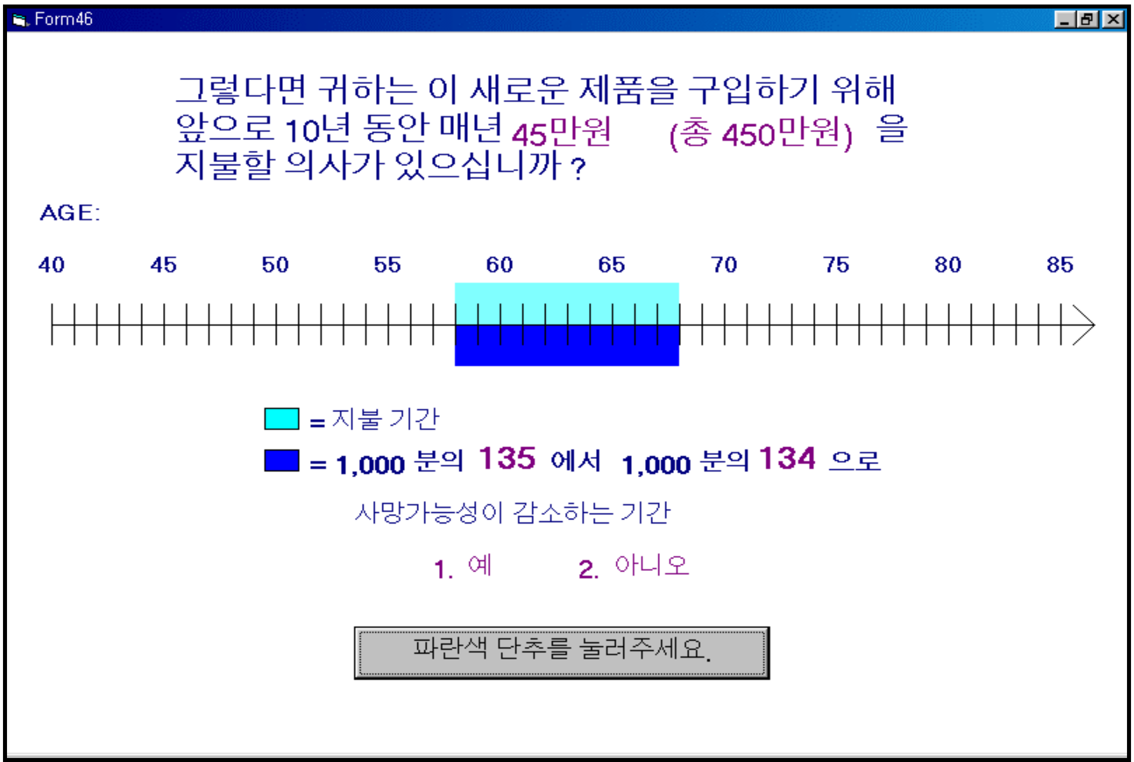
귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 30만원 (총 300만원) 을
지불할 의사가 있으십니까 ?

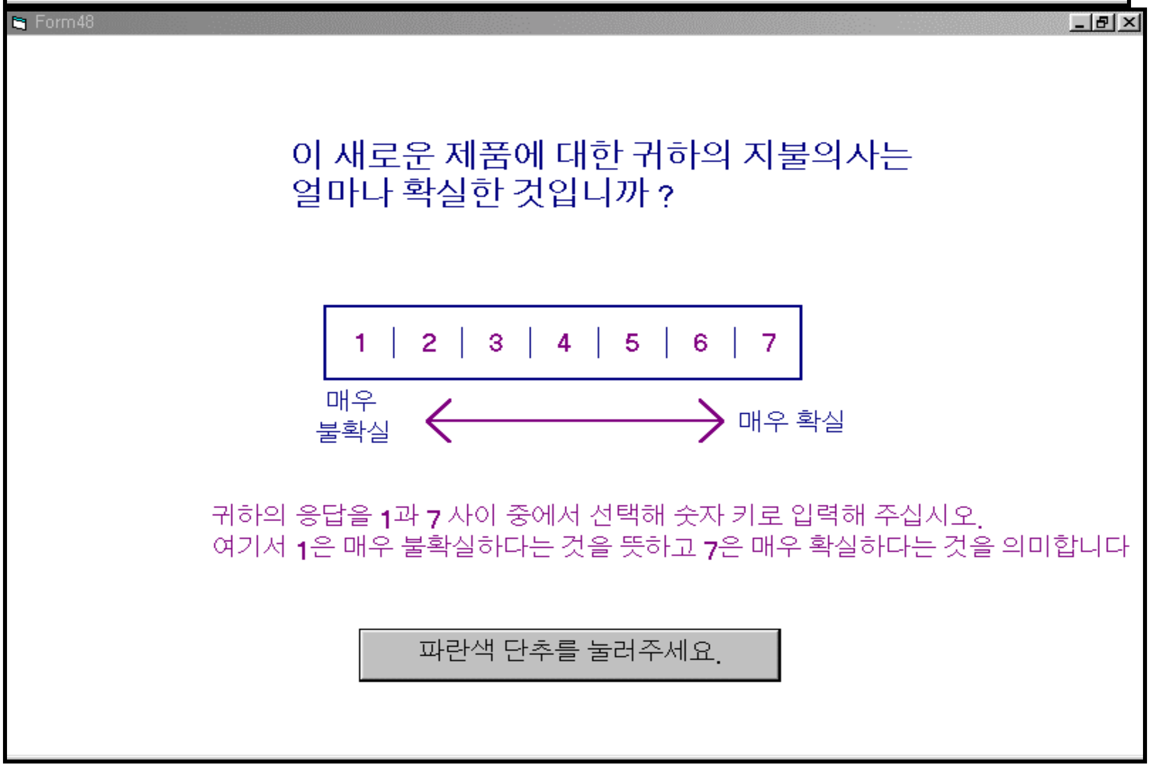
AGE:
40 45 50 55 60 65 70 75 80 85

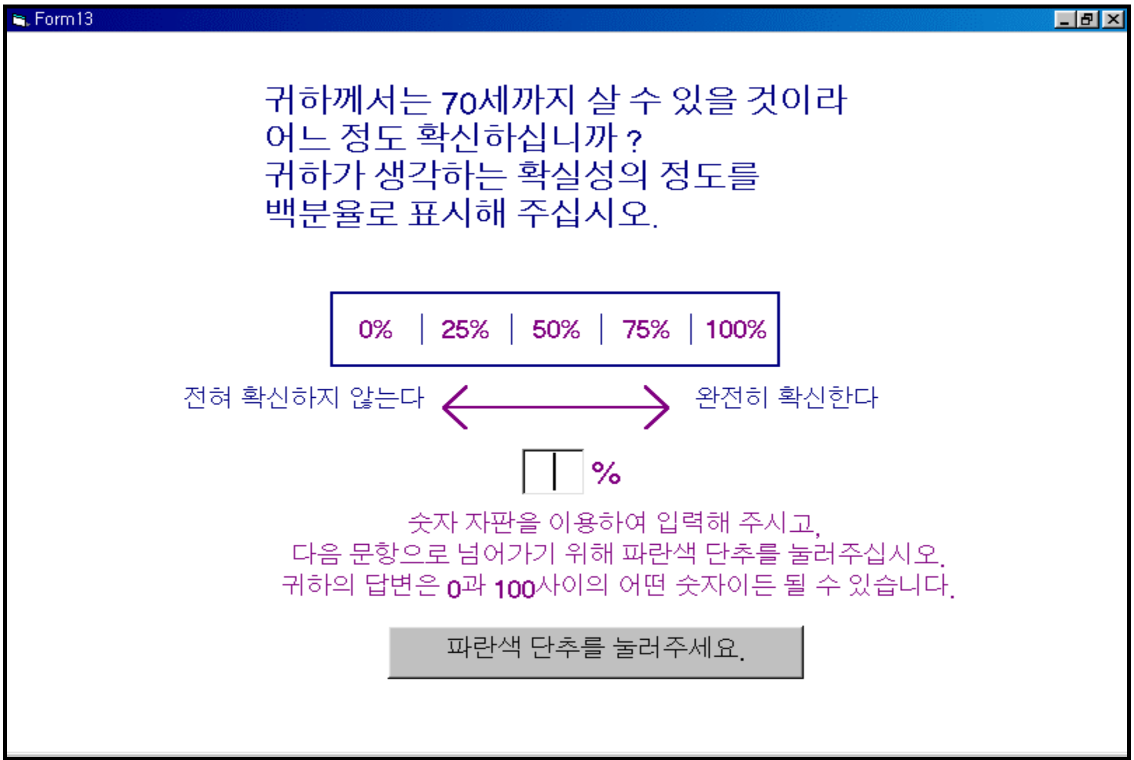
= 지불 기간
= 1,000 분의 135 에서 1,000 분의 134 으로
사망가능성이 감소하는 기간

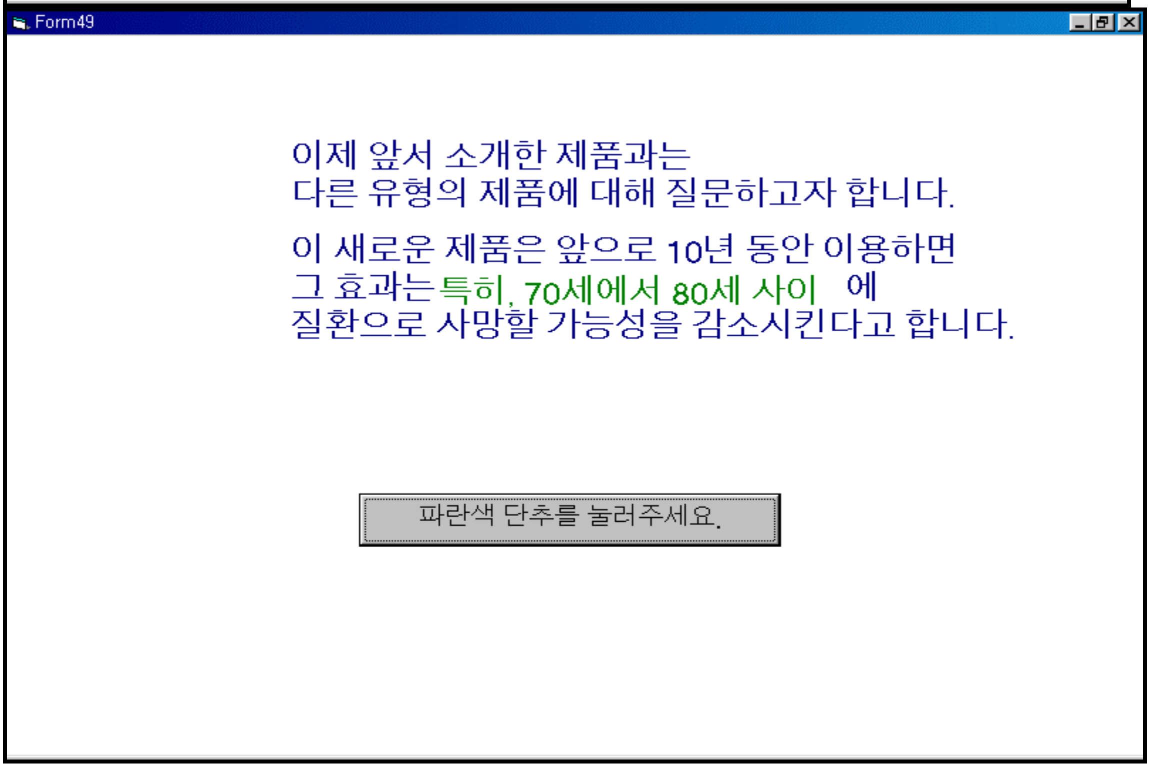
1. 예 2. 아니오

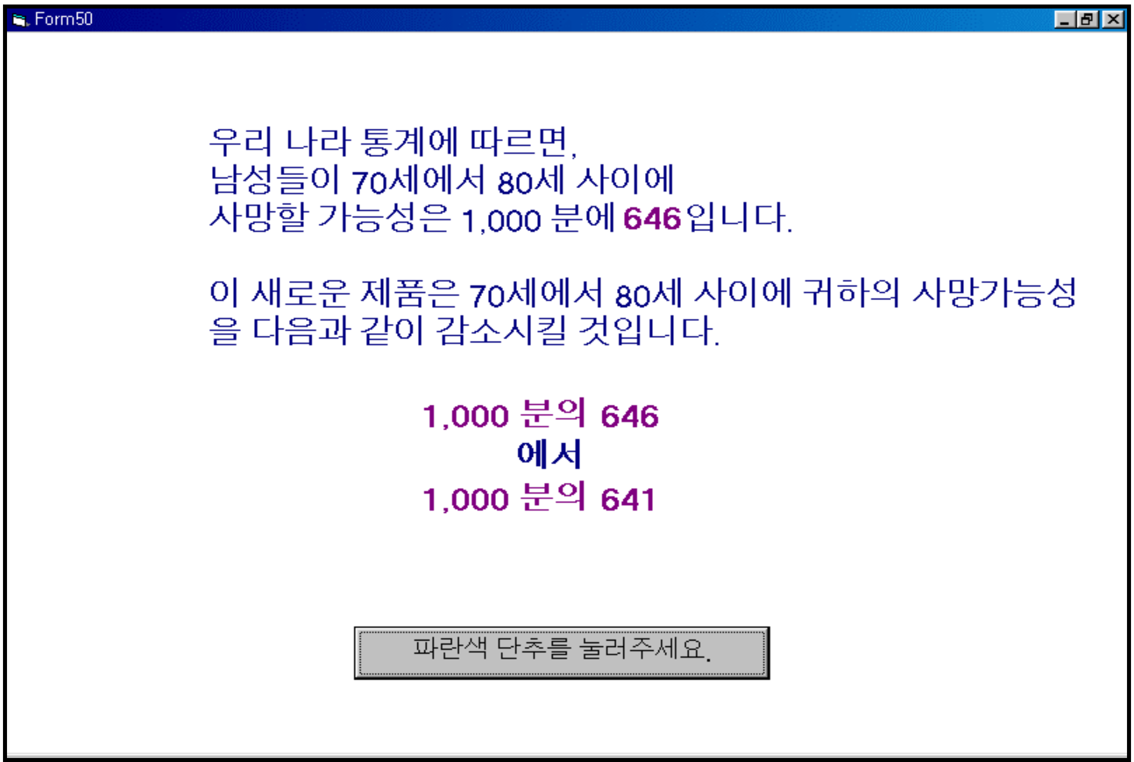
파란색 단추를 눌러주세요.

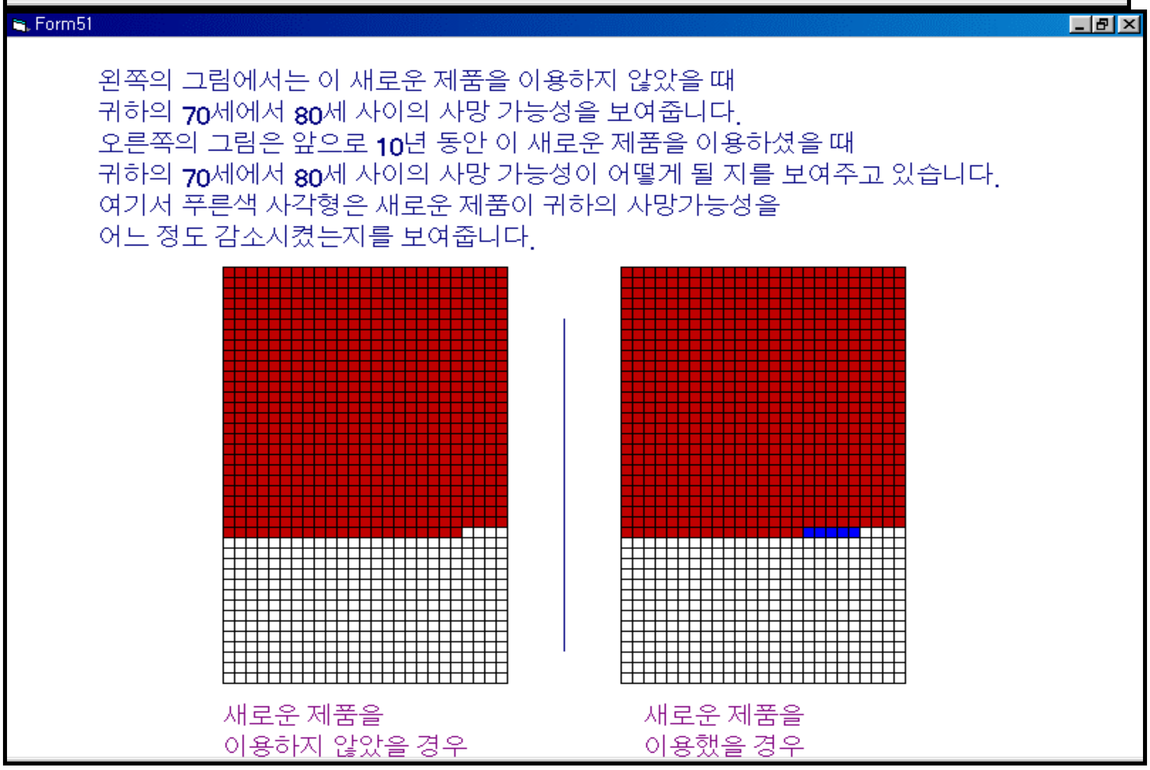

Form46
그렇다면 귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 45만원 (총 450만원) 을
지불할 의사가 있으십니까?
AGE:
40 45 50 55 60 65 70 75 80 85
= 지불 기간
= 1,000 분의 135 에서 1,000 분의 134 으로
사망가능성이 감소하는 기간
1. 예 2. 아니오
파란색 단추를 눌러주세요.

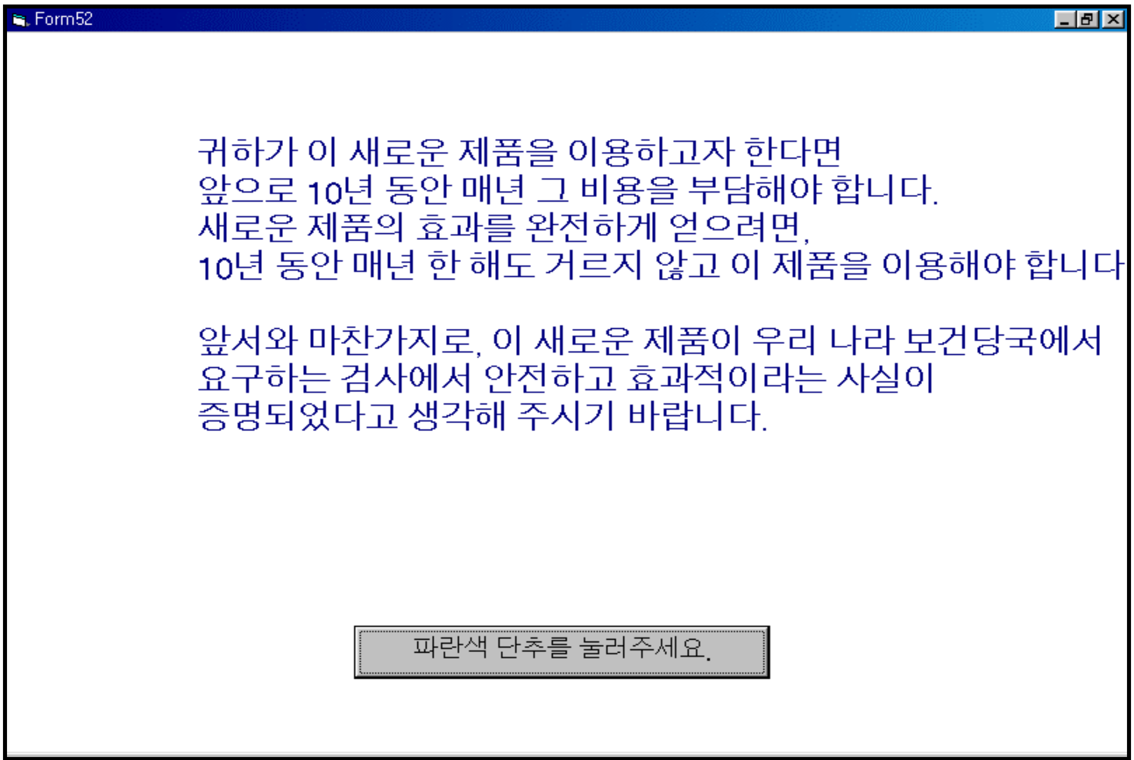

Form48
이 새로운 제품에 대한 귀하의 지불의사는
얼마나 확실한 것입니까?
1 2 3 4 5 6 7
매우 불확실
매우 확실
귀하의 응답을 1과 7 사이 중에서 선택해 숫자 키로 입력해 주십시오.
여기서 1은 매우 불확실하다는 것을 뜻하고 7은 매우 확실하다는 것을 의미합니다
파란색 단추를 눌러주세요.

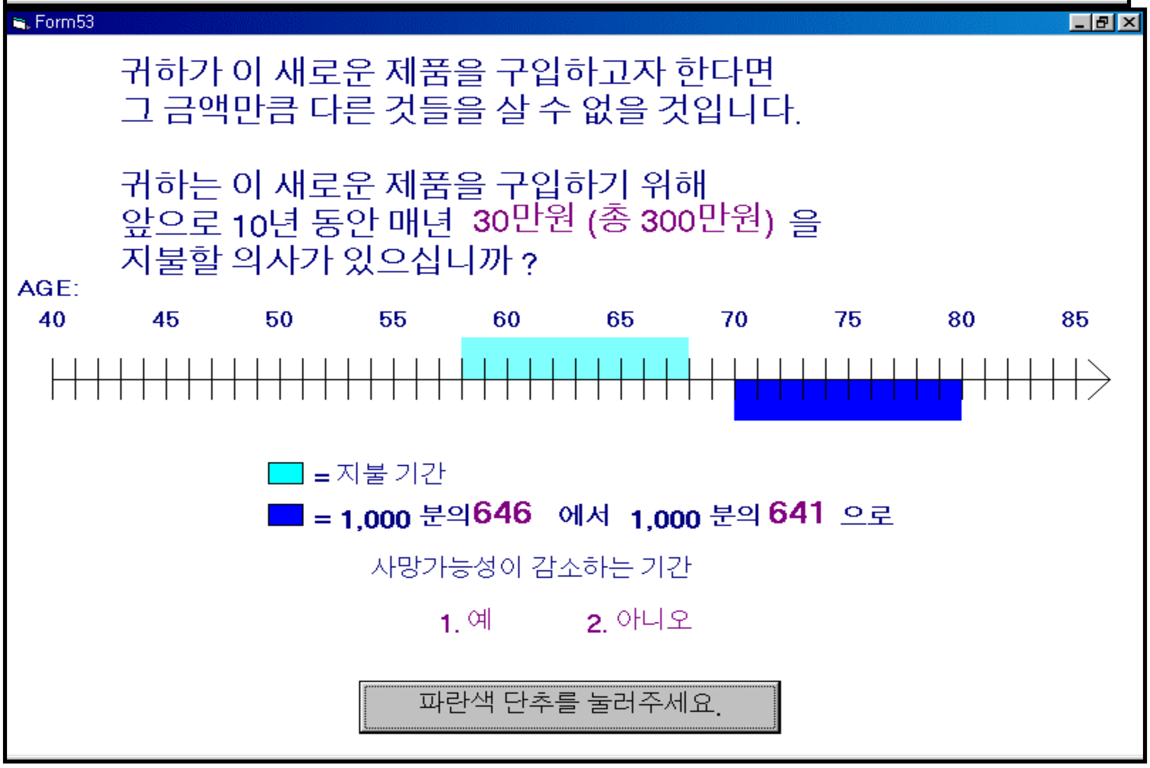

Form13
귀하께서는 70세까지 살 수 있을 것이라
어느 정도 확신하십니까 ?
귀하가 생각하는 확실성의 정도를
백분율로 표시해 주십시오.
0% | 25% | 50% | 75% | 100%
전혀 확신하지 않는다
완전히 확신한다
%
숫자 자판을 이용하여 입력해 주시고,
다음 문항으로 넘어가기 위해 파란색 단추를 눌러주십시오.
귀하의 답변은 0과 100사이의 어떤 숫자이든 될 수 있습니다.
파란색 단추를 눌러주세요.

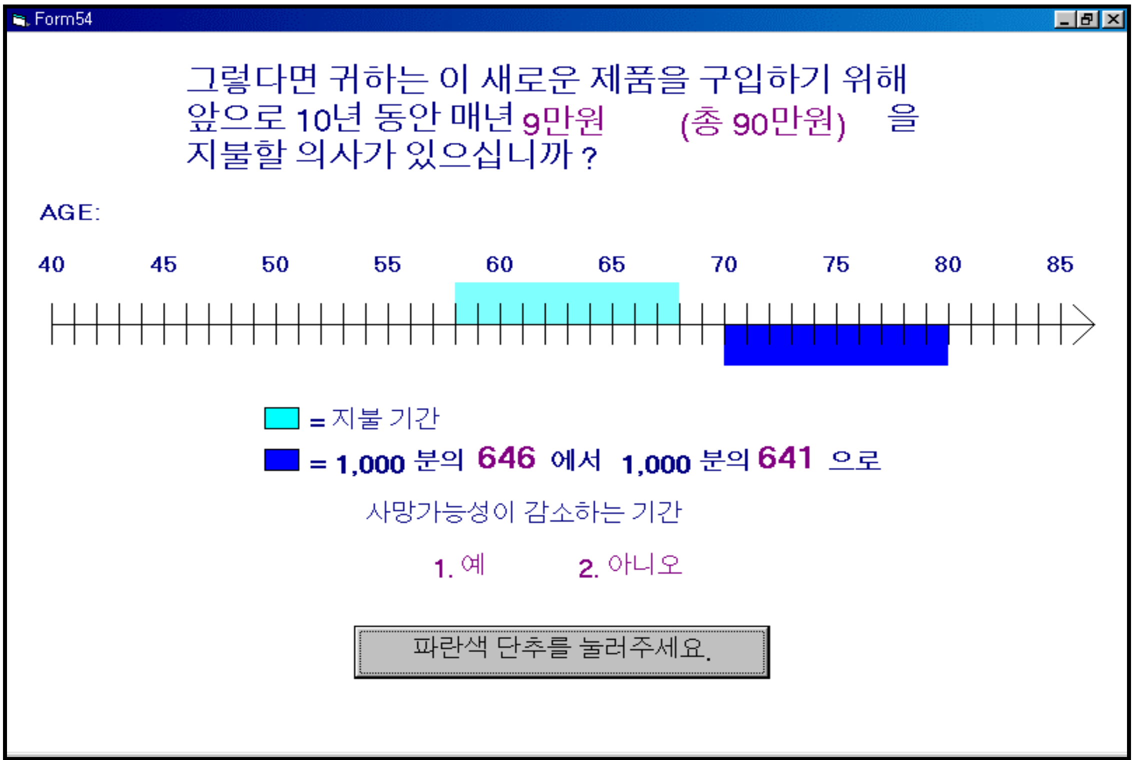

Form49
이제 앞서 소개한 제품과는
다른 유형의 제품에 대해 질문하고자 합니다.
이 새로운 제품은 앞으로 10년 동안 이용하면
그 효과는 특히, 70세에서 80세 사이 에
질환으로 사망할 가능성을 감소시킨다고 합니다.
파란색 단추를 눌러주세요.

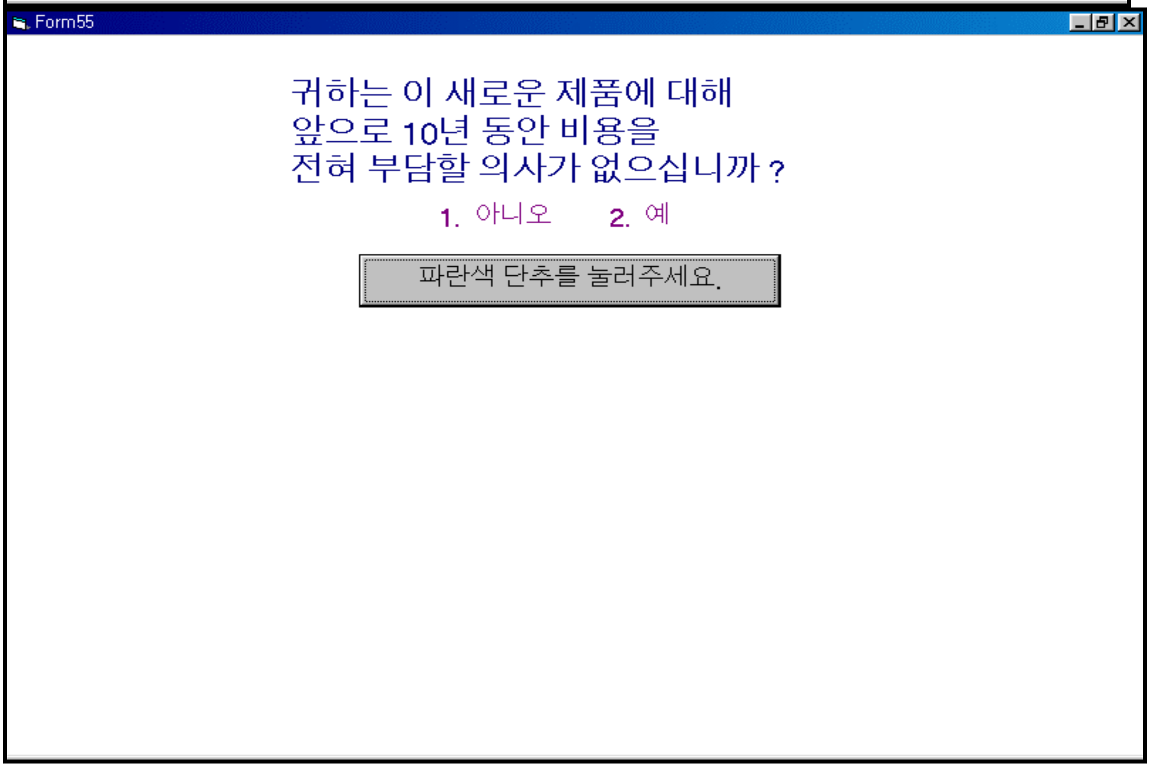

Form50
우리 나라 통계에 따르면,
남성들이 70세에서 80세 사이에
사망할 가능성은 1,000 분에 646 입니다.
이 새로운 제품은 70세에서 80세 사이에 귀하의 사망가능성
을 다음과 같이 감소시킬 것입니다.
1,000 분의 646
에서
1,000 분의 641
파란색 단추를 눌러주세요.

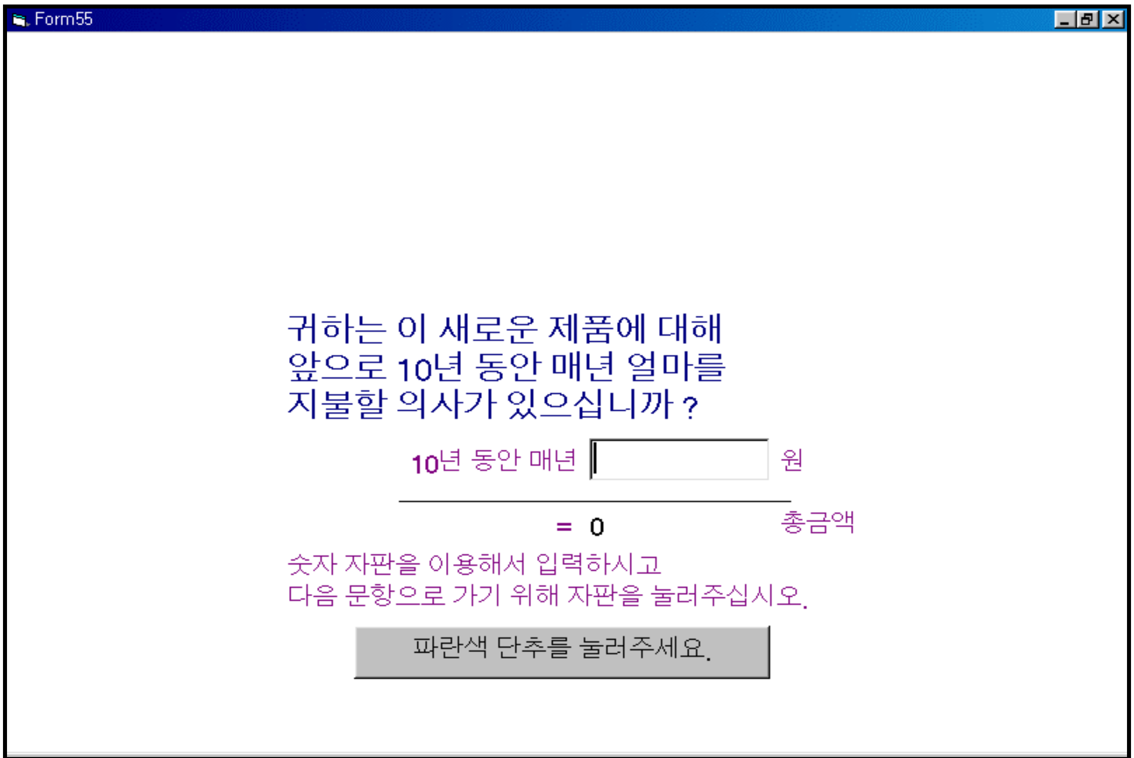

Form51
왼쪽의 그림에서는 이 새로운 제품을 이용하지 않았을 때
귀하의 70세에서 80세 사이의 사망 가능성을 보여줍니다.
오른쪽의 그림은 앞으로 10년 동안 이 새로운 제품을 이용하셨을 때
귀하의 70세에서 80세 사이의 사망 가능성이 어떻게 될 지를 보여주고 있습니다.
여기서 푸른색 사각형은 새로운 제품이 귀하의 사망가능성을
어느 정도 감소시켰는지를 보여줍니다.
새로운 제품을
이용하지 않았을 경우
새로운 제품을
이용했을 경우

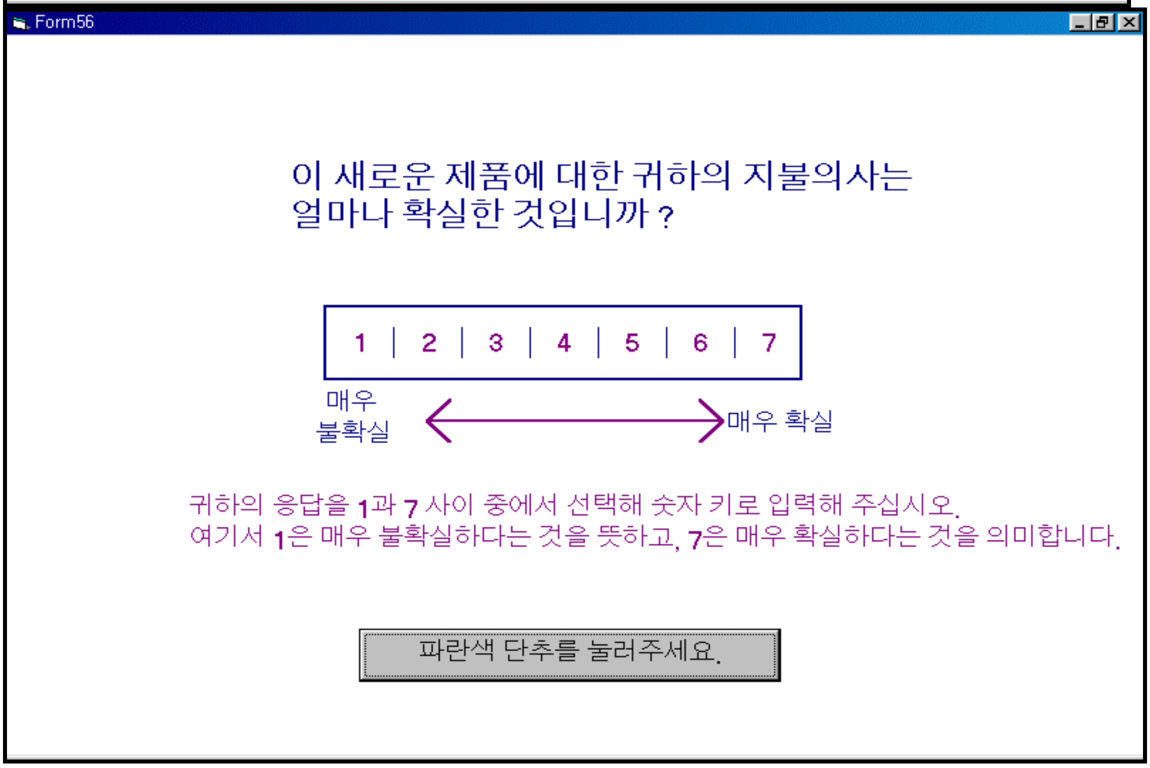

Form52
귀하가 이 새로운 제품을 이용하고자 한다면
앞으로 10년 동안 매년 그 비용을 부담해야 합니다.
새로운 제품의 효과를 완전하게 얻으려면,
10년 동안 매년 한 해도 거르지 않고 이 제품을 이용해야 합니다
앞서와 마찬가지로, 이 새로운 제품이 우리 나라 보건당국에서
요구하는 검사에서 안전하고 효과적이라는 사실이
증명되었다고 생각해 주시기 바랍니다.
파란색 단추를 눌러주세요.

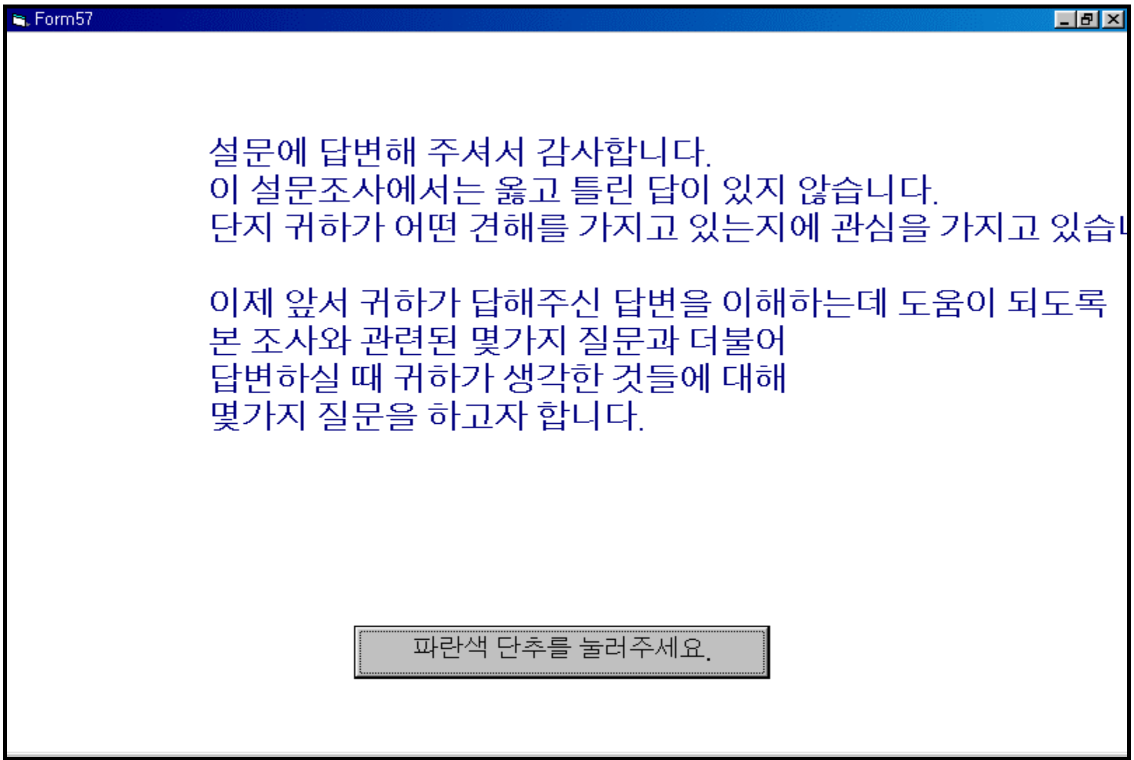

Form53
귀하가 이 새로운 제품을 구입하고자 한다면
그 금액만큼 다른 것들을 살 수 없을 것입니다.
귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 30만원 (총 300만원) 을
지불할 의사가 있으십니까 ?
AGE:
40 45 50 55 60 65 70 75 80 85
= 지불 기간
= 1,000 분의646 에서 1,000 분의 641 으로
사망가능성이 감소하는 기간
1. 예
2. 아니오
파란색 단추를 눌러주세요.

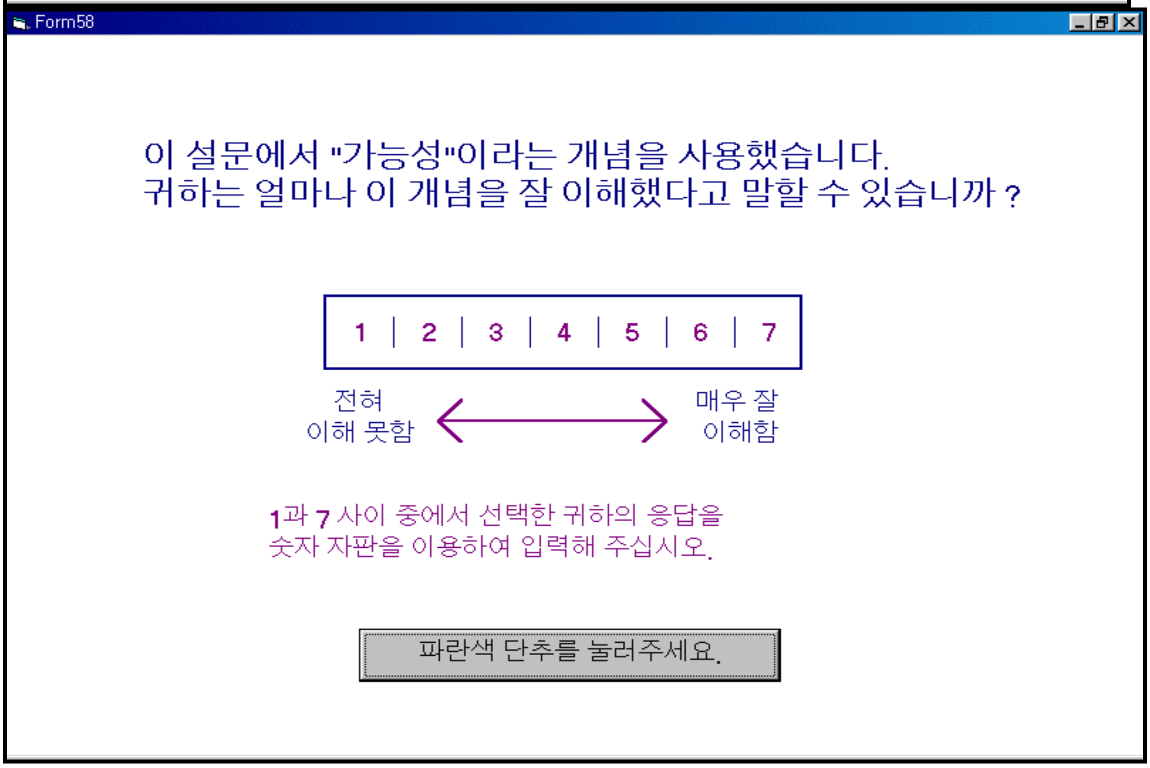

Form54
그렇다면 귀하는 이 새로운 제품을 구입하기 위해
앞으로 10년 동안 매년 9만원 (총 90만원) 을
지불할 의사가 있으십니까?
AGE:
40 45 50 55 60 65 70 75 80 85
= 지불 기간
= 1,000 분의 646 에서 1,000 분의 641 으로
사망가능성이 감소하는 기간
1. 예 2. 아니오
파란색 단추를 눌러주세요.

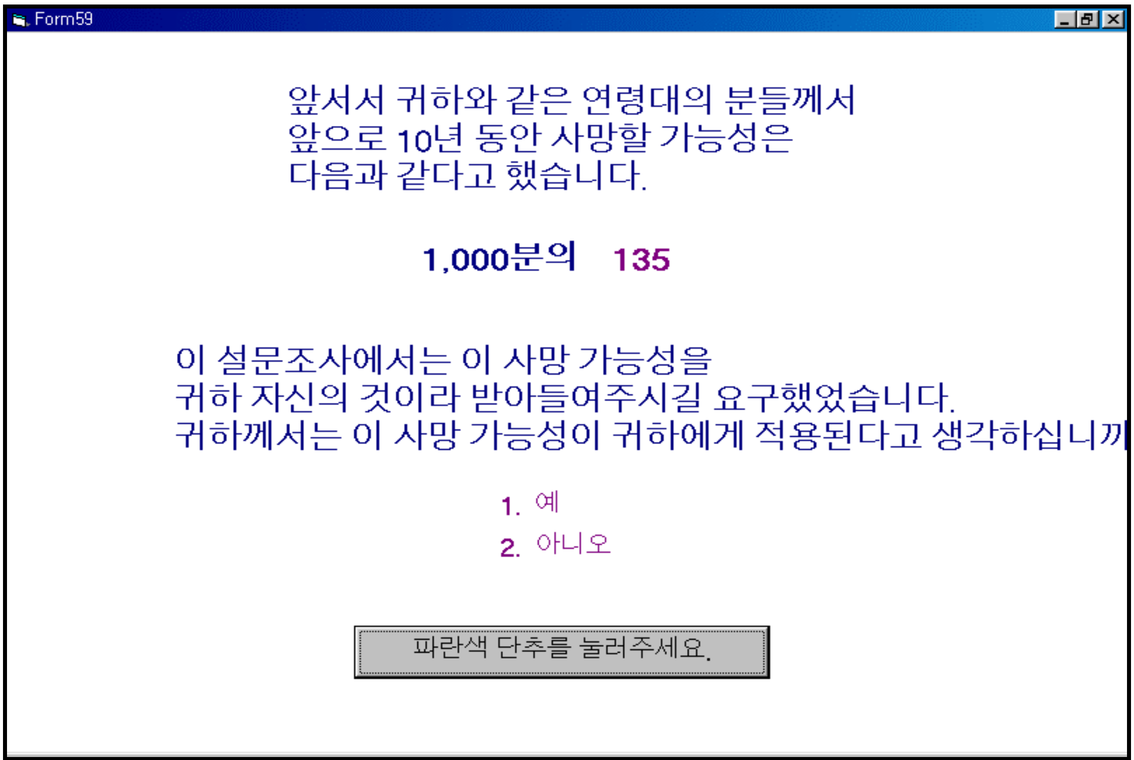

Form55
귀하는 이 새로운 제품에 대해
앞으로 10년 동안 비용을
전혀 부담할 의사가 없으십니까?
1. 아니오 2. 예
파란색 단추를 눌러주세요.

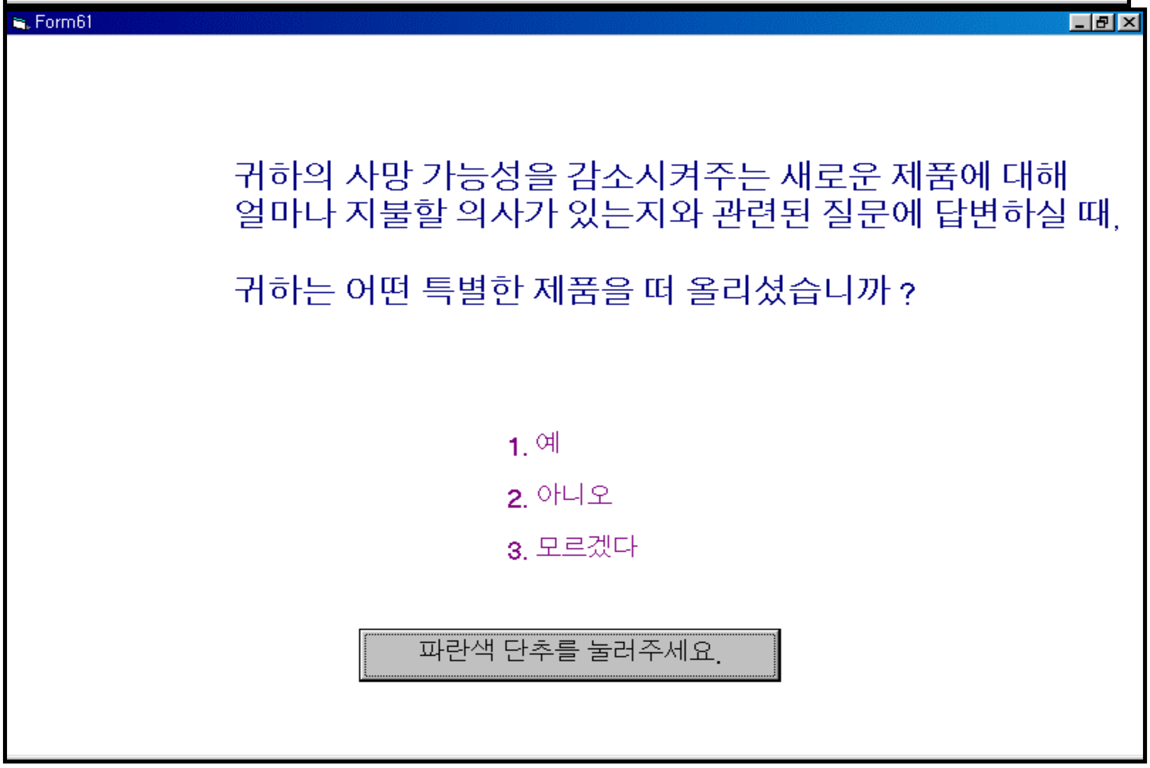

Form55
귀하는 이 새로운 제품에 대해
앞으로 10년 동안 매년 얼마를
지불할 의사가 있으십니까 ?
10년 동안 매년
원
= 0
총금액
숫자 자판을 이용해서 입력하시고
다음 문항으로 가기 위해 자판을 눌러주십시오.
파란색 단추를 눌러주세요.

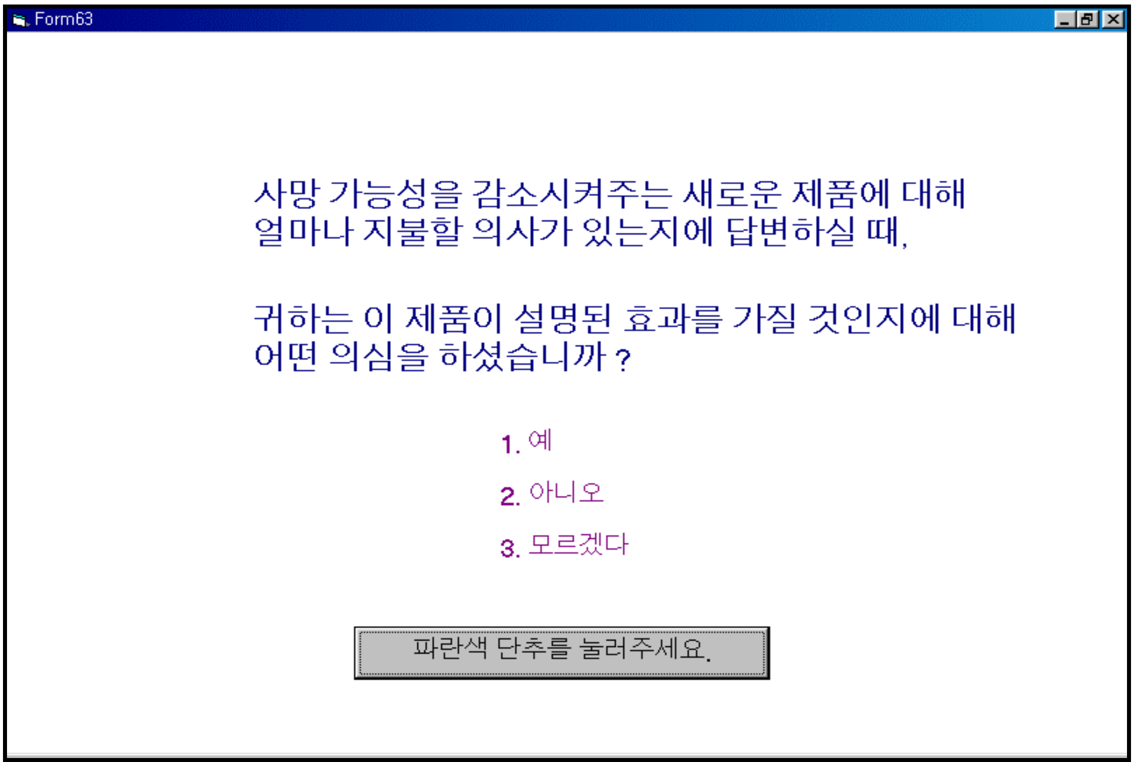

Form56
이 새로운 제품에 대한 귀하의 지불의사는
얼마나 확실한 것입니까 ?
1 | 2 | 3 | 4 | 5 | 6 | 7
매우
불확실
매우 확실
귀하의 응답을 1과 7 사이 중에서 선택해 숫자 키로 입력해 주십시오.
여기서 1은 매우 불확실하다는 것을 뜻하고, 7은 매우 확실하다는 것을 의미합니다.
파란색 단추를 눌러주세요.

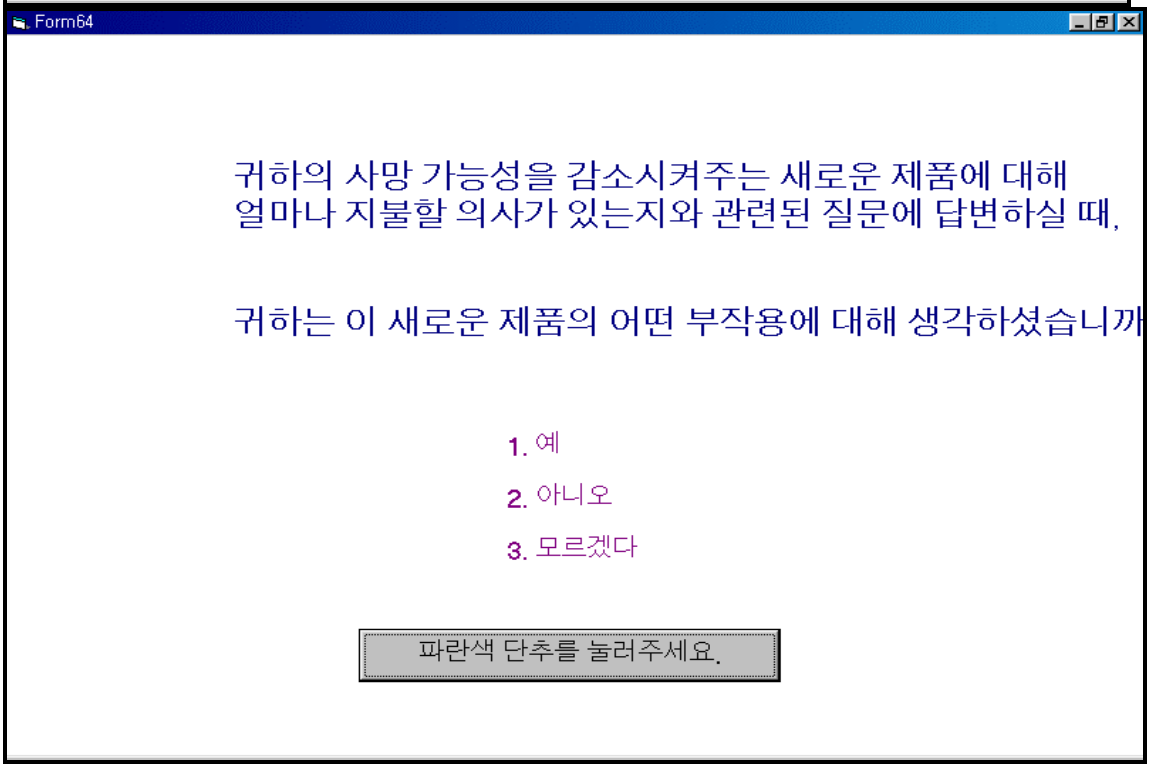

Form57
설문에 답변해 주셔서 감사합니다.
이 설문조사에서는 옳고 틀린 답이 있지 않습니다.
단지 귀하가 어떤 견해를 가지고 있는지에 관심을 가지고 있습
이제 앞서 귀하가 답해주신 답변을 이해하는데 도움이 되도록
본 조사와 관련된 몇가지 질문과 더불어
답변하실 때 귀하가 생각한 것들에 대해
몇가지 질문을 하고자 합니다.
파란색 단추를 눌러주세요.

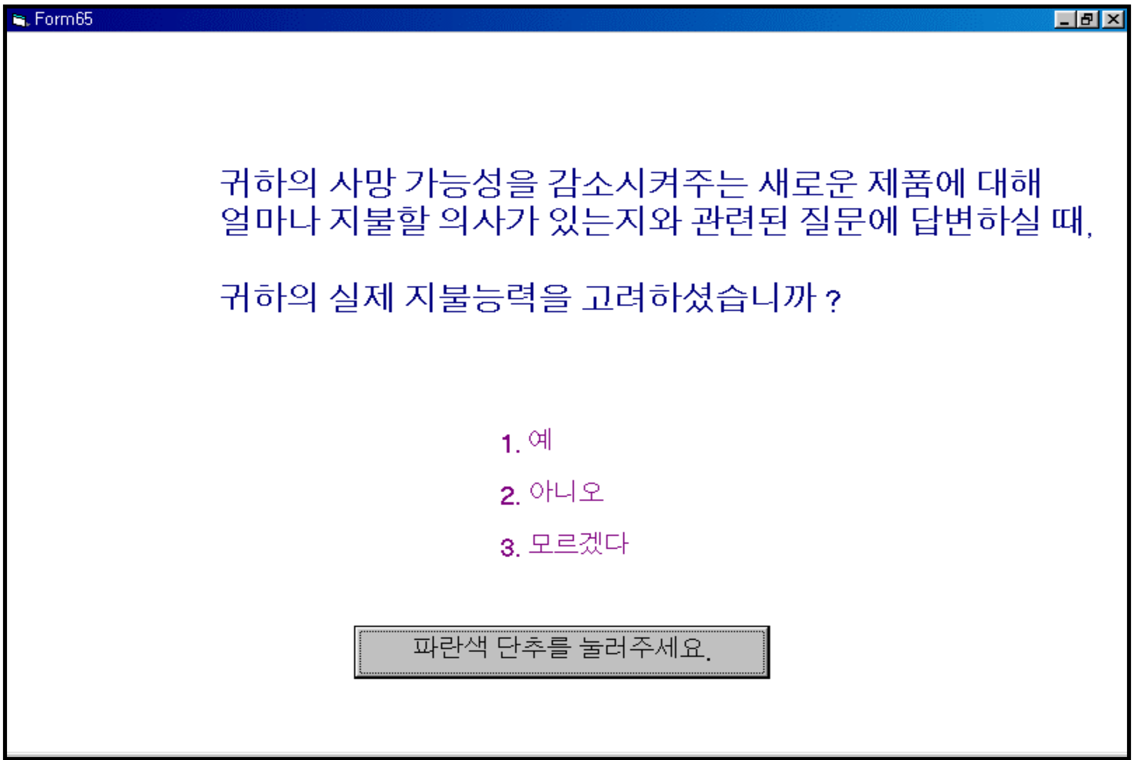

Form58
이 설문에서 "가능성"이라는 개념을 사용했습니다.
귀하는 얼마나 이 개념을 잘 이해했다고 말할 수 있습니까?
1 | 2 | 3 | 4 | 5 | 6 | 7
전혀 이해 못함
매우 잘 이해함
1과 7 사이 중에서 선택한 귀하의 응답을
숫자 자판을 이용하여 입력해 주십시오.
파란색 단추를 눌러주세요.

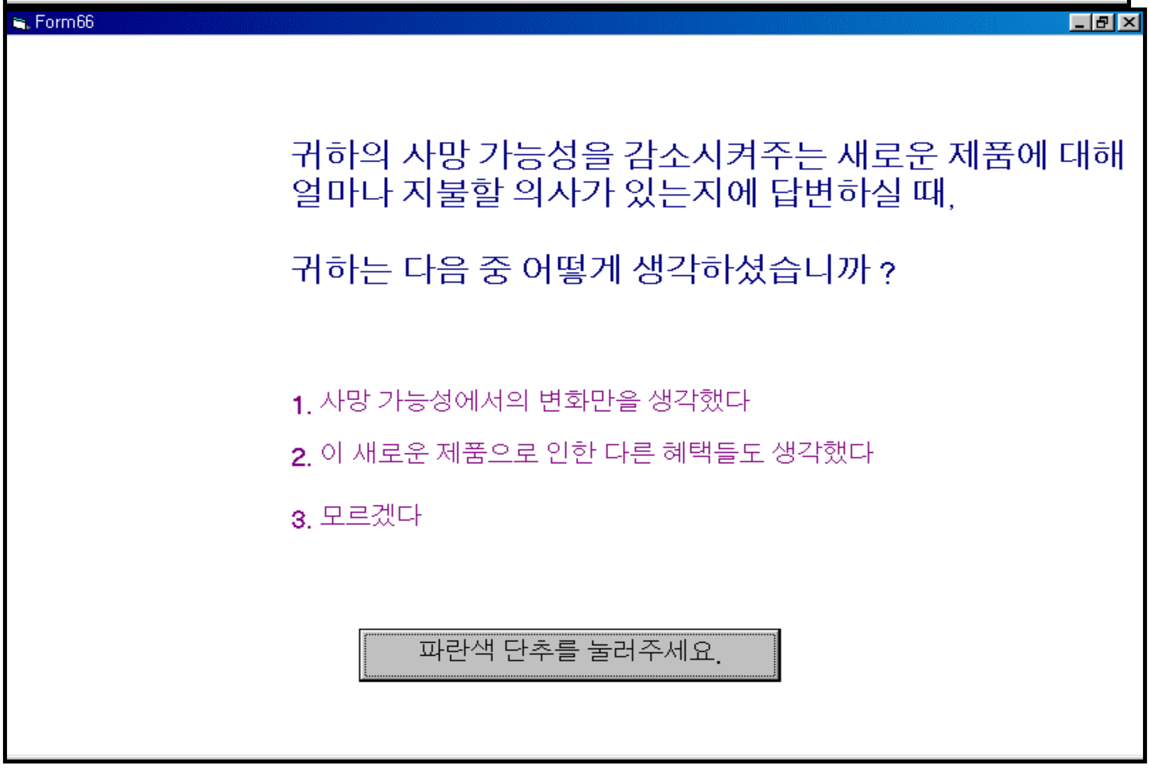

Form59
앞서서 귀하와 같은 연령대의 분들께서
앞으로 10년 동안 사망할 가능성은
다음과 같다고 했습니다.
1,000분의 135
이 설문조사에서는 이 사망 가능성을
귀하 자신의 것이라 받아들여주시길 요구했었습니다.
귀하께서는 이 사망 가능성이 귀하에게 적용된다고 생각하십니
1. 예
2. 아니오
파란색 단추를 눌러주세요.

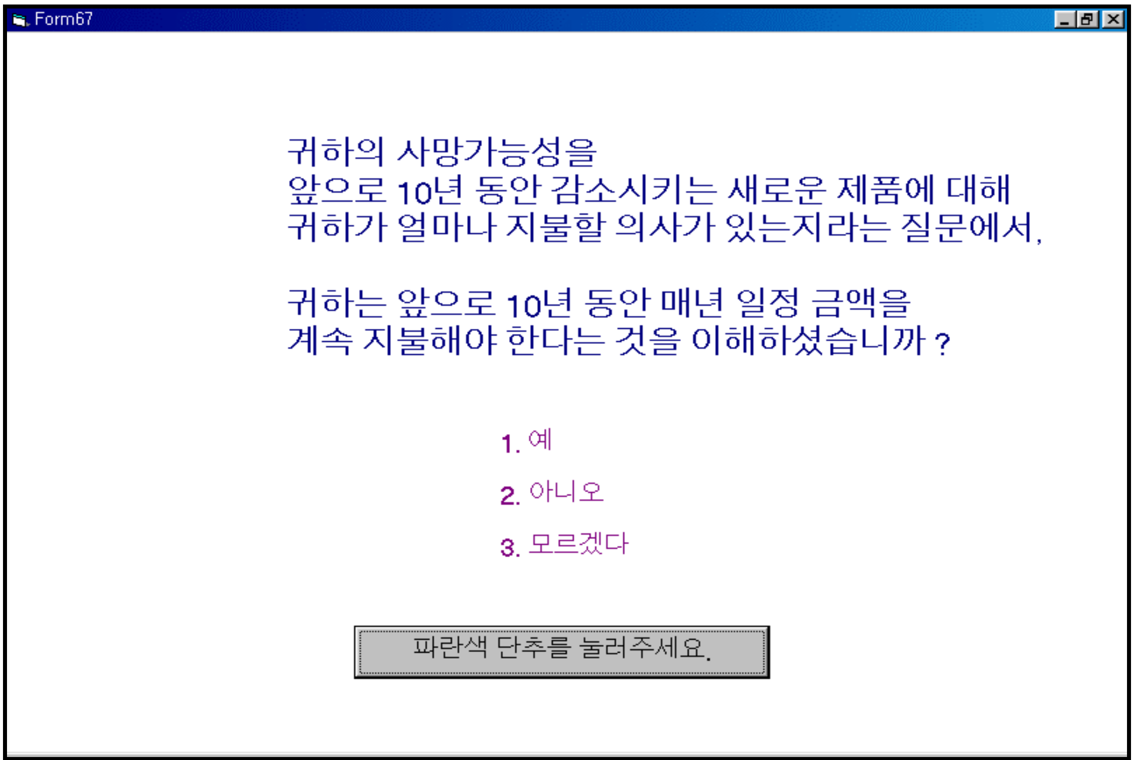

Form61
귀하의 사망 가능성을 감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지와 관련된 질문에 답변하실 때,
귀하는 어떤 특별한 제품을 떠 올리셨습니까 ?
1. 예
2. 아니오
3. 모르겠다
파란색 단추를 눌러주세요.

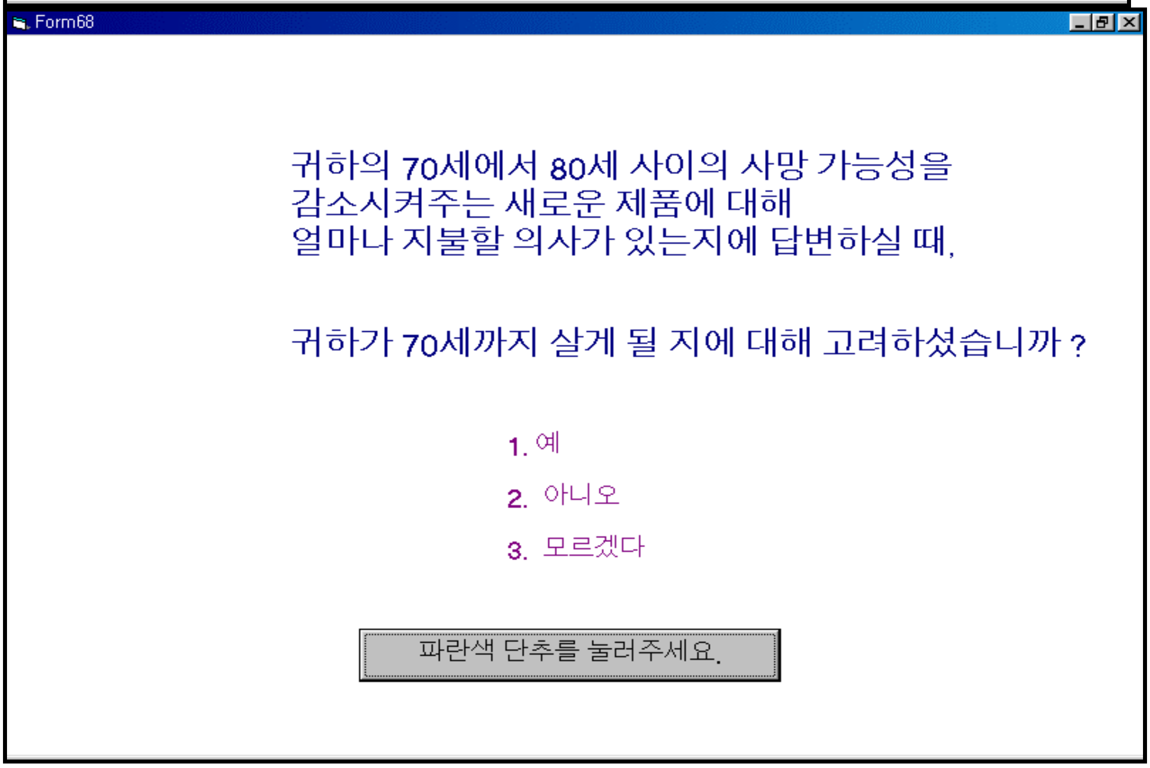

Form63
사망 가능성을 감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지에 답변하실 때,
귀하는 이 제품이 설명된 효과를 가질 것인지에 대해
어떤 의심을 하셨습니까 ?
1. 예
2. 아니오
3. 모르겠다
파란색 단추를 눌러주세요.

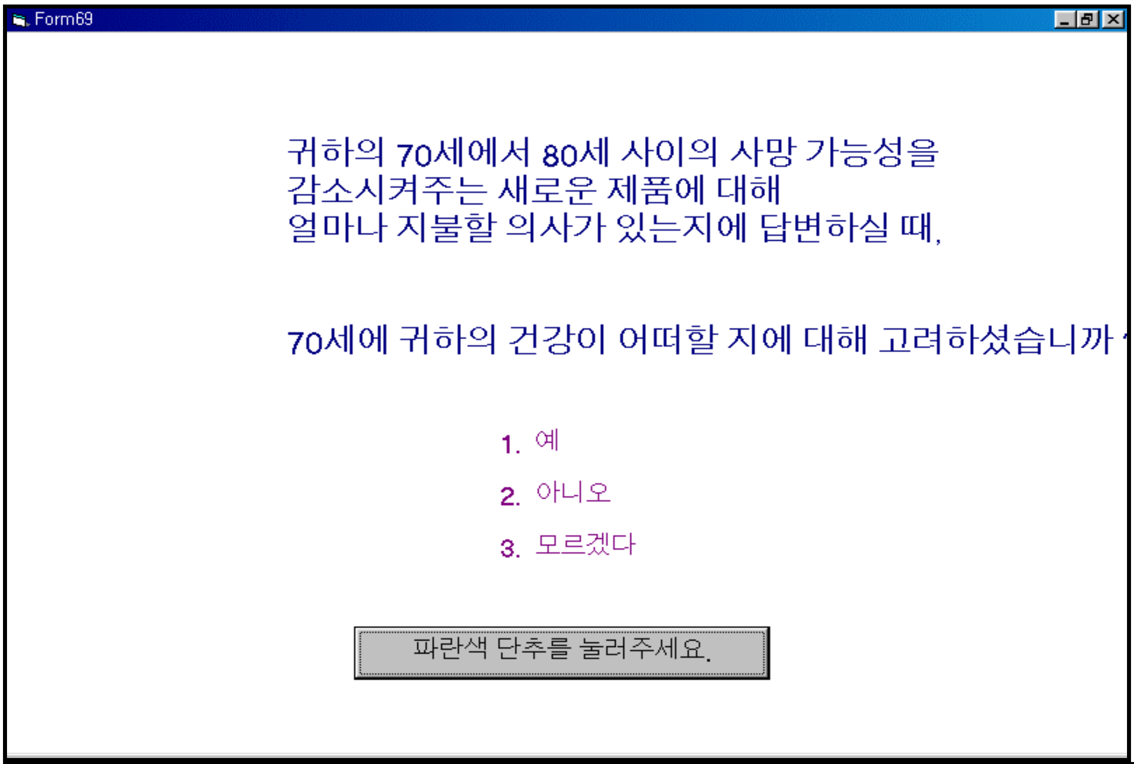

Form64
귀하의 사망 가능성을 감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지와 관련된 질문에 답변하실 때,
귀하는 이 새로운 제품의 어떤 부작용에 대해 생각하셨습니까
1. 예
2. 아니오
3. 모르겠다
파란색 단추를 눌러주세요.


Form65
귀하의 사망 가능성을 감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지와 관련된 질문에 답변하실 때,
귀하의 실제 지불능력을 고려하셨습니까?
1. 예
2. 아니오
3. 모르겠다
파란색 단추를 눌러주세요.


Form66
귀하의 사망 가능성을 감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지에 답변하실 때,
귀하는 다음 중 어떻게 생각하셨습니까?
1. 사망 가능성에서의 변화만을 생각했다
2. 이 새로운 제품으로 인한 다른 혜택들도 생각했다
3. 모르겠다
파란색 단추를 눌러주세요.


Form67
귀하의 사망가능성을
앞으로 10년 동안 감소시키는 새로운 제품에 대해
귀하가 얼마나 지불할 의사가 있는지라는 질문에서,
귀하는 앞으로 10년 동안 매년 일정 금액을
계속 지불해야 한다는 것을 이해하셨습니까 ?
1. 예
2. 아니오
3. 모르겠다
파란색 단추를 눌러주세요.


Form68
귀하의 70세에서 80세 사이의 사망 가능성을
감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지에 답변하실 때,
귀하가 70세까지 살게 될 지에 대해 고려하셨습니까 ?
1. 예
2. 아니오
3. 모르겠다
파란색 단추를 눌러주세요.



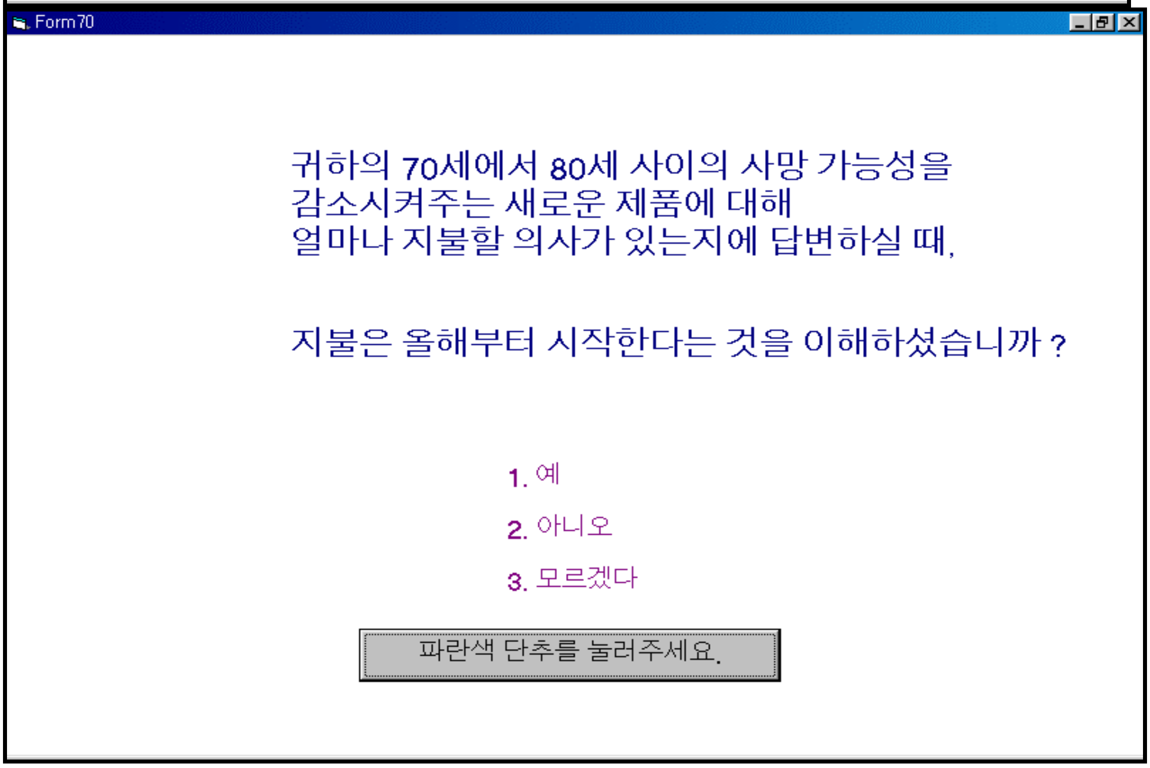
Form69

귀하의 70세에서 80세 사이의 사망 가능성을
감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지에 답변하실 때,

70세에 귀하의 건강이 어떠할 지에 대해 고려하셨습니까

1. 예
2. 아니오
3. 모르겠다

파란색 단추를 눌러주세요.



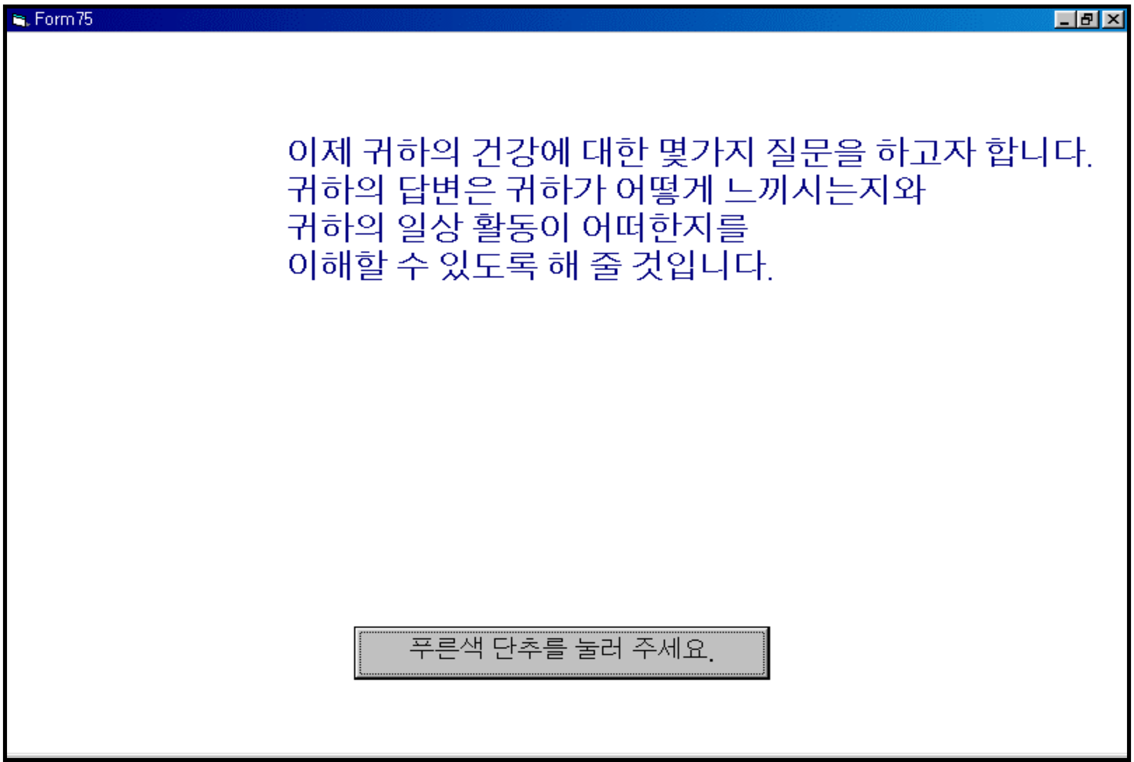
Form70

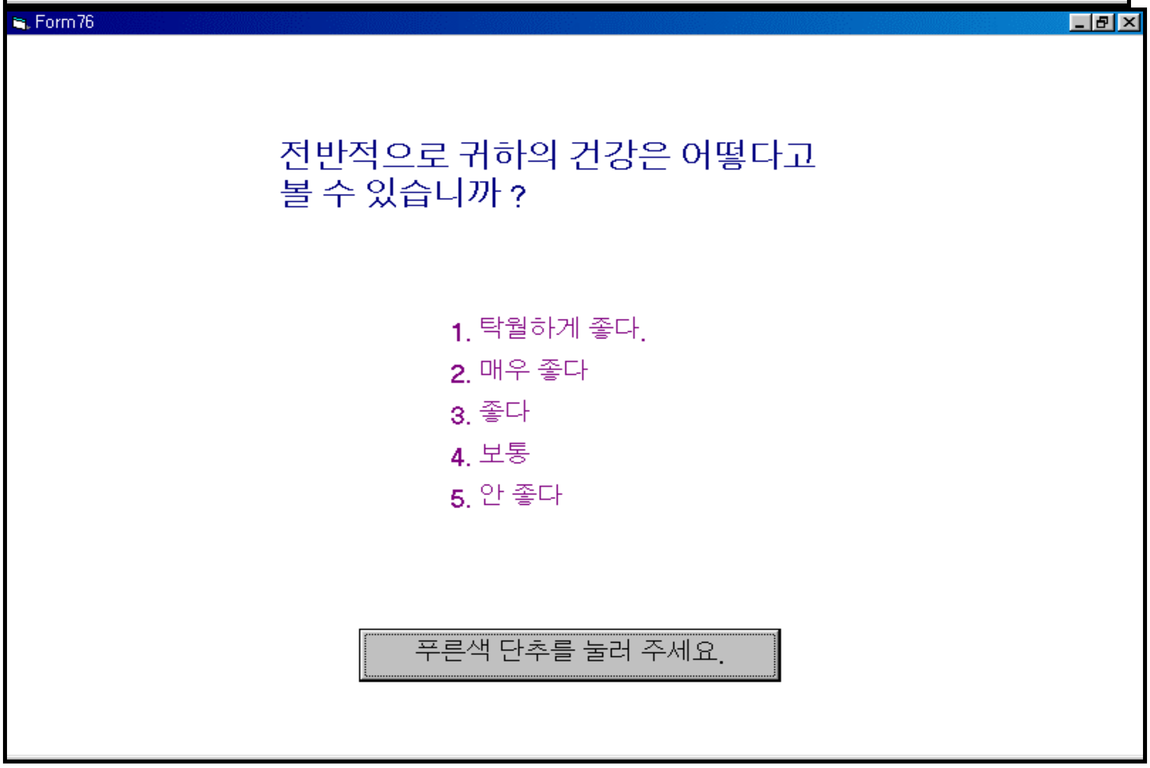
귀하의 70세에서 80세 사이의 사망 가능성을
감소시켜주는 새로운 제품에 대해
얼마나 지불할 의사가 있는지에 답변하실 때,

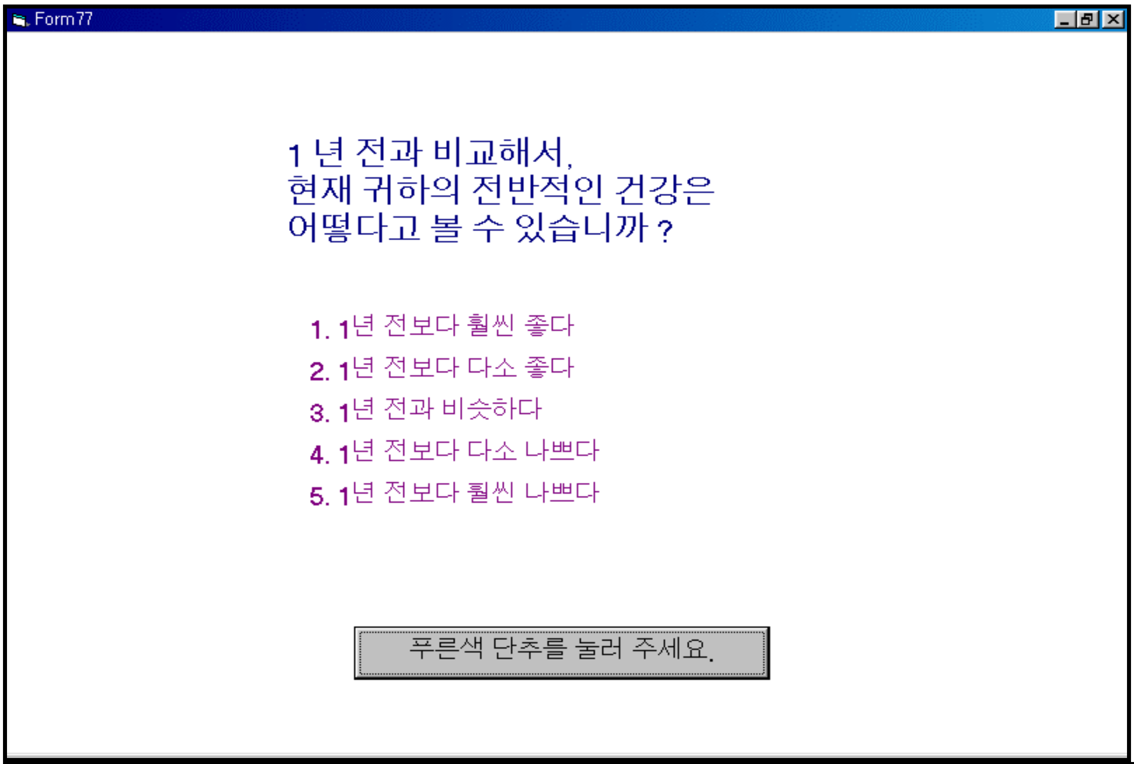
지불은 올해부터 시작한다는 것을 이해하셨습니까 ?

1. 예
2. 아니오
3. 모르겠다

파란색 단추를 눌러주세요.


Form75
이제 귀하의 건강에 대한 몇가지 질문을 하고자 합니다.
귀하의 답변은 귀하가 어떻게 느끼시는지와
귀하의 일상 활동이 어떠한지를
이해할 수 있도록 해 줄 것입니다.
푸른색 단추를 눌러 주세요.


Form76
전반적으로 귀하의 건강은 어떻다고
볼 수 있습니까 ?
1. 탁월하게 좋다.
2. 매우 좋다
3. 좋다
4. 보통
5. 안 좋다
푸른색 단추를 눌러 주세요.

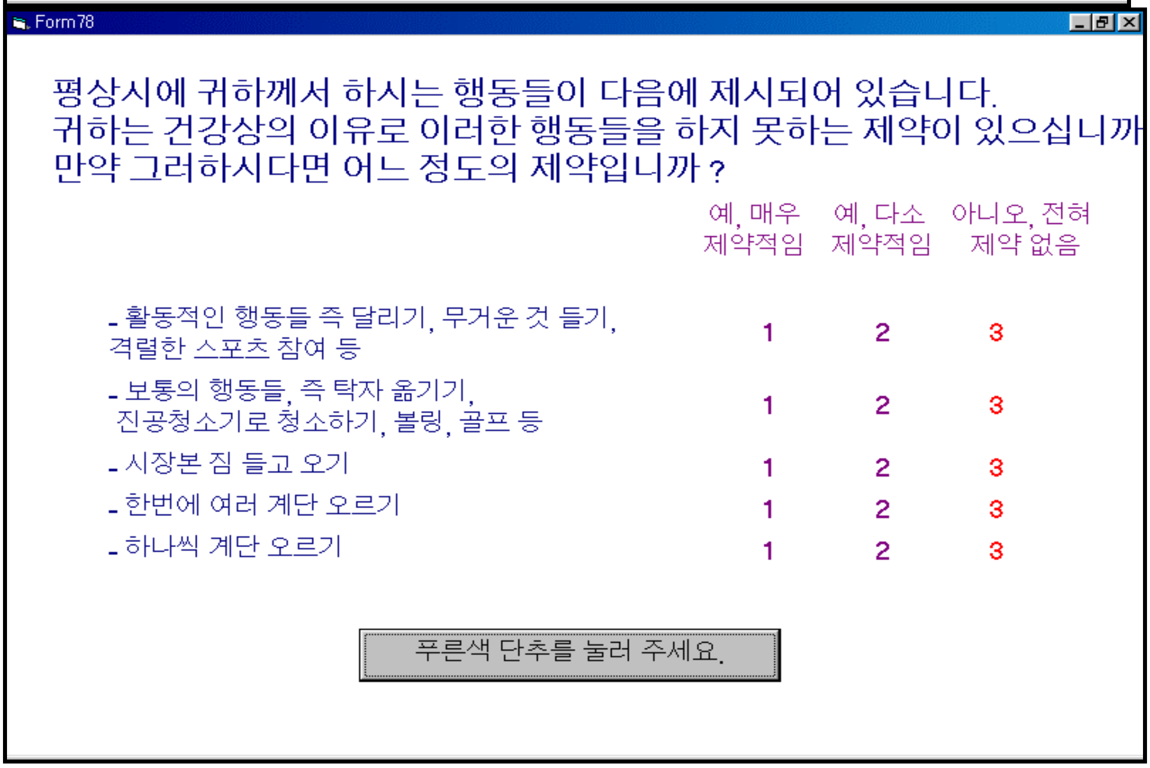


Form77

1 년 전과 비교해서,
현재 귀하의 전반적인 건강은
어떻다고 볼 수 있습니까?

1. 1년 전보다 훨씬 좋다
2. 1년 전보다 다소 좋다
3. 1년 전과 비슷하다
4. 1년 전보다 다소 나쁘다
5. 1년 전보다 훨씬 나쁘다

푸른색 단추를 눌러 주세요.

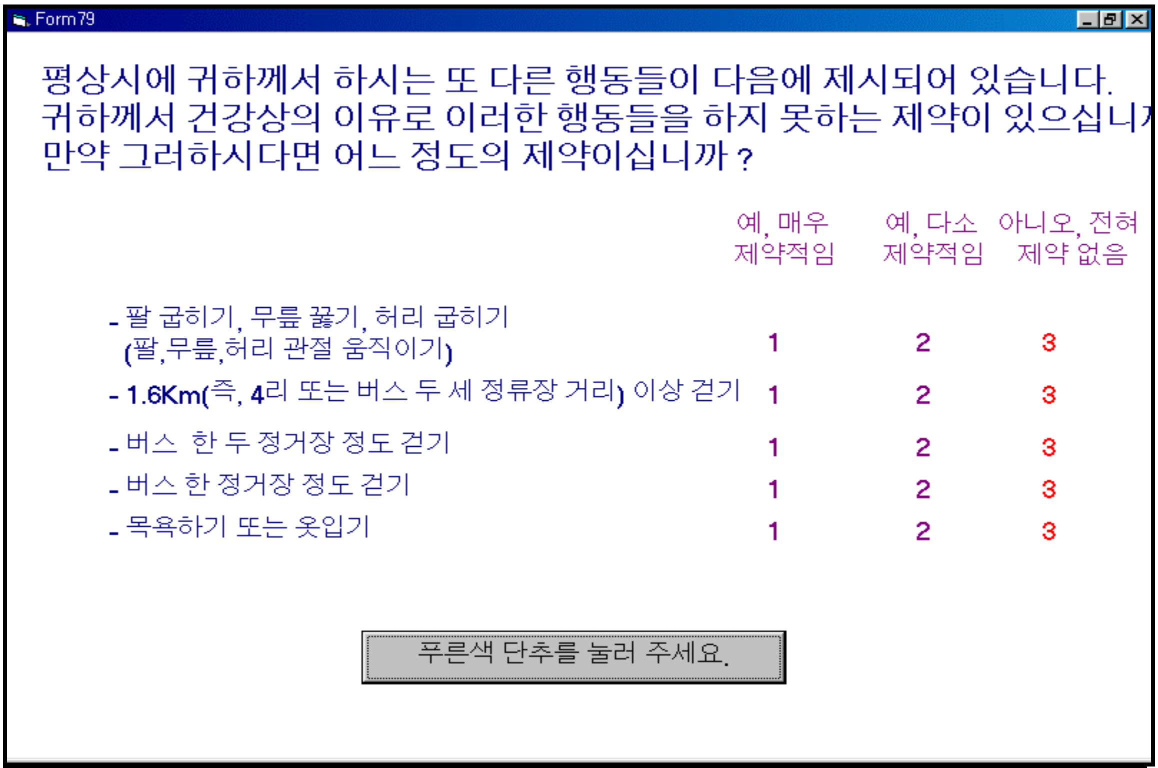


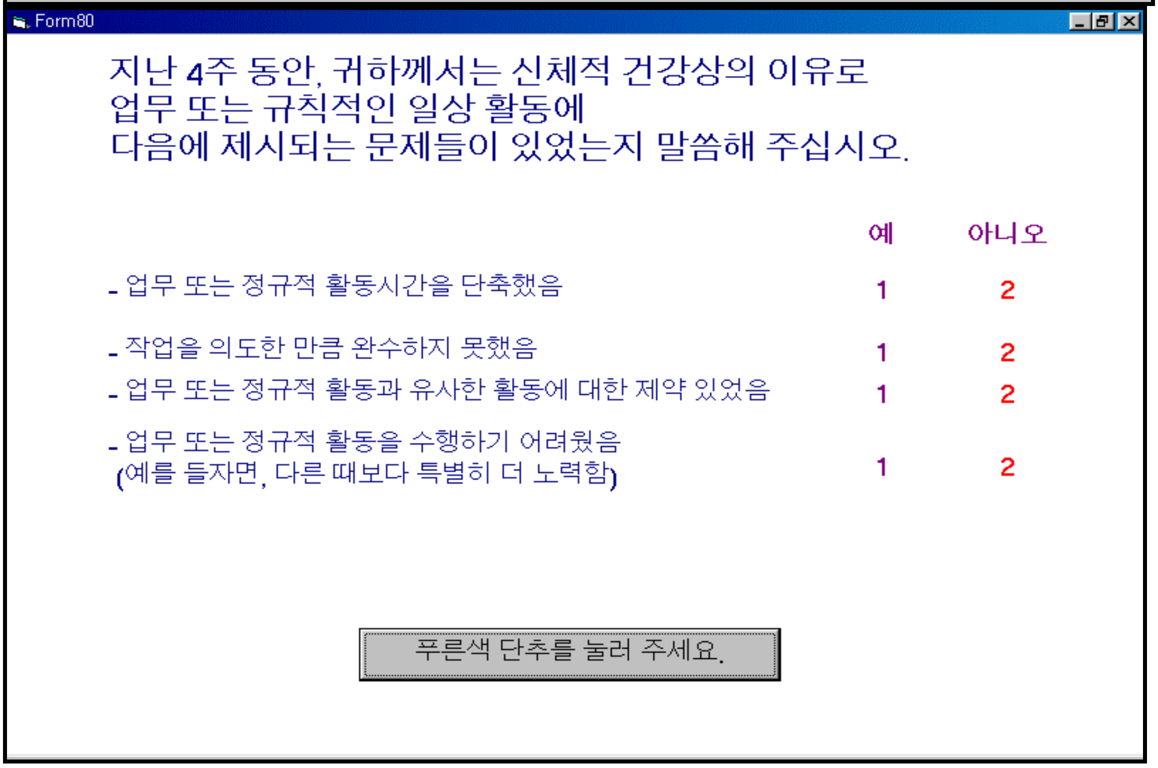
Form78

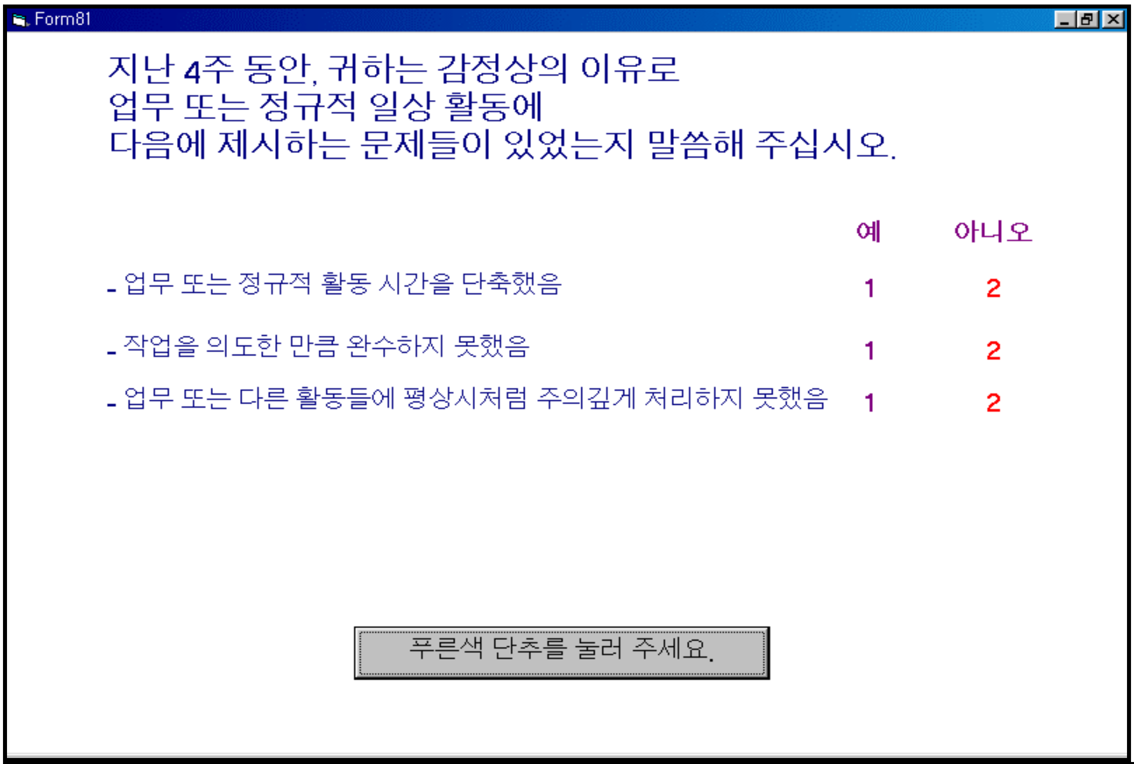
평상시에 귀하께서 하시는 행동들이 다음에 제시되어 있습니다.
귀하는 건강상의 이유로 이러한 행동들을 하지 못하는 제약이 있으십니까
만약 그러하시다면 어느 정도의 제약입니까?

	예, 매우 제약적임	예, 다소 제약적임	아니오, 전혀 제약 없음
- 활동적인 행동들 즉 달리기, 무거운 것 들기, 격렬한 스포츠 참여 등	1	2	3
- 보통의 행동들, 즉 탁자 옮기기, 진공청소기로 청소하기, 볼링, 골프 등	1	2	3
- 시장본 짐 들고 오기	1	2	3
- 한번에 여러 계단 오르기	1	2	3
- 하나씩 계단 오르기	1	2	3

푸른색 단추를 눌러 주세요.


Form79
평상시에 귀하께서 하시는 또 다른 행동들이 다음에 제시되어 있습니다.
귀하께서 건강상의 이유로 이러한 행동들을 하지 못하는 제약이 있으십니
만약 그러하시다면 어느 정도의 제약이십니까?
예, 매우 제약적임
예, 다소 제약적임
아니오, 전혀 제약 없음
- 팔 굽히기, 무릎 꿇기, 허리 굽히기 (팔,무릎,허리 관절 움직이기) 1 2 3
- 1.6Km(즉, 4리 또는 버스 두 세 정류장 거리) 이상 걷기 1 2 3
- 버스 한 두 정거장 정도 걷기 1 2 3
- 버스 한 정거장 정도 걷기 1 2 3
- 목욕하기 또는 옷입기 1 2 3
푸른색 단추를 눌러 주세요.


Form80
지난 4주 동안, 귀하께서는 신체적 건강상의 이유로
업무 또는 규칙적인 일상 활동에
다음에 제시되는 문제들이 있었는지 말씀해 주십시오.
예
아니오
- 업무 또는 정규적 활동시간을 단축했음 1 2
- 작업을 의도한 만큼 완수하지 못했음 1 2
- 업무 또는 정규적 활동과 유사한 활동에 대한 제약 있었음 1 2
- 업무 또는 정규적 활동을 수행하기 어려웠음 (예를 들자면, 다른 때보다 특별히 더 노력함) 1 2
푸른색 단추를 눌러 주세요.

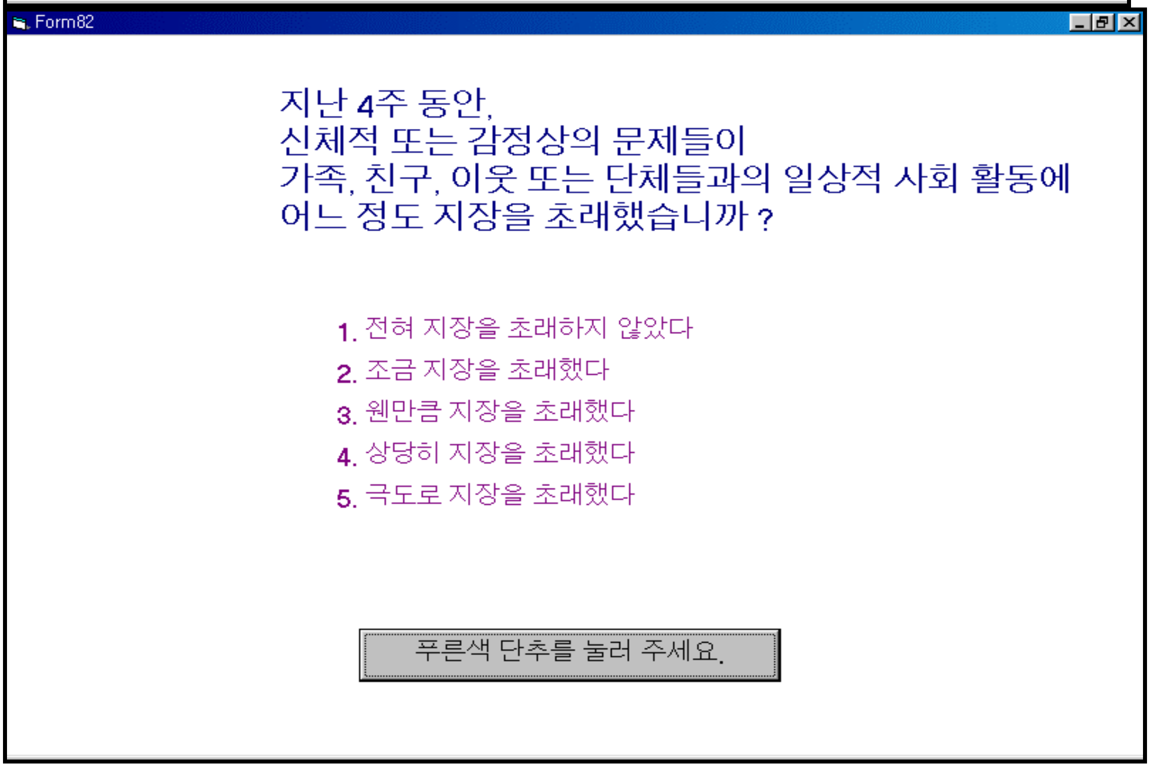


Form81

지난 4주 동안, 귀하는 감정상의 이유로
업무 또는 정규적 일상 활동에
다음에 제시하는 문제들이 있었는지 말씀해 주십시오.

	예	아니오
- 업무 또는 정규적 활동 시간을 단축했음	1	2
- 작업을 의도한 만큼 완수하지 못했음	1	2
- 업무 또는 다른 활동들에 평상시처럼 주의깊게 처리하지 못했음	1	2

푸른색 단추를 눌러 주세요.

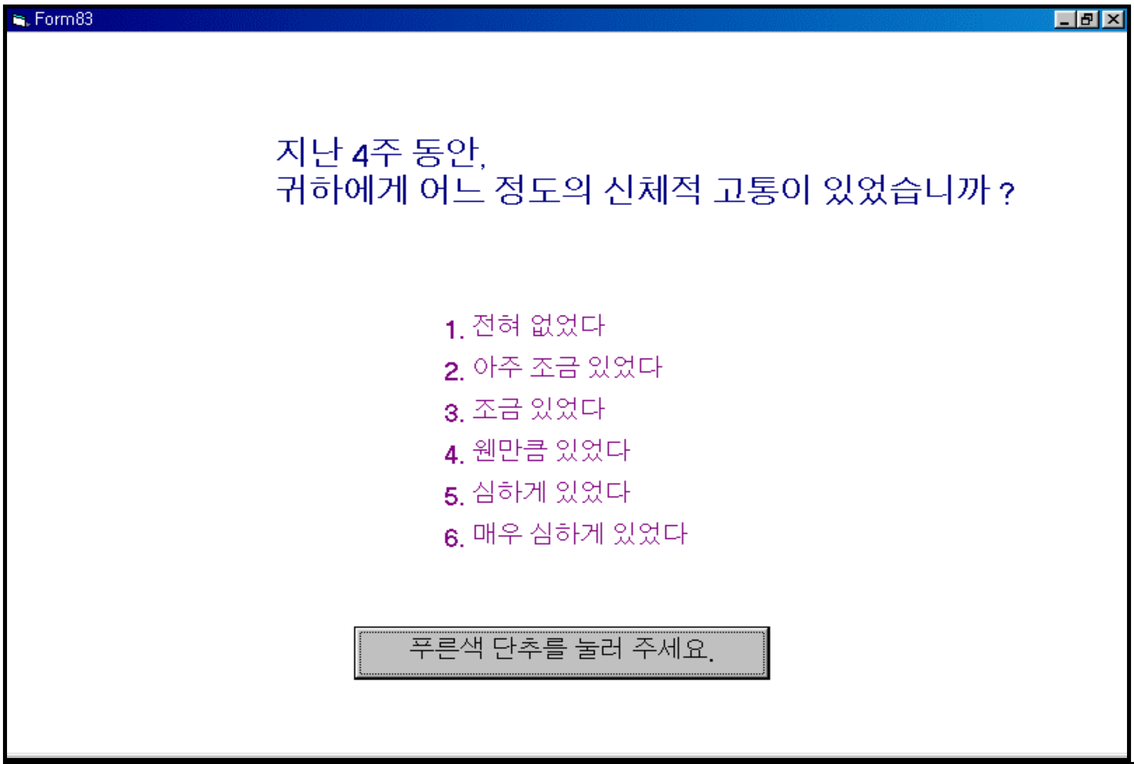


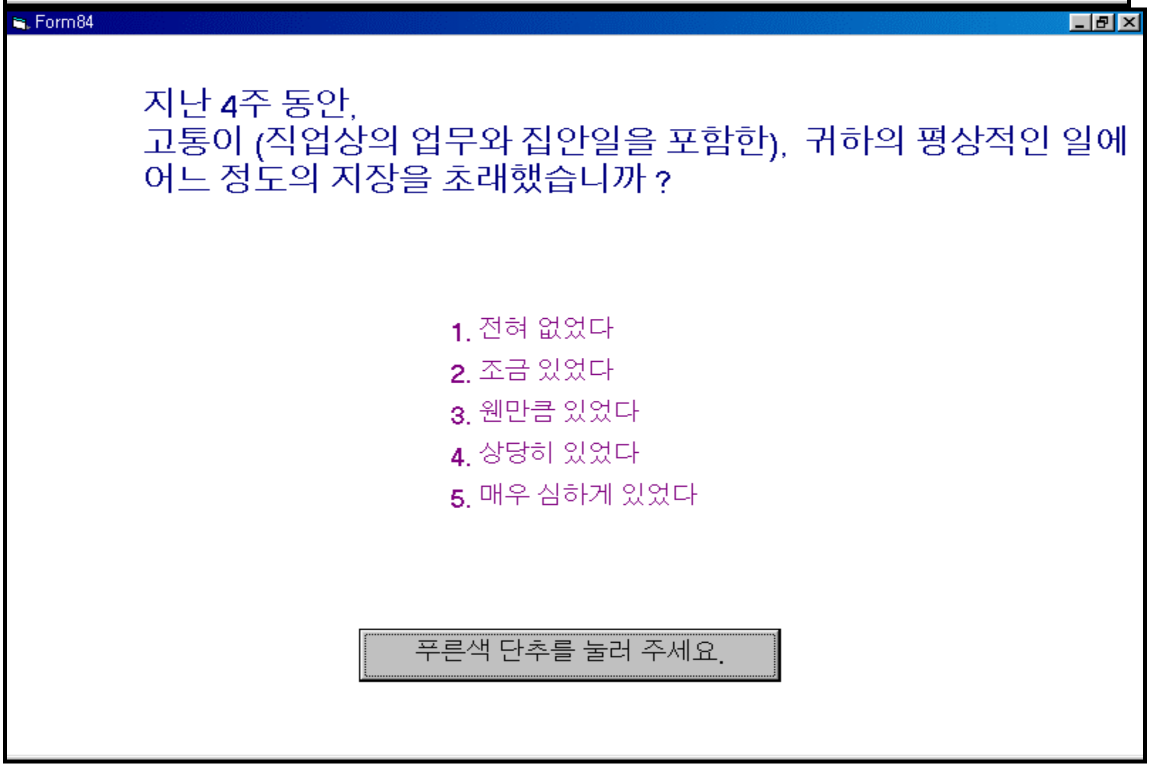
Form82

지난 4주 동안,
신체적 또는 감정상의 문제들이
가족, 친구, 이웃 또는 단체들과의 일상적 사회 활동에
어느 정도 지장을 초래했습니까 ?

1. 전혀 지장을 초래하지 않았다
2. 조금 지장을 초래했다
3. 웬만큼 지장을 초래했다
4. 상당히 지장을 초래했다
5. 극도로 지장을 초래했다

푸른색 단추를 눌러 주세요.


Form83
지난 4주 동안,
귀하에게 어느 정도의 신체적 고통이 있었습니까 ?
1. 전혀 없었다
2. 아주 조금 있었다
3. 조금 있었다
4. 웬만큼 있었다
5. 심하게 있었다
6. 매우 심하게 있었다
푸른색 단추를 눌러 주세요.


Form84
지난 4주 동안,
고통이 (직업상의 업무와 집안일을 포함한), 귀하의 평상적인 일에
어느 정도의 지장을 초래했습니까 ?
1. 전혀 없었다
2. 조금 있었다
3. 웬만큼 있었다
4. 상당히 있었다
5. 매우 심하게 있었다
푸른색 단추를 눌러 주세요.

Form85

다음의 질문들은 지난 4주 동안 귀하가 어떻게 느끼고
귀하의 상태가 어떠했는지와 관련된 질문들입니다.
각 문항에서 귀하가 느끼고 있는 것과
가장 가깝다고 생각하는 보기를 골라 주십시오.

지난 4주 동안 귀하는 얼마나 자주

	항상	대부분	상당한 시간동안	약간의 시간동안	매우 잠시 동안	전ㅎ
- 활기(원기)로 가득차 있다고 느끼셨습니까?	1	2	3	4	5	6
- 매우 초조하다고 느끼셨습니까?	1	2	3	4	5	6
- 최악의 상태에 처해있다고 느껴서 무엇으로도 기분을 풀 수가 없었습니까?	1	2	3	4	5	6
- 침착하고 평화롭다고 느끼셨습니까?	1	2	3	4	5	6
- 매우 정력적이었습니까?	1	2	3	4	5	6

푸른색 단추를 눌러 주세요.

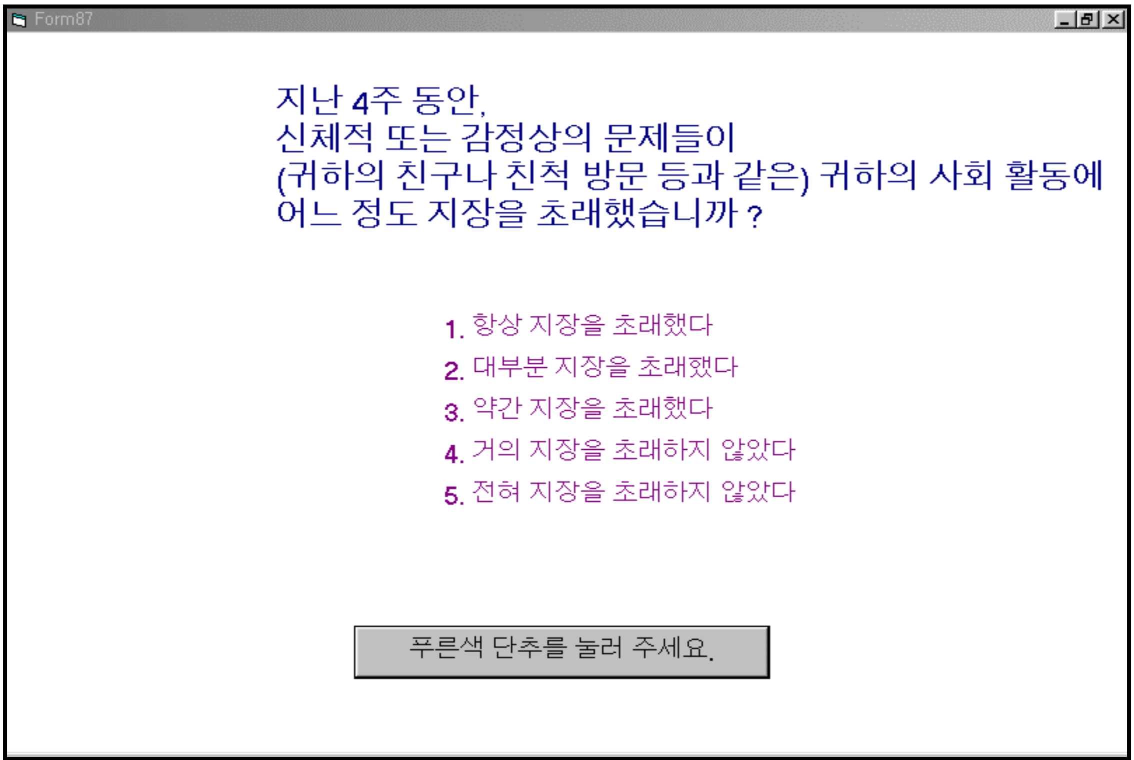
Form86

다음의 질문들은 지난 4주 동안 귀하가 어떻게 느끼시고
귀하의 상태가 어떠했는지와 관련된 질문들입니다.
각 문항에서 귀하가 느끼고 있는 것과
가장 가깝다고 생각하는 보기를 골라 주십시오.

지난 4주 동안 귀하는 얼마나 자주

	항상	대부분	상당한 시간동안	약간의 시간동안	매우 잠시동안	전ㅎ
- 마음이 상하거나 우울하다고 느끼셨습니까?	1	2	3	4	5	6
- 피로에 지쳤다고 느끼셨습니까?	1	2	3	4	5	6
- 행복한 사람이라고 느끼셨습니까?	1	2	3	4	5	6
- 피곤하다고 느끼셨습니까?	1	2	3	4	5	6

푸른색 단추를 눌러 주세요.

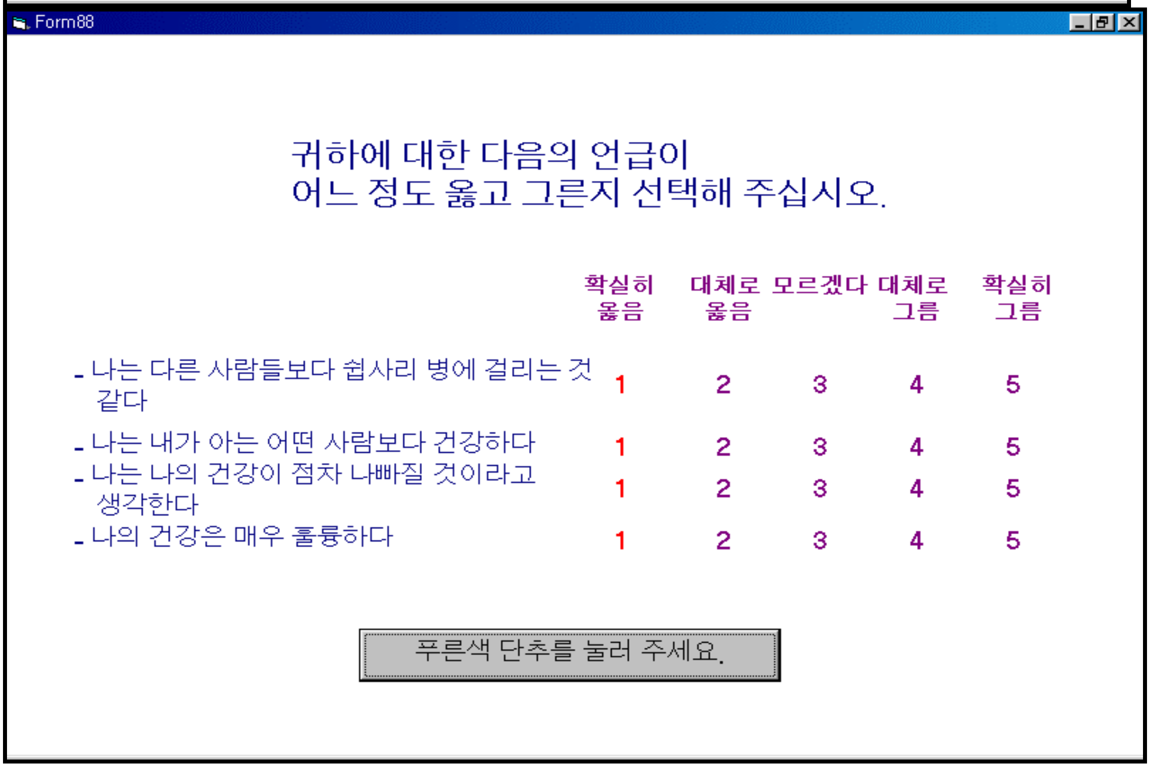


Form87

지난 4주 동안,
신체적 또는 감정상의 문제들이
(귀하의 친구나 친척 방문 등과 같은) 귀하의 사회 활동에
어느 정도 지장을 초래했습니까 ?

1. 항상 지장을 초래했다
2. 대부분 지장을 초래했다
3. 약간 지장을 초래했다
4. 거의 지장을 초래하지 않았다
5. 전혀 지장을 초래하지 않았다

푸른색 단추를 눌러 주세요.

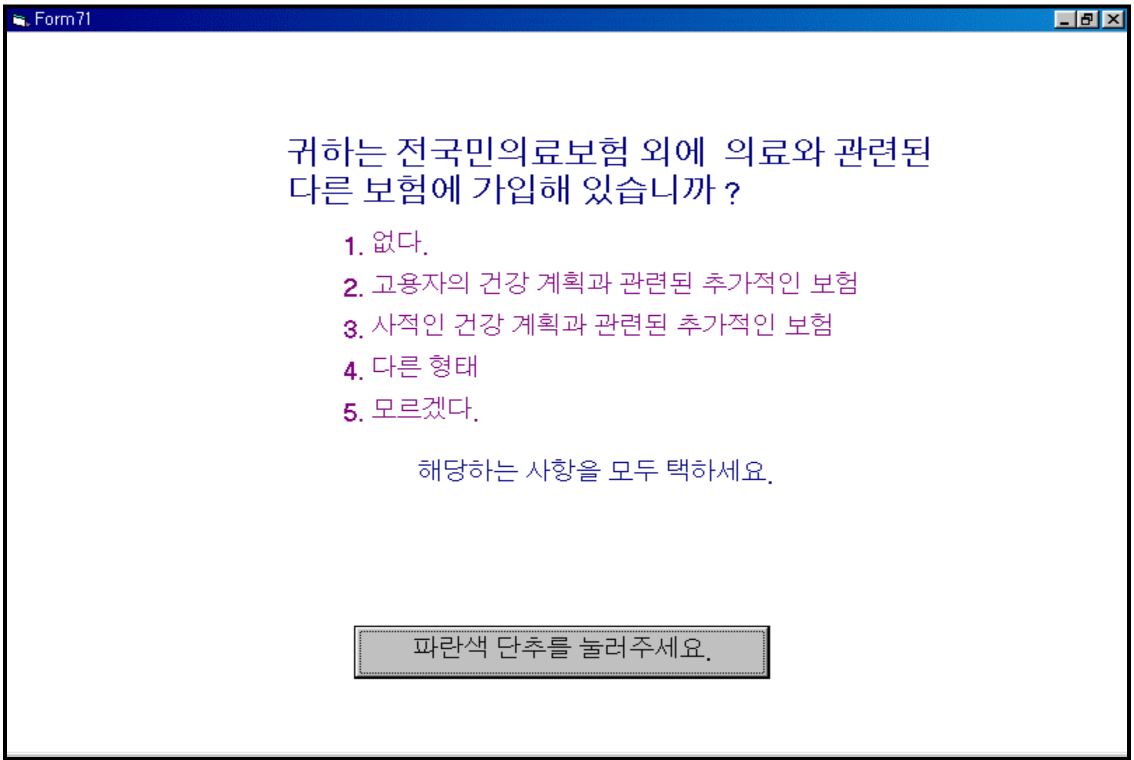


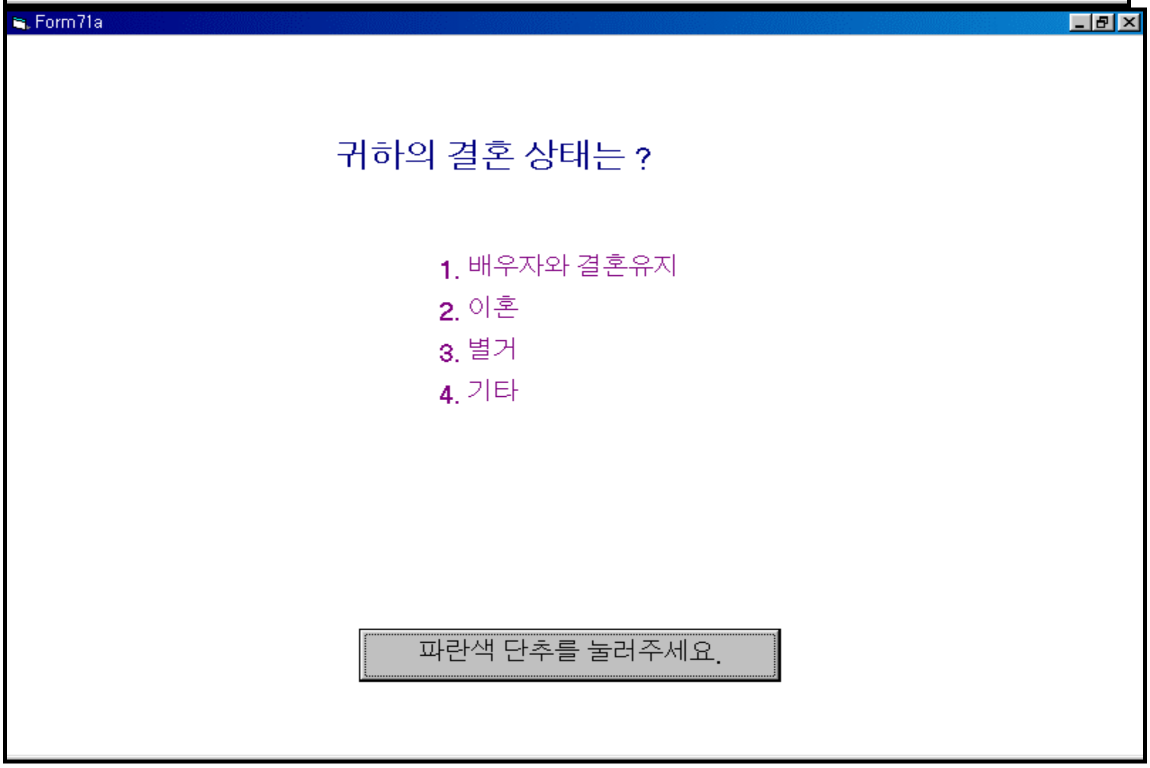
Form88

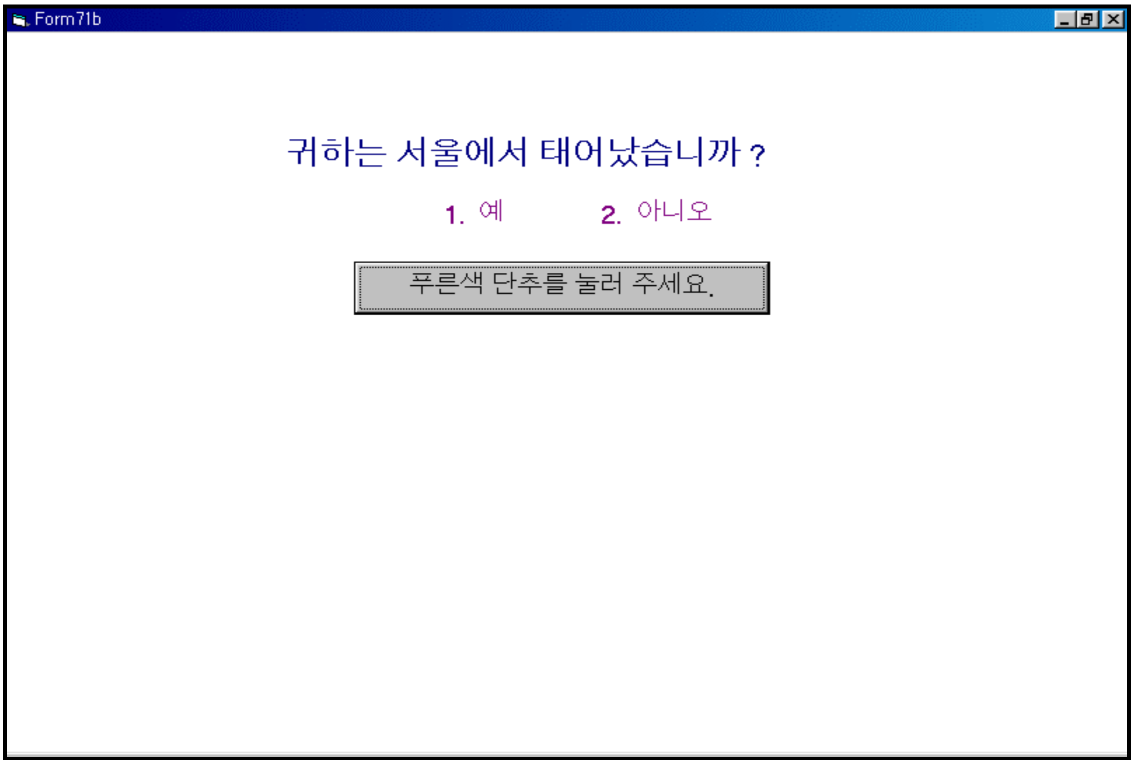
귀하에 대한 다음의 언급이
어느 정도 옳고 그른지 선택해 주십시오.

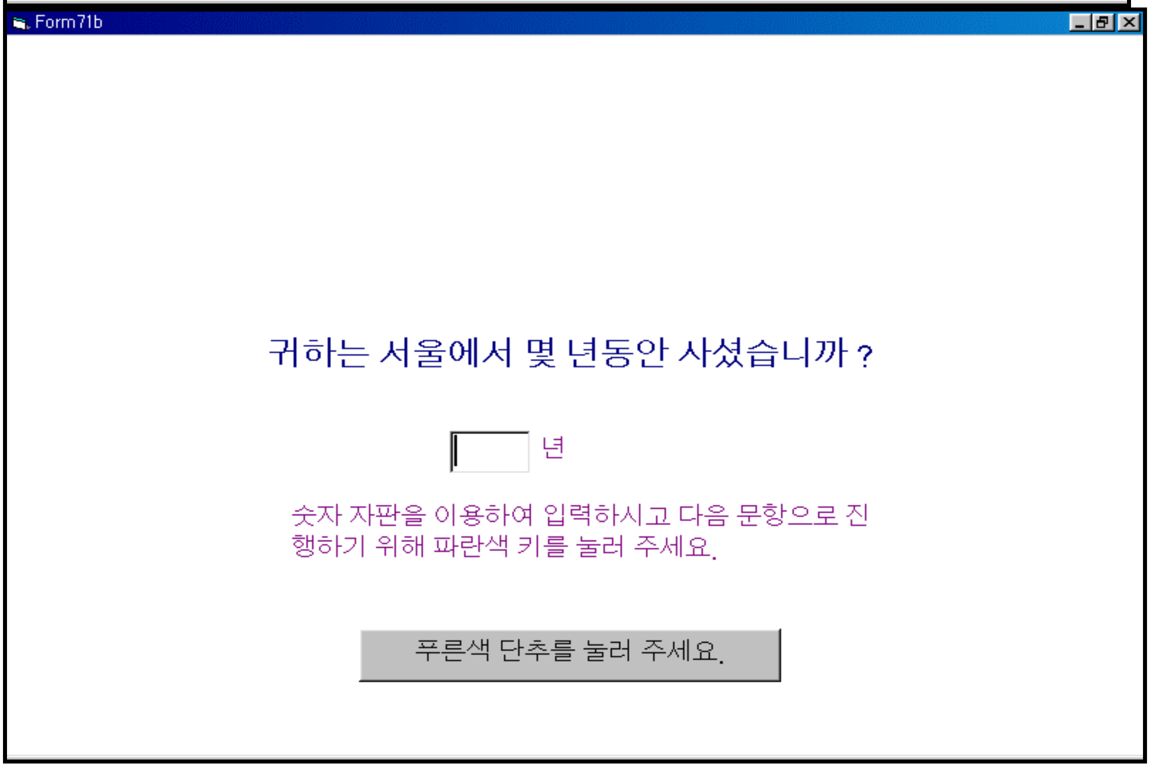
	확실히 옳음	대체로 옳음	모르겠다	대체로 그름	확실히 그름
- 나는 다른 사람들보다 쉽사리 병에 걸리는 것 같다	1	2	3	4	5
- 나는 내가 아는 어떤 사람보다 건강하다	1	2	3	4	5
- 나는 나의 건강이 점차 나빠질 것이라고 생각한다	1	2	3	4	5
- 나의 건강은 매우 훌륭하다	1	2	3	4	5

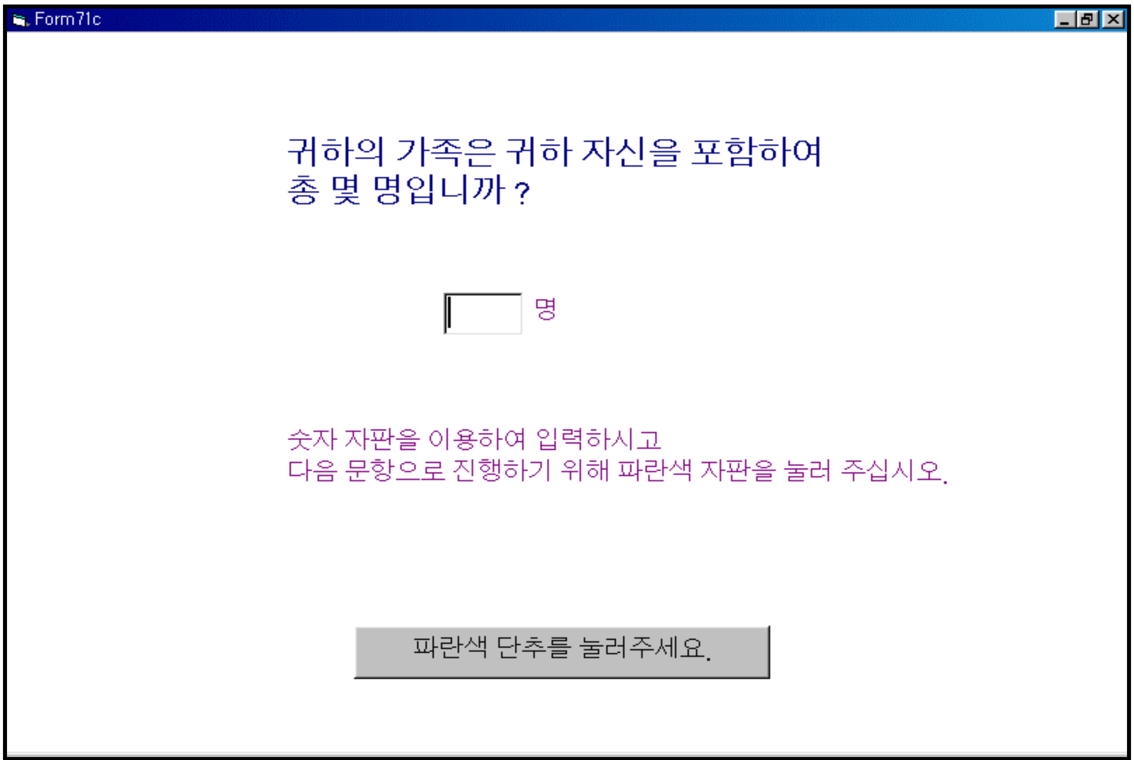
푸른색 단추를 눌러 주세요.

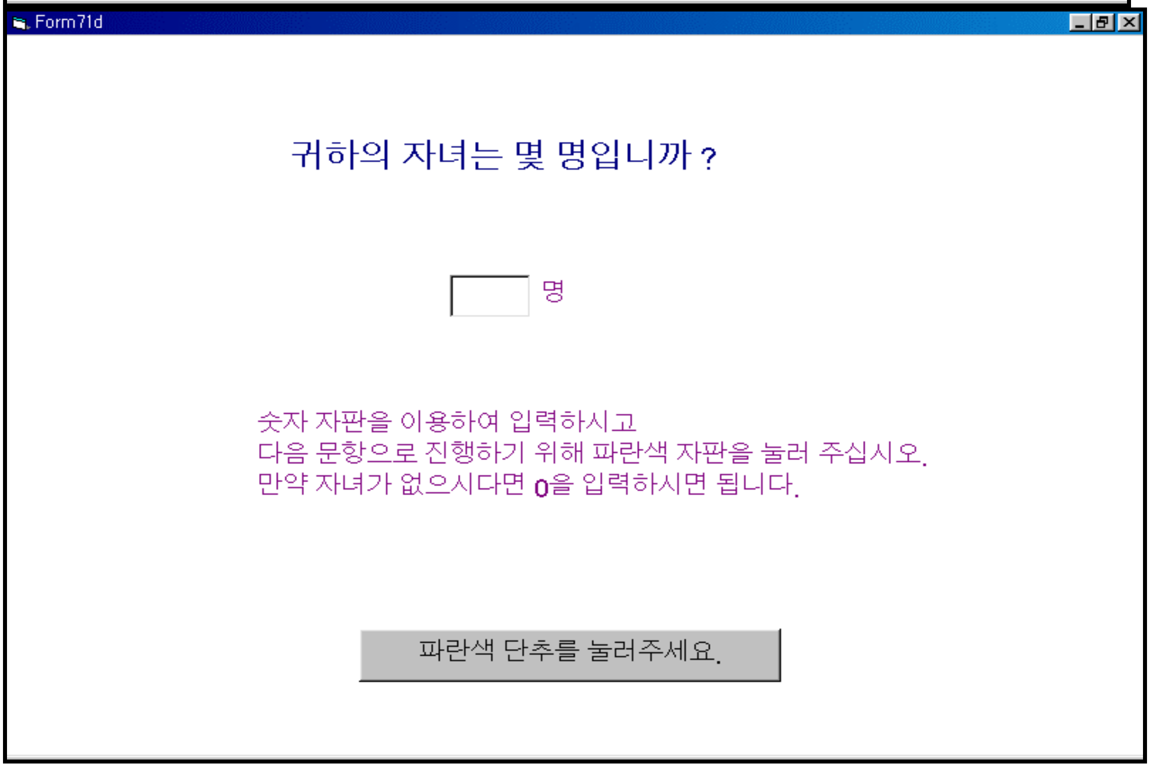

Form71
귀하는 전국민의료보험 외에 의료와 관련된
다른 보험에 가입해 있습니까 ?
1. 없다.
2. 고용자의 건강 계획과 관련된 추가적인 보험
3. 사적인 건강 계획과 관련된 추가적인 보험
4. 다른 형태
5. 모르겠다.
해당하는 사항을 모두 택하세요.
파란색 단추를 눌러주세요.

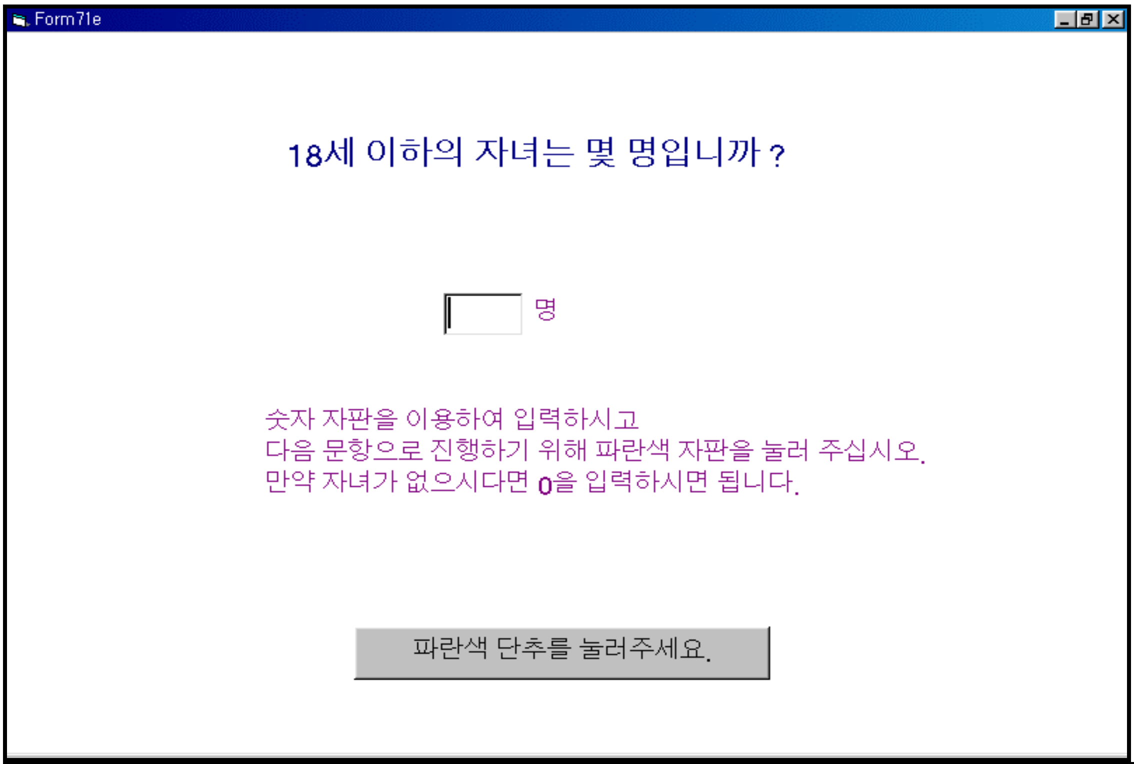

Form71a
귀하의 결혼 상태는 ?
1. 배우자와 결혼유지
2. 이혼
3. 별거
4. 기타
파란색 단추를 눌러주세요.

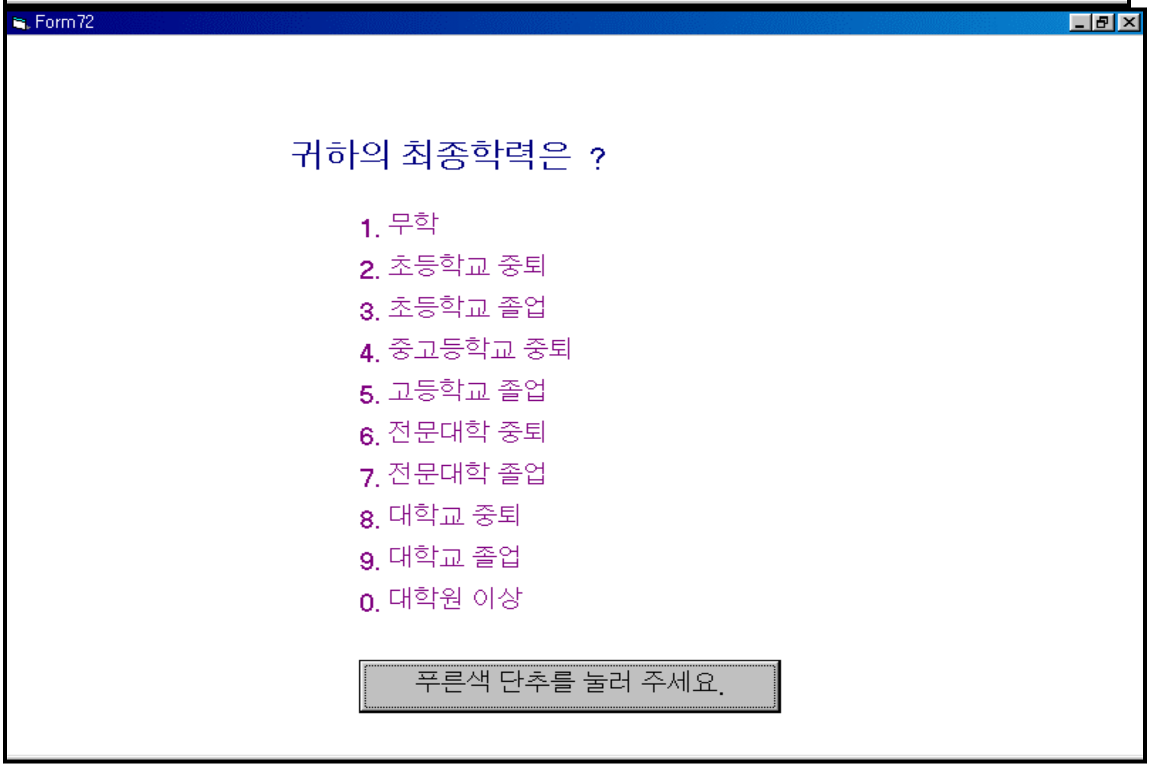

Form71b
귀하는 서울에서 태어났습니까?
1. 예
2. 아니오
푸른색 단추를 눌러 주세요.

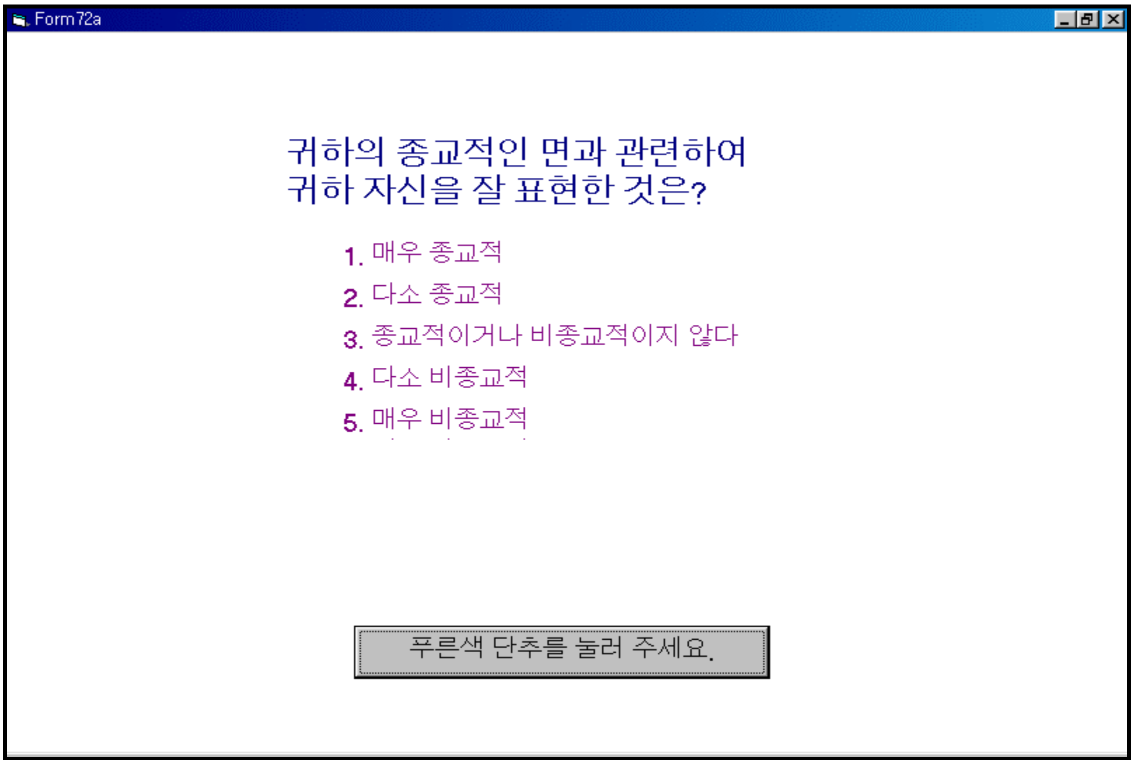

Form71b
귀하는 서울에서 몇 년동안 사셨습니까?
년
숫자 자판을 이용하여 입력하시고 다음 문항으로 진
행하기 위해 파란색 키를 눌러 주세요.
푸른색 단추를 눌러 주세요.

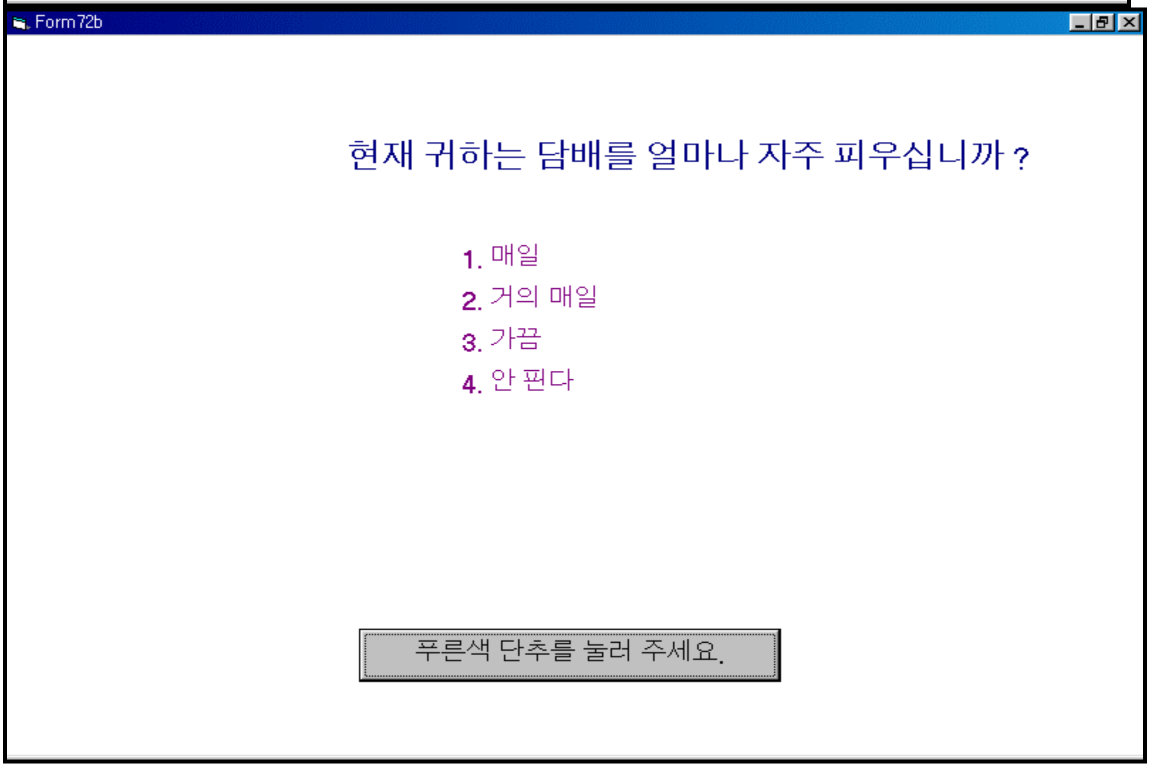

Form71c
귀하의 가족은 귀하 자신을 포함하여
총 몇 명입니까 ?
명
숫자 자판을 이용하여 입력하시고
다음 문항으로 진행하기 위해 파란색 자판을 눌러 주십시오.
파란색 단추를 눌러주세요.

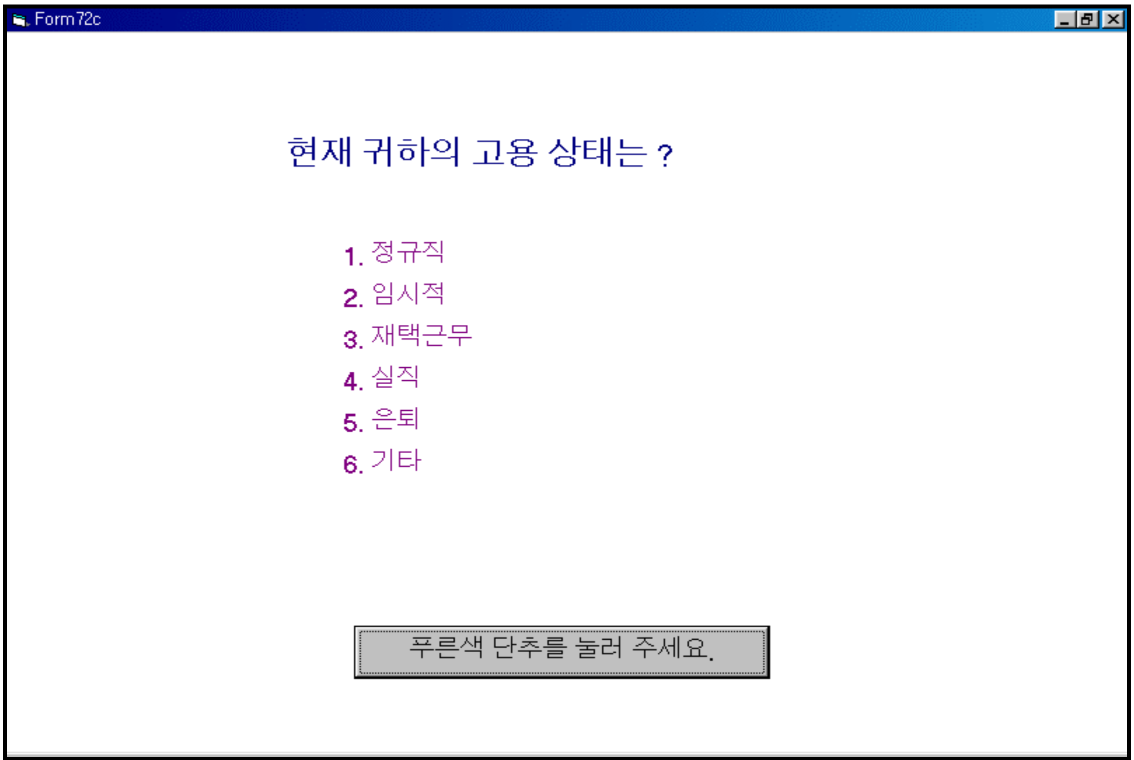

Form71d
귀하의 자녀는 몇 명입니까 ?
명
숫자 자판을 이용하여 입력하시고
다음 문항으로 진행하기 위해 파란색 자판을 눌러 주십시오.
만약 자녀가 없으시다면 0을 입력하시면 됩니다.
파란색 단추를 눌러주세요.

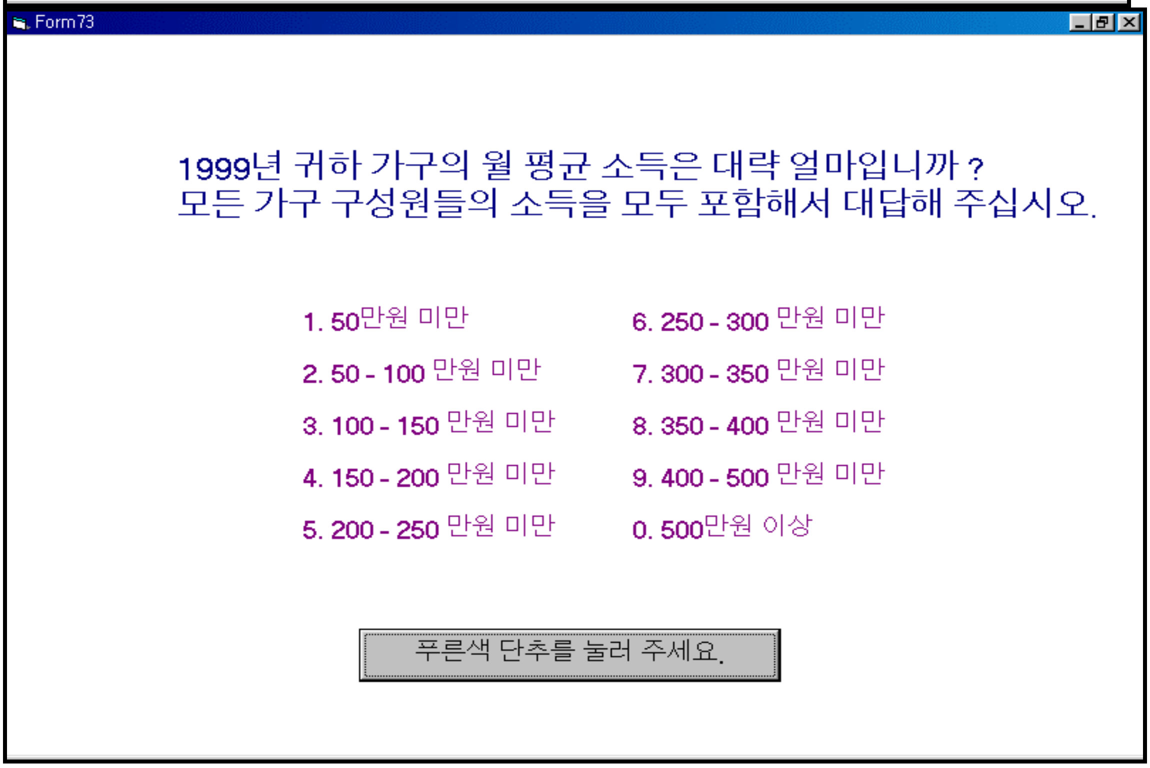

Form71e
18세 이하의 자녀는 몇 명입니까 ?
명
숫자 자판을 이용하여 입력하시고
다음 문항으로 진행하기 위해 파란색 자판을 눌러 주십시오.
만약 자녀가 없으시다면 0을 입력하시면 됩니다.
파란색 단추를 눌러주세요.

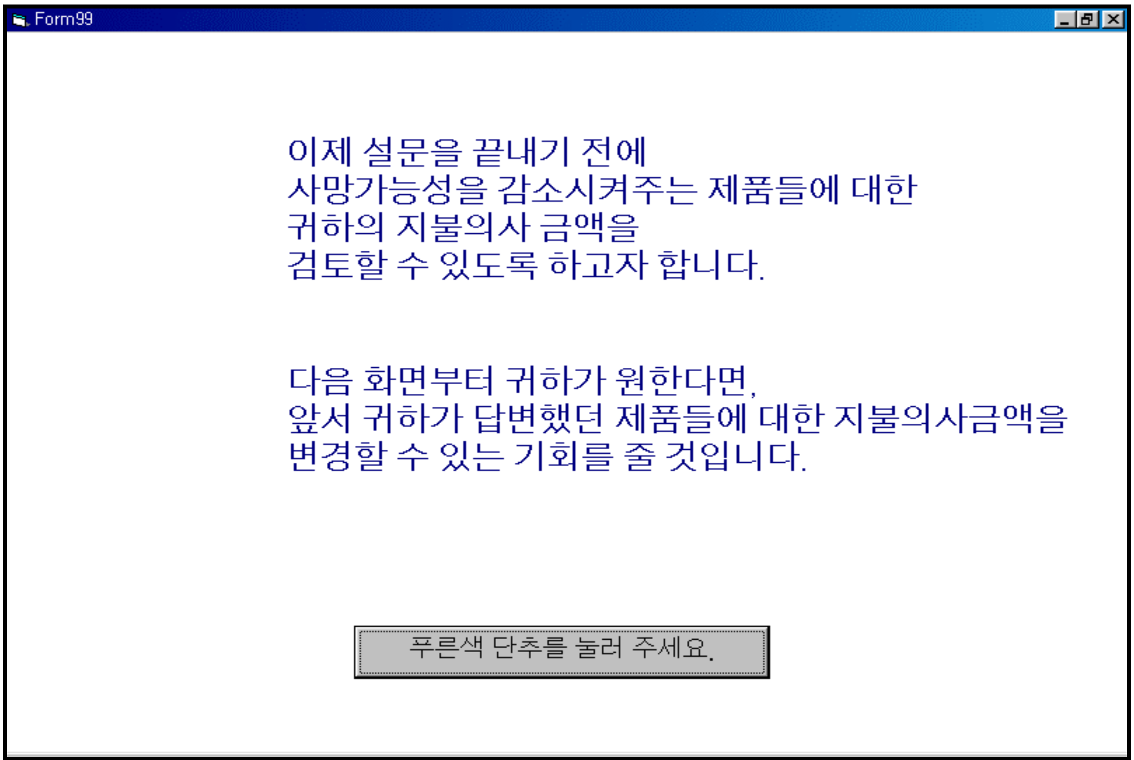

Form72
귀하의 최종학력은 ?
1. 무학
2. 초등학교 중퇴
3. 초등학교 졸업
4. 중고등학교 중퇴
5. 고등학교 졸업
6. 전문대학 중퇴
7. 전문대학 졸업
8. 대학교 중퇴
9. 대학교 졸업
0. 대학원 이상
푸른색 단추를 눌러 주세요.

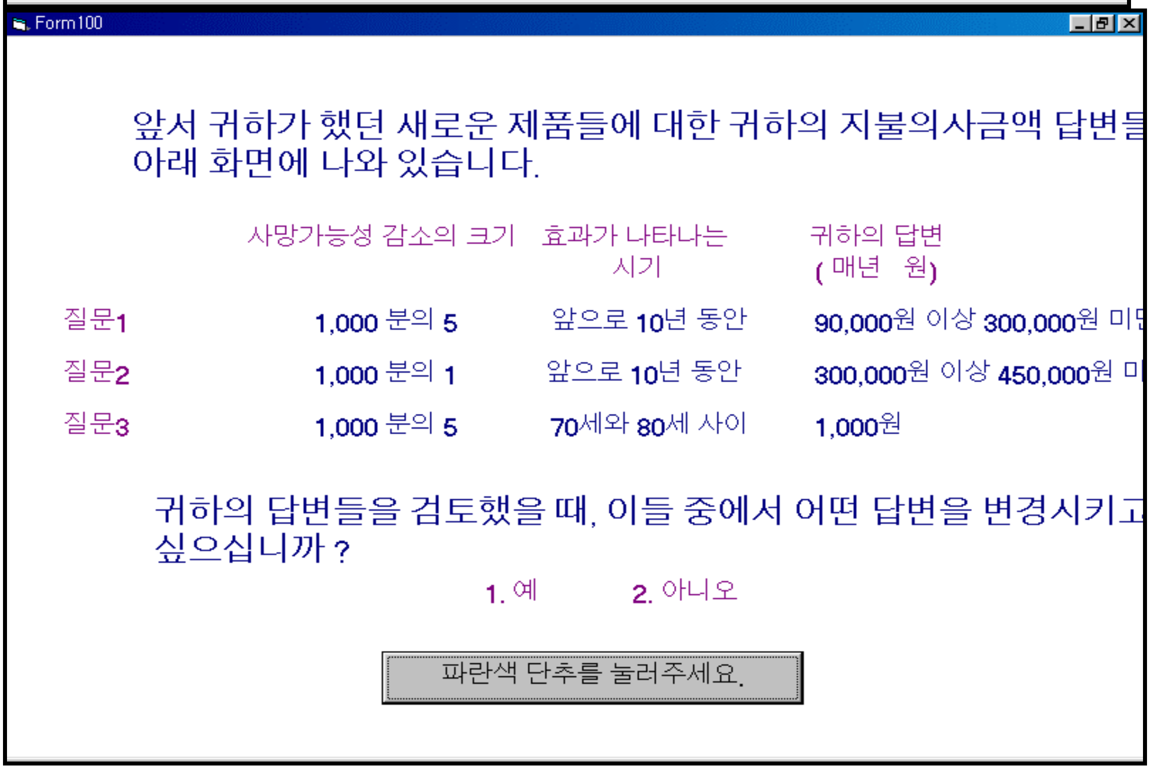

Form72a
귀하의 종교적인 면과 관련하여
귀하 자신을 잘 표현한 것은?
1. 매우 종교적
2. 다소 종교적
3. 종교적이거나 비종교적이지 않다
4. 다소 비종교적
5. 매우 비종교적
푸른색 단추를 눌러 주세요.

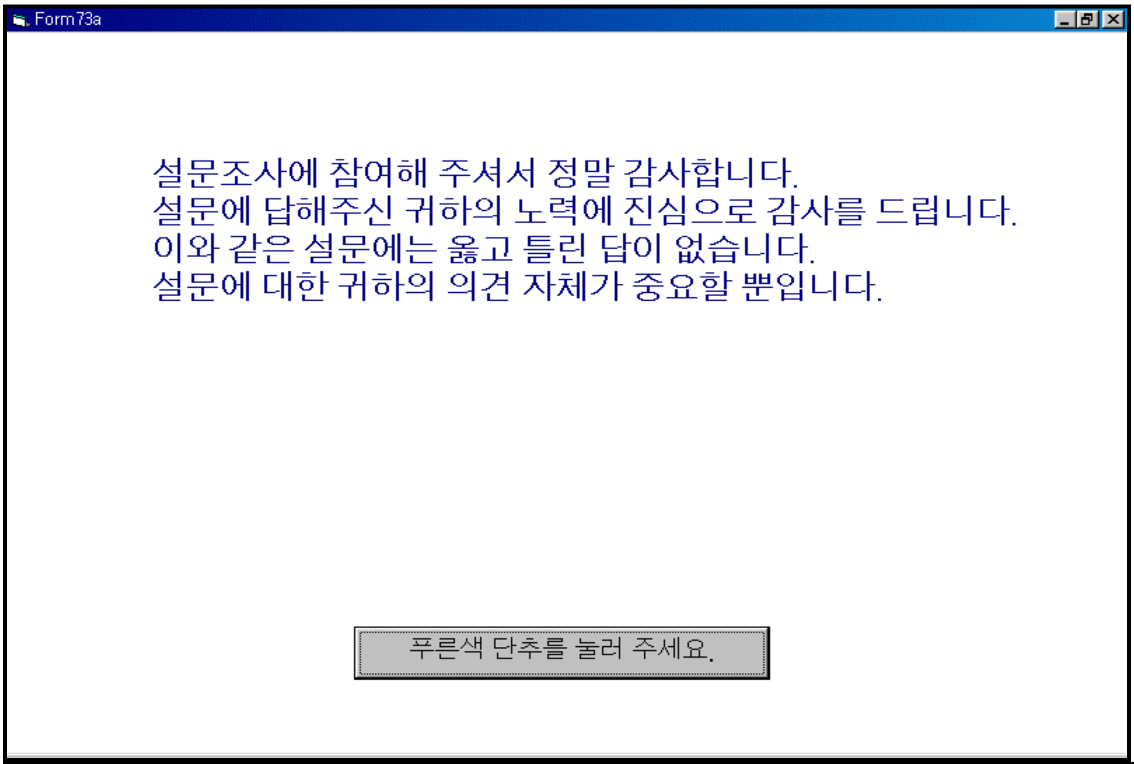

Form72b
현재 귀하는 담배를 얼마나 자주 피우십니까 ?
1. 매일
2. 거의 매일
3. 가끔
4. 안 핀다
푸른색 단추를 눌러 주세요.

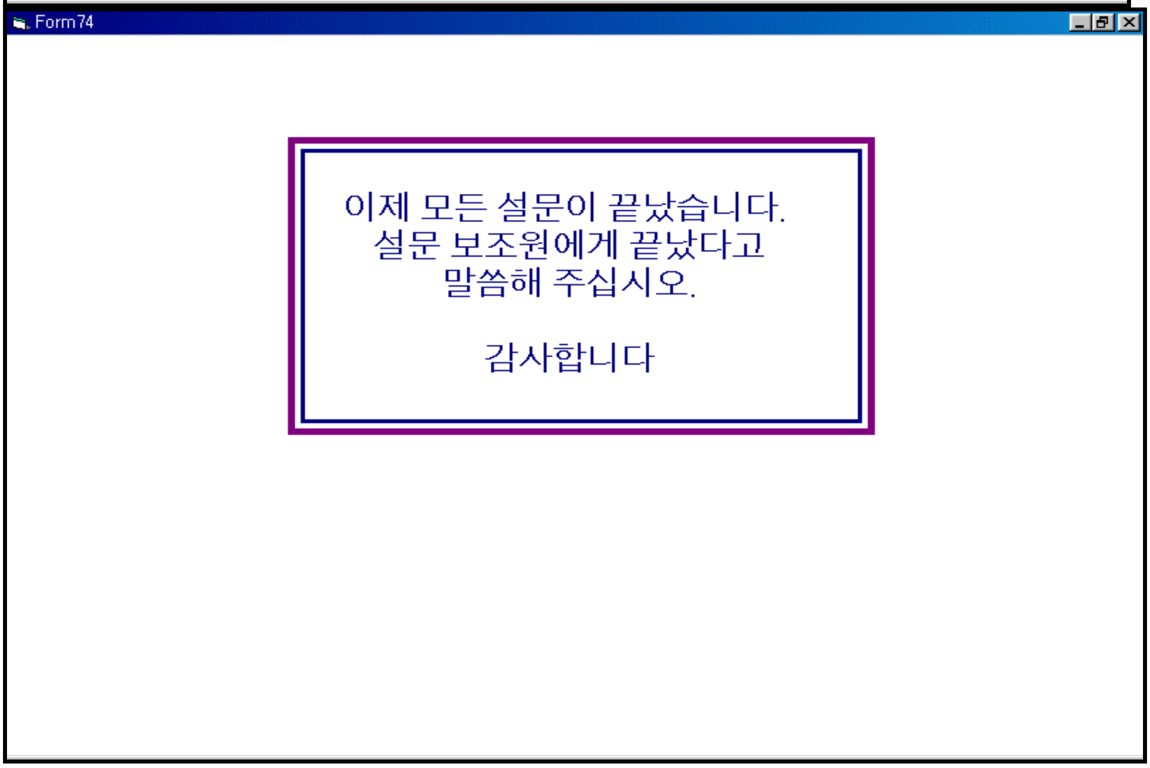

Form72c
현재 귀하의 고용 상태는 ?
1. 정규직
2. 임시적
3. 재택근무
4. 실직
5. 은퇴
6. 기타
푸른색 단추를 눌러 주세요.


Form73
1999년 귀하 가구의 월 평균 소득은 대략 얼마입니까 ?
모든 가구 구성원들의 소득을 모두 포함해서 대답해 주십시오.
1. 50만원 미만
2. 50 - 100 만원 미만
3. 100 - 150 만원 미만
4. 150 - 200 만원 미만
5. 200 - 250 만원 미만
6. 250 - 300 만원 미만
7. 300 - 350 만원 미만
8. 350 - 400 만원 미만
9. 400 - 500 만원 미만
0. 500만원 이상
푸른색 단추를 눌러 주세요.


Form99
이제 설문을 끝내기 전에
사망가능성을 감소시켜주는 제품들에 대한
귀하의 지불의사 금액을
검토할 수 있도록 하고자 합니다.
다음 화면부터 귀하가 원한다면,
앞서 귀하가 답변했던 제품들에 대한 지불의사금액을
변경할 수 있는 기회를 줄 것입니다.
푸른색 단추를 눌러 주세요.


Form100
앞서 귀하가 했던 새로운 제품들에 대한 귀하의 지불의사금액 답변들
아래 화면에 나와 있습니다.
사망가능성 감소의 크기
효과가 나타나는 시기
귀하의 답변 (매년 원)
질문1 1,000 분의 5 앞으로 10년 동안 90,000원 이상 300,000원 미만
질문2 1,000 분의 1 앞으로 10년 동안 300,000원 이상 450,000원 미
질문3 1,000 분의 5 70세와 80세 사이 1,000원
귀하의 답변들을 검토했을 때, 이들 중에서 어떤 답변을 변경시키고
싶으십니까?
1. 예
2. 아니오
파란색 단추를 눌러주세요.


Form73a
설문조사에 참여해 주셔서 정말 감사합니다.
설문에 답해주신 귀하의 노력에 진심으로 감사를 드립니다.
이와 같은 설문에는 옳고 틀린 답이 없습니다.
설문에 대한 귀하의 의견 자체가 중요할 뿐입니다.
푸른색 단추를 눌러 주세요.


Form74
이제 모든 설문이 끝났습니다.
설문 보조원에게 끝났다고
말씀해 주십시오.
감사합니다