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Relative Risk Ratio of Residents Living Near the Municipal Solid Waste Landfill Site at Some Province in South Korea

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Abstract: The purposes of this study were to investigate the symptoms, diseases and deaths of residents living near the municipal solid waste landfill site, and to compare the relative risk ratio of their adverse health effects with control group. In self-evaluation, the scores were especially severe lowest in residents of v2 and v3 villages(which were located about 500 m toward under the landfill site) such as 32.2 and 16.7 for village-environment, 24.8 and 16.0 for management of landfill site, and 23.5 and 16.5 for confidence of environmental policy, respectively. On symptoms, relative risk ratios were also highest as 3.53 and 3.55 for breathing difficulty, and 3.36 and 3.00 for respiratory symptom in v2 and v3 villages, respectively. On morbidity, they were slightly high as much as 1.39 and 1.24 in v5 and v2 villages, respectively. On mortality, relative risk ratios were 1.15~2.46 in experimental villages. They were especially high as much as 2.46 in v3 village where located near under the landfill site, and also 2.14 in v5 village where located at area affected with the landfill site, but near the sea. The rate of cancer causing death was average 35.2% of total deaths. It was very highest as much as 61.1% in v2 village, where was closely located near under the landfill site. Cancers causing death in this village were lung cancer(3 cases), larynx cancer(2 cases), stomach cancer(2 cases), pancreatic cancer(1 case), thryoid cancer(1 case), leukemia(1 case) and other(1 case). Our data, although based on limited number of cases and geographical coverage, suggest that residents living near landfill site have the increasing relative risks of various symptoms and mortality causing cancer. No causal mechanisms are available to explain these findings. But the possibility of a causal association between the increased adverse health effects and the municipal solid waste landfill site cannot be fully excluded.

Keywords: landfill, relative risk ratio, symptoms, morbidity, mortality

Introduction

Solid waste, discarded materials other than fluids, were collected and disposed of by municipalities. Municipal garbage included glass paper and paperboard (by far the largest constituent); in addition enormous tonnages of food residues, yard trimmings, textiles, plastics, and sludge formed in sewage treatment were produced. Although the amount of the increase has been slowed somewhat by recycling and composting programs and improvements in packaging, the amount of solid waste continues to increase annually. Moreover, the most common disposal methods pollute land, water, or air to some degree. Management of solid waste therefore presents an increasingly acute problem (Diaz *et al.*, 2004).

Approximately 62% of municipal waste is placed in landfills. If the waste is dumped untreated, it can promote the proliferation of rats, flies, and other vermin, encourage growth of disease-carrying organisms, contaminate surface and underground water, scar the land, and preempt open space. An alternative method of solid waste disposal is the sanitary landfill, first employed in Fresno, Calif., in 1937 (Louis, 2004). Waste is spread in thin layers, each tamped compactly and covered by a layer of earth. While more expensive than open dumping, the sanitary landfill eliminates health hazards and permits reclamation of the site for construction, recreation, or other purposes.

The disposal of wastes in landfill sites has increasingly caused concern about possible adverse health effects for populations living nearby. Landfill sites are perceived by nearby residents to be a serious environmental health hazard and reports of clusters of cancers, birth defects, and other diseases around sites reflect and contribute to these concerns (Heller & Catapreta, 2003). Despite widespread public concern and media attention, not much is

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known about the extent to which chemicals present in landfill sites may expose the populations living close to sites. Exposure to landfill sites is likely to be to low levels of mixtures of chemicals over a long period of time, which makes it very hard to establish associations with health effects.

Lee (2004) and Jung *et al.* (2003) reported that the incineration stacks of domestic and industrial municipal solid waste emitted the typical air pollutants, such as SOx, NOx, CO, HCl, PCDD/DFs, the volatile heavy metals such as Hg, Pb, As (Jung *et al.*, 1997). Baek *et al.* (2003) reported the municipal landfill could be an important emission sources of atmospheric VOCs, particularly in the vicinities of the landfill.

In 1996, residents living in the wards near the Nanty-Gwyddon landfill site voiced increasing concerns that odorous from the landfill were causing illnesses. Symptoms and diseases they associated with exposure included stress, fatigue, headaches, eye infectious or irritation, coughs, stuffy nose, dry throat and nausea, sarcoidosis, asthma, gastroschisis, and spontaneous abortions (Fielder *et al.*, 2000). The similar issues were submitted, but not yet studied the relative risk ratio of adverse health effects about residents living near the landfill site in South Korea.

The purposes of this study were to investigate of various symptoms, diseases and death, to compare the relative risk ratios of symptoms, morbidity and mortality causing cancer in residents living near municipal solid waste landfill site with control group. Specially, the target's area have had a big conflict between local autonomy and residents living near the landfill site because of health problem and environmental pollutants. This local autonomy was applied the sanitary landfill method for the municipal wastes. But residents said that it applied open landfill for a long time.

Subjects and Method

Target's Landfill Site

The municipality had 25,852 household, and 70,254 persons in 2003, which use the target's area as landfill of household solid wastes during 10 years, from January, 1999 to December 2003. The landfill site was 37,500 m^2 in area, 313,000 m^3 in total volume, and 132,900 m^3 (42.5%) in residual volume.

The landfill site was located the foot of the small mountain, and 7 villages were located about 2 km around area from under the landfill. 2 villages(v2 and v3), which were closely located about 500 m near under them, especially had a lots of complains for their health problems. Fig. 1 is a schematic map of landfill sites survey in this study.

Research Design

Fig. 2 shows the research design for health risk assessment of resident living near the municipal solid-waste landfill site. Experimental group was composed of 7 villages near under the landfill site. Control group was composed of 2 villages, where was located the same municipal area but not affected by landfill site.

Statistic Analysis

Adverse health effects for study were various self-consciousness symptoms, diagnostic diseases and deaths occurred among people in each villages. Data were collected by using the self-

Table 1. Emission rate of the municipality solid wastes

Year	Municipality		Emission rate (Ton/day)	Treatment method (Ton/day)		
	Area (km^2)	Population (person)		Landfill	Incineration	Reuse
1997	364.04	81,111	34.0	15.1(44.4%)	5.9(17.4%)	13.0(38.2%)
1998	357.67	80,202	33.0	12.6(38.2%)	4.6(13.9%)	15.8(47.9%)
1999	357.59	78,073	30.5	12.8(42.0%)	4.6(15.1%)	13.1(43.0%)
2000	357.63	75,400	30.0	14.7(49.0%)	3.6(12.0%)	11.7(39.0%)
2001	357.74	72,770	33.5	14.6(43.6%)	4.3(12.8%)	14.6(43.6%)
2002	357.85	70,114	35.0	17.1(47.5%)	4.9(13.6%)	14.0(38.9%)

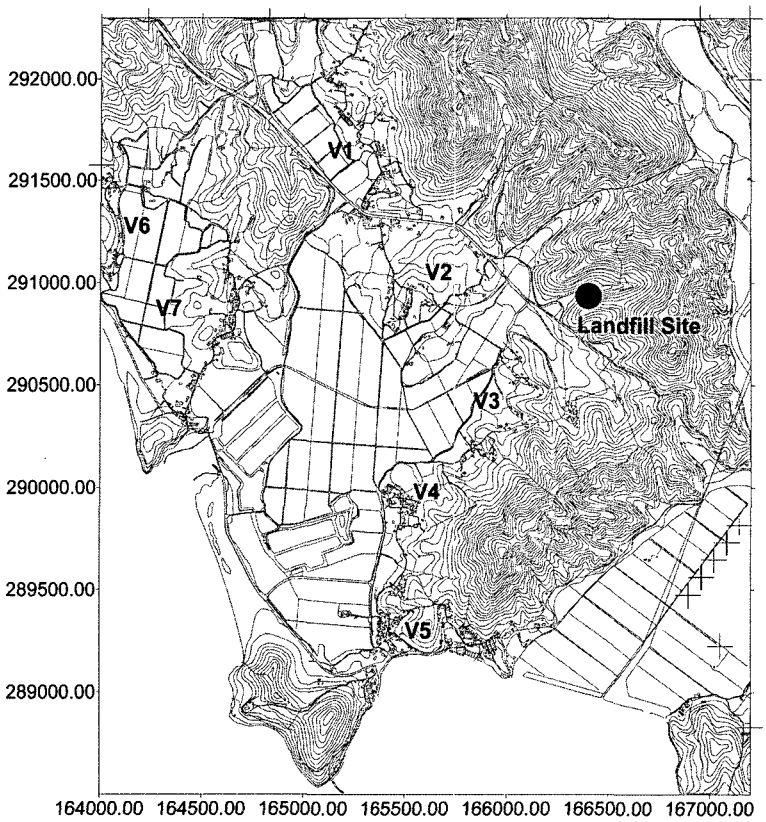

Fig. 1. A schematic map of landfill sites survey in this study.

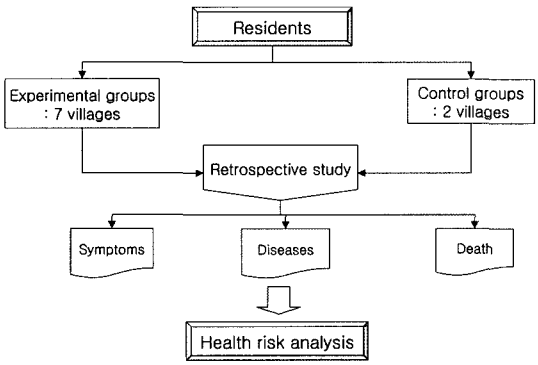

Fig. 2. Research design for health risk assessment of residents living near the municipal solid waste landfill site.

developed questionnaires from residents and documents deposited in township office. The trained investigators visit every house and interview to one adult per household during 7 days (June 28-July 3, 2004).

Chi-square test was used for analyzing the distribution differences among 9 villages of control and experimental groups. And the relative risk ratios was used as the comparative index of symptoms, morbidity and mortality causing cancer of residents between control and experimental groups. The relative risk ratio of control is 1. If 0 < relative risk ratio < 1, its risk is less the control, and if relative risk > 1, its risk is more than control. The more the relative risk ratios are above 1.0, the more risk of villages are serious.

Results and Discussion

Respondents' Characteristics

Table 2 shows the response rates. Total rate was 66.1% (415 household) of total 628 target households. The rates of each group are 53.8~74.4% in experimental groups, and 63.3~70.1% in control groups.

Table 3 is the composition of population in each

Table 2. Response rates in each village

Villages (household)		Target household	Respondents		Rate of total %
			Household	%	
Experiment (493)	V1	78	58	74.4	14.0
	V2	39	28	71.8	6.7
	V3	62	46	74.2	11.1
	V4	55	40	72.7	9.6
	V5	75	50	66.7	12.0
	V6	42	26	61.9	6.3
	V7	143	77	53.8	18.6
Control (134)	C1	77	54	70.1	13.0
	C2	57	36	63.2	8.7
Total		628	415	66.1	100.0

Table 3. Age composition in each village

Unit : person (%)

Villages		>40	40-49	50-59	60-69	70-79	80	Total
Experiment	V1	4(6.9)	8(13.8)	12(20.7)	13(22.4)	16(27.6)	5(8.6)	58(100.0)
	V2	-	6(21.4)	2(7.1)	9(32.1)	8(28.6)	3(10.7)	28(100.0)
	V3	3(6.5)	5(10.9)	6(13.0)	10(21.7)	19(41.3)	3(6.5)	46(100.0)
	V4	2(5.0)	6(15.0)	7(17.5)	12(30.0)	8(20.0)	5(12.5)	40(100.0)
	V5	3(6.0)	7(14.0)	20(40.0)	7(14.0)	11(22.0)	2(4.0)	50(100.0)
	V6	-	5(19.2)	5(19.2)	3(11.5)	12(46.2)	1(3.8)	26(100.0)
	V7	8(10.4)	17(22.1)	18(23.4)	20(26.0)	10(13.0)	4(5.2)	77(100.0)
Control	C1	1(1.9)	5(9.3)	6(11.1)	21(38.9)	16(29.6)	5(9.3)	54(100.0)
	C2	1(2.8)	3(8.3)	7(19.4)	10(27.8)	14(38.9)	1(2.8)	36(100.0)
Total		22(5.3)	62(14.9)	83(20.0)	105(25.3)	114(27.5)	29(7.0)	415(100.0)

χ^2 = 61.988, p = 0.014, The rate of above 60 year old was 59.8%

Table 4. The residence periods of respondents in each village

Unit : person (%)

Villages		>40	40-49	50-59	60-69	70-79	80	Total
Experiment	V1	5(8.6)	7(12.1)	3(5.2)	9(15.5)	8(13.8)	26(44.8)	58(100.0)
	V2	2(7.1)	1(3.6)	4(14.3)	2(7.1)	5(17.9)	14(50.0)	28(100.0)
	V3	3(6.5)	-	5(10.9)	9(19.6)	7(15.2)	22(47.8)	46(100.0)
	V4	5(12.5)	3(7.5)	4(10.0)	2(5.0)	3(7.5)	23(57.5)	40(100.0)
	V5	2(4.0)	6(12.0)	7(14.0)	7(14.0)	5(10.0)	23(46.0)	50(100.0)
	V6	-	2((7.7)	4(15.4)	2(7.7)	4(15.4)	14(53.8)	26(100.0)
	V7	5(6.5)	6(7.8)	12(15.6)	7(9.1)	14(18.2)	33(42.9)	77(100.0)
Control	C1	4(7.4)	2(3.7)	4(7.4)	4(7.4)	7(13.0)	33(61.1)	54(100.0)
	C2	4(11.1)	2(5.6)	1(2.8)	3(8.3)	4(11.1)	22(61.1)	36(100.0)
Total		30(7.2)	29(7.0)	44(10.6)	45(10.8)	57(13.7)	210(50.6)	415(100.0)

χ^2 = 36.413, p = 0.632, The rate of above 10 years of residence period was 92.8%

village which showed the typical agriculture pattern. The rate of the above 60 years old residents was 59.8%, but the below 40 years old was only 5.3%. This trend was similar to control and experimental groups. Rates of the below 40 years old residents were 0.0~10.4% in experimental, and 1.9~2.8% in

control group.

Table 4 shows the residential period of respondents which was very long. the respondents' rate of the above 50 years residential period was 50.6%, and the above 10 years residential period was 92.8%. It said that they knew very well how administrate and manage the target landfill site was. And it were also high possible to affected to residents who lived near the site by environmental pollutants.

Level of Residents' Complaint about Adverse Health Effects

Fig. 3 shows the result about the question "Have landfill site threatened your family's health ?". the rates of "Yes" were 82.8~95.7% in residents of 7 experimental villages living near the landfill site, but 33.3~35.2% in residents of 2 control villages. This showed that almost all residents, who lived near the landfill site, worried about the threat of the environmental pollutants from landfill site.

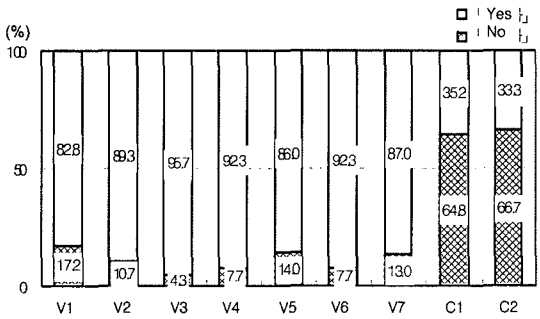

Fig. 3. The answering result of question "Have landfill site threatened your family's health?".

And also they seriously felt adverse effects about their family's health, and had a big complaint about landfill site itself and its management. Fielder, *et al.* (2000) reported that hydrogen sulphide from landfill site was probably responsible for odors by showing the environmental monitoring (Jung *et al.*, 1997). Al-Yaqout & Hamoda (2002) reported that dust created within the landfill site and gas emissions cause a public nuisance.

Table 5 shows the results of residents' self-evaluation scores about self-health, village-environment, management of landfill site, and confidence of environmental policy. Scores of almost fields were lower in experimental than control villages, and severe lowest in residents of v2 and v3 villages which were closely near the landfill site.

Scores of self-health were 40.4 and 43.7 in residents of v2 and v3 villages, 53.6~63.6 in the others. Scores of village-environment were 32.2 and 16.7 in residents of v2 and v3 villages, 52.0~85.6 in the others. Scores of management of landfill site were 24.8 and 16.0 in residents of v2 and v3 villages, 38.3~62.0 in the others. Scores of confidence of environmental policy were 23.5 and 16.5 in residents of v2 and v3 villages, 38.7~66.1 in the others. Especially, the scores of village-environment, management of landfill site, and confidence of environmental policy were specially lowest in residents of v2 and v3 villages.

It is very high possibility that residents' health will be bad because of the environment pollutants causing the wrong management and policy of landfill site. Al-Yaqout & Hamoda (2002) reported

Table 5. Self-evaluation scores of respondents about each filed (N = 415)

Unit : Mean (S.D.)

Villages		Self-health	Environment of village	Management of landfill site	Confidence of environmental policy
Experiment	V1	56.67(27.22)	59.72(23.46)	38.30(25.56)	39.58(27.67)
	V2	43.70(28.44)	32.22(24.23)	24.80(23.83)	23.60(21.19)
	V3	40.44(28.36)	16.67(20.56)	16.00(22.16)	16.51(21.48)
	V4	55.75(18.66)	52.63(21.51)	40.53(20.13)	39.36(21.77)
	V5	63.57(19.90)	52.04(28.13)	33.04(28.06)	38.65(28.00)
	V6	58.48(20.31)	62.81(18.44)	62.00(20.98)	52.73(15.55)
	V7	62.08(22.66)	56.69(16.38)	44.64(19.45)	43.84(21.19)
Control	C1	53.58(25.35)	85.57(12.54)	62.04(21.02)	66.05(20.60)
	C2	58.06(24.79)	67.58(20.62)	46.00(24.58)	60.37(41.22)
Average		55.60(25.04)	54.91(27.83)	38.48(25.96)	41.22(26.89)

Table 6. Relative risk ratio of residents' symptoms during of 1 year
(July 1, 2003~June 31, 2004)

Villages		Skin	Respiratory	Headache	Nausea	Diarrhea, abdomen pain	Mucosal irritation of eye and nose	Breathing difficulty	Average
Experiment	V1	1.25	1.48	1.42	1.96	1.42	1.92	2.22	1.67
	V2	2.35	3.36	1.61	2.38	1.26	2.44	3.53	2.42
	V3	1.96	3.00	1.85	2.47	2.13	2.43	3.55	2.48
	V4	2.51	2.86	1.67	2.61	2.05	2.16	1.98	2.26
	V5	1.66	2.29	1.65	2.03	1.96	2.18	2.22	2.00
	V6	2.00	1.31	1.44	1.57	2.35	2.16	1.78	1.83
	V7	1.26	1.49	1.40	1.63	1.37	1.73	1.48	1.48
	mean	1.86	2.26	1.58	2.09	1.79	2.15	2.39	2.02
Control	C1 C2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

the management problems of solid waste landfills in Kuwat. The landfill sites receive all kinds of wastes such as food wastes, oil products, debris, dead animals, agricultural wastes, chemical wastes, wastewater and sewage sludge. The waste are dumped, spread and compacted in an uncontrolled manner and cover material is nor applied regularly. Baek *et al.* (2003) reported the municipal landfill could be an important emission sources of atmospheric VOCs, particularly in the vicinities of the landfill.

Relative Risk Ratio of Residents' Symptoms

Table 6 shows the relative risk ratio of residents' symptoms in experimental villages during 1 year, from July 1, 2003 to June 31, 2004.

Relative risk ratios were high as much as 2.39 and 2.26 for breathing difficulty and respiratory symptom, 2.15 for mucosus irritation of eye and nose and 2.09 for nausea symptom. Especially in v2 and v3 villages, they were very highest as 3.53 and 3.55 for breathing difficulty, and 3.36 and 3.00 for respiratory symptom.

It is very high possibility that air pollutants, which were occurred from landfill site, were affected to residents. Fielder *et al.* (2000) also reported that hospital data revealed a transient increase in admissions for asthma during the 3 years that

Table 7. Incidence rate of diagnostic diseases for 10 years
(Jan. 1, 1994~Dec. 31, 2003)

Villages		Incidence rate of diagnostic diseases (1994~2003)						Relative risk ratio
		Yes		No		Total		
		Household	%	Household	%	Household	%	
Experiment	V1	26	44.8	32	55.2	58	100.0	0.92
	V2	17	60.7	11	39.3	28	100.0	1.24
	V3	22	47.8	24	52.2	46	100.0	0.98
	V4	22	55.0	18	45.0	40	100.0	1.13
	V5	34	68.0	16	32.0	50	100.0	1.39
	V6	13	50.0	13	50.0	26	100.0	1.02
	V7	34	44.2	43	55.8	77	100.0	0.90
Control	C1	26	48.1	28	51.9	54	100.0	1.00
	C2	18	50.0	18	50.0	36	100.0	1.00
Total		212	51.1	203	48.9	415	100.0	

$\chi^2 = 9.809$, $p = 0.279$

preceded the peak in odor complaints. The study of ATSDR (2004) raised the possibility of increased respiratory disease during the period of time that landfill was burning but failed to find a persisting effects after the fires were extinguished. Air pollution sources other than the burning landfill were thought to be another important source of exposure.

Incidence Rate of Diagnostic Diseases

Table 7 shows the incidence rates of diagnostic diseases for 10 years, from January 1, 1994 to December 31, 2003.

Relative risk ratios were slightly high as much as 1.39 and 1.24 in v5 and v2 villages, respectively. v5 village was located at area affected with landfill site, but near the sea, and v2 village was located near the landfill site. Fielder *et al.* (2000) reported that there were no consistent differences in mortality, rate of hospital admissions, or proportion of low birth-weight infants between before opening of landfill site and after that. Fielder *et al.* (2000) also reported, on study about residents near the Trecatti landfill site located in South Wales, UK, that mortality rates were higher for all causes and neoplastic diseases in the exposed wards.

Incidence Rate of Death

Table 8 shows the incidence of deaths for 10 years, from January 1, 1994 to December 31, 2003.

Relative risk ratios were high as much as 1.15~2.46 in experimental villages. They were especially very high as much as 2.46 in v3 village where located toward near the landfill site, and also 2.14 in v5 village where located at area affected with the landfill site, but near the sea.

Table 9 shows the causes of death in each village for the same 10 years. The rate of cancer causing death was average 35.2% of total death. It was very highest as much as 61.1% in v2 village, where was closely located near the landfill site. Cancers causing death in this village were lung cancer(3 cases), larynx cancer(2 cases), stomach cancer(2 cases), pancreatic cancer(1 case), thryoid cancer(1 case), leukemia(1 case), other(1 case).

Florida DOH (2004) conducted a cancer incidence data analysis for the landfill area and calculated Standardized Incidence Ratios(SIR). In their study, those SIRs increased, were cancer of the kidney (1.3, 1.2), the liver(1.2), melanoma(skin cancer (1.2), non-Hodgkin's lymphoma(1.3, 1.1), the other respiratory system(1.6), and soft tissue sarcomas (1.8), but were not statistically significant.

Conclusion

For investigating the adverse health effects of residents living near the municipal solid-waste landfill site at some province in South Korea, we

Table 8. Incidence rate of deaths for 10 years

(Jan. 1, 1994~Dec. 31, 2003)

Villages		Incidence rate of deaths (1994~2003)						Relative risk ratio
		Yes		No		Total		
		Household	%	Household	%	Household	%	
Experiment	V1	17*	28.8	42	71.2	59	100.0	1.85
	V2	7	25.0	21	75.0	28	100.0	1.61
	V3	18*	38.3	29	61.7	47	100.0	2.46
	V4	12*	29.3	29	70.7	41	100.0	1.88
	V5	17*	33.3	34	66.7	51	100.0	2.14
	V6	6	23.1	20	76.9	26	100.0	1.48
	V7	14*	17.9	64	82.1	78	100.0	1.15
Control	C1	12	22.2	42	77.8	54	100.0	1.00
	C2	2	5.6	34	94.4	36	100.0	1.00
Total		105	24.1	315	75.9	415	100.0	

$\chi^2 = 16.554$, $p = 0.035$

*: One household have 2 cases, respectively

Table 9. Causes of deaths occurred for 10 years (Jan. 1, 1994~Dec. 31, 2003)

Unit : person (%)

Causes of deaths		V1	V2	V3	V4	V5	V6	V7	C1	C2	Total (%)
Cancer	Liver	2	1								3 (8.1)
	Larynx	1		2							3 (8.1)
	Lung	1	1	3				2			7 (18.9)
	Mouth	1									1 (2.7)
	Stomach			2	1	2	1	1			7 (18.9)
	Breast	1									1 (2.7)
	Colon		1							1	2 (5.4)
	Bladder						1				1 (2.7)
	Pancreatic			1							1 (2.7)
	Prostatitis								1		1 (2.7)
	Thyroid			1		1					2 (5.4)
	Lymphatic gland					1					1 (2.7)
	Skin				1						1 (2.7)
	Brain tumor							1			1 (2.7)
	Leukemia			1							1 (2.7)
	Others			1	1	1			1		4 (10.8)
	Sub-total	6	3	11	3	5	2	4	2	1	37 (100.0)
	% of total death	(35.3)	(42.8)	(61.1)	(25.0)	(29.4)	(33.3)	(28.6)	(16.7)	(50.0)	(35.2)
Lung diseases				1				1			2
Liver diseases		1						1			2
Breathing difficulty		1	2	1				1	1		6
Old age		5	1	4	4	6	3	3	6	1	33
Others	Highertensions Stroke, Diabetes Accidents	4	1	1	5	6	1	4	3		25
	Total	17	7	18	12	17	6	14	12	2	105
	(%)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

survey the experimental group, which include 7 villages toward near the landfill site, and control groups which included 2 villages. Residents living in this villages showed the typical agriculture pattern, The rate of the above 60 years old residents was 59.8%, but the below 40 years old was only 5.3%.

Residents living near the landfill site, had the big complaint about them. and seriously worried about the health causing the their pollutants emission. In self-evaluation, the scores were very low in village-environment, management of landfill site, and confidence of environmental policy, and especially severe lowest in residents of v2 and v3 villages (which were located about 500m under the landfill site) such as 32.2 and 16.7 for village-environment, 24.8 and 16.0 for management of landfill site, and 23.5 and 16.5 for confidence of environmental policy, respectively.

On symptoms, relative risk ratios were also very highest as 3.53 and 3.55 for breathing difficulty, and 3.36 and 3.00 for respiratory symptom in v2 and v3 villages, respectively.

Relative risk ratios of mobility were slightly high as much as 1.39 and 1.24 in v5 and v2 villages, respectively. Relative risk ratios of mortality were 1.15~2.46 in experimental villages. They were especially very high as much as 2.46 in v3 village where located near the landfill site, and also 2.14 in v5 village where located at area affected with

the landfill site, but near the sea.

The rate of cancer causing death was average 35.2% of total deaths. It was very highest as much as 61.1% in v2 village, where was closely located near the landfill site. Cancers causing death in this village were lung cancer(3 cases), larynx cancer(2 cases), stomach cancer(2 cases), pancreatic cancer (1 case), thryoid cancer(1 case), leukemia(1 case), other(1 case).

Our data, although based on limited number of cases and geographical coverage, suggest that residents living near landfill site have a increased relative risk of various symptoms and mortality causing cancer. No causal mechanisms are available to explain these findings. But the possibility of a causal association between the increased adverse health effects and the municipal solid waste landfill site cannot be fully excluded.

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