Effects of Paraquat Ban on Herbicide Poisoning-related Mortality

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Effects of Paraquat Ban on Herbicide Poisoning-related Mortality

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ABSTRACT

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Introduction

Paraquat is a life-threatening poison. In Korea, approval for the use of paraquat was discontinued in November 2011 and a complete sales ban took effect in November 2012. The suicide mortality by pesticide was decreased from 5.26 to 2.67 per 100,000 populations between 2011 and 2013. A single center study showed that the total number of suicide attempts decreased, and the proportion of paraquat to pesticides decreased from 63.4% to 24.5% from 2011 to 2014.
The purpose of this study is to evaluate the effect of paraquat ban on incidence and mortality of herbicide poisoning in Korea.

Materials and Methods

This retrospective study involved herbicide poisoning patients who were admitted to emergency medical facilities throughout South Korea between January 1, 2010 and December 31, 2014. To determine if there were any changes in the characteristics before and after the paraquat sales ban, an analysis was

performed using a chi-square test and independent two sample t-test. P-value < 0.05 was considered statistically significant. We performed univariate analysis to evaluate relationships among demographic characteristics. And identified independent prognostic factors for death of herbicide intoxication using multivariate logistic regression analysis integrating major covariates (selected here as variables with a P <0.05) indicated from our univariate analysis. Results were expressed as odds ratios (ORs) and 95% confidential intervals (CIs). To determine if there were any changes in the mortality rates before and after the paraquat sales ban, and to determine the time point of any such significant changes in mortality, the R version 3.0.3 (package, bcp) was used to perform a Bayesian change point analysis

Results

A total of 2,257 patients were selected as study subjects and consisted of higher number of males (n=2,053, 90.9%). There are significant difference between the survival group and the death group except sex. The univariate analysis revealed that age, herbicide type, exposure route, paraquat ban, sex, co-ingestion, dose and intention were significantly different between death and survival. The multivariate logistic regression model revealed that same result to univariate analysis except paraquat ban and exposure route. In the Bayesian change point analysis, major increase in the change rate of herbicide mortality was observed in February 2012 , approximately 3 months after the paraquat ban was enforced, which correlates with a prominent decrease in the mortality rate. After that, the mortality rate decreased slightly and then stabilized until November 2013, when it dropped by a wide margin. This resulted in another major increase in the change rate that was higher than the previous change. This was approximately 1 year after the complete sales ban in November 2012.

Conclusions

This study suggests that the paraquat ban affected to decreased intentionality for herbicide ingestion and it is contributed to lowering the mortality rate associated with herbicide poisoning. The change point analysis shows that certain time frame may be required for the effects of the regulatory measures to manifest.

Key words: paraquat ban, herbicide, poisoning

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I. INTRODUCTION

Paraquat is a non-selective herbicide that is widely used in agriculture, as it is fast-acting and non-persistent in the environment. Although it has caused significant mortality worldwide when ingested, there is still little strong evidence of effective therapies.[1] Therefore, various measures were tried to reduce the mortality rate from paraquat poisoning. The INTEON formulation containing a natural alginate that immediately gels under gastric pH environment was developed to reduce gastrointestinal absorption of the paraquat.[2] However, this formulation did not show significant improvement of the survival rate.[3]

There are controversies whether the restriction or sales ban of highly toxic pesticide could reduce the mortality from pesticide poisoning. A study from the India shows that restriction of pesticide availability and accessibility by non-pesticide management has the potential to reduce suicidal attempts.[4] However, an experience from Sri Lanka shows shows the propensity to switch to the use of other pesticides that are often as toxic as the banned agent in agricultural practice.[5]

In Europe, the sale of paraquat was banned since 2007. A study from France analyzed poisoning-related cases that occurred 4.5 years before and after the sales ban revealed only a slight decrease after the sales ban.[6] The decrease was found mostly in unintentional poisoning cases. In Korea, the complete sales ban of paraquat products took effect in 2012. The pesticide-related suicide mortality decreased from 5.26 to 2.67 per 100,000 population between 2011 and 2013.[7] A single center study showed that the total number of suicide attempts decreased, and the proportion of paraquat to pesticides decreased from 63.4% to 24.5% from 2011 to 2014.[8] The purpose of this study is to evaluate the effect of paraquat ban on incidence and mortality of herbicide poisoning in Korea.

II. MATERIALS AND METHODS

Data Collection

The present study is a multicenter retrospective cohort study. We selected 18 hospitals across the country in order to determine the distribution of paraquat poisoning at the national level: 4 hospitals in Seoul, 2 in Gyeonggi, 2 in Busan, 2 in Daejeon, 2 in Daegu, 2 in Gwangju, 2 in Chungcheong, 1 in Gang won, 1 in Jeolla, 1 in Gyeongsang province (Figure 1). This study was approved by the institutional review board and informed consent was waived by the IRB. The hospitals were selected after verifying the willingness of the clinical toxicologists in each hospital to participate. Among the patients who visited each emergency departments between January 2010 and December 2014, those with herbicide poisoning were electronically retrieved by a final diagnostic code of toxic effect of herbicides and fungicides (ICD-10 code, T60.3). All routes of exposure such as the skin and eye contact as well as ingestion were included. Patients exposed to unknown herbicide product were excluded. We reviewed the medical records and extracted personal information (admission date, age, and sex), poisoning related information (product name, route of exposure, ingestion amount, time elapsed since exposure, and intentionality), and outcome (death or survival). If we could not obtain information about survival with the given medical record, a telephone survey was conducted. On the other hand, the number of suicide-related mortalities and unintentional exposure to poison (ICD codes, X60-X84 and X40-X49, respectively) between January 2010 and December 2014 was surveyed from the Korean Statistical Information Service (KOSIS) to determine changes by comparing the mortality rate before and after the sales ban.

Statistical analysis

The data were summarized as numbers and percentages. The mortality rate during the study period, the proportion of sex, intentionality, and percentage of poisoning patients according to the region were calculated. Then, to determine the difference in changes between paraquat and other herbicides, the exposed drugs were classified as paraquat, glyphosate, glufosinate, and other groups for the analysis. To account for the changes in the quantities sold and used, glyphosate and glufosinate, which are non-selective herbicides similar to paraquat were included in the herbicide group of substances that can be substituted for paraquat. Furthermore, the other substances such as benrazone sodium, 2-methyl-4-chlorophenoxyacetic acid (MCPA), orthosulfamuron, fenoxaprop-P-ethyl and mixtures of various agents were grouped together for the analysis since they were a few. We performed univariate analysis to evaluate relationships between demographic characteristics. Furthermore, we identified independent prognostic factors for death from herbicide intoxication using multivariate logistic regression analysis integrating major covariates (selected here as variables with a $P<0.05$), indicated from our univariate analysis. The results were expressed as odds ratios (ORs) and 95% confidential intervals (CIs). The statistical analysis software version 9.2 (SAS Institute, Cary, NC, USA) was used for all the data analyses.

Based on the mortality rates calculated for each drug type, an analysis was performed using a chi-square test and a P-value < 0.05 was considered statistically significant. To determine if there were any changes in the characteristics before and after the paraquat sales ban, an analysis was performed using a chi-square test and independent two sample t-test. A p-value < 0.05 was considered statistically significant. To determine if there were any changes in the mortality rates before and after the paraquat sales ban, and to determine the time point of any such significant changes in mortality, the R version 3.0.3 (package, bcp) was used to perform a Bayesian change point analysis.[9,10]

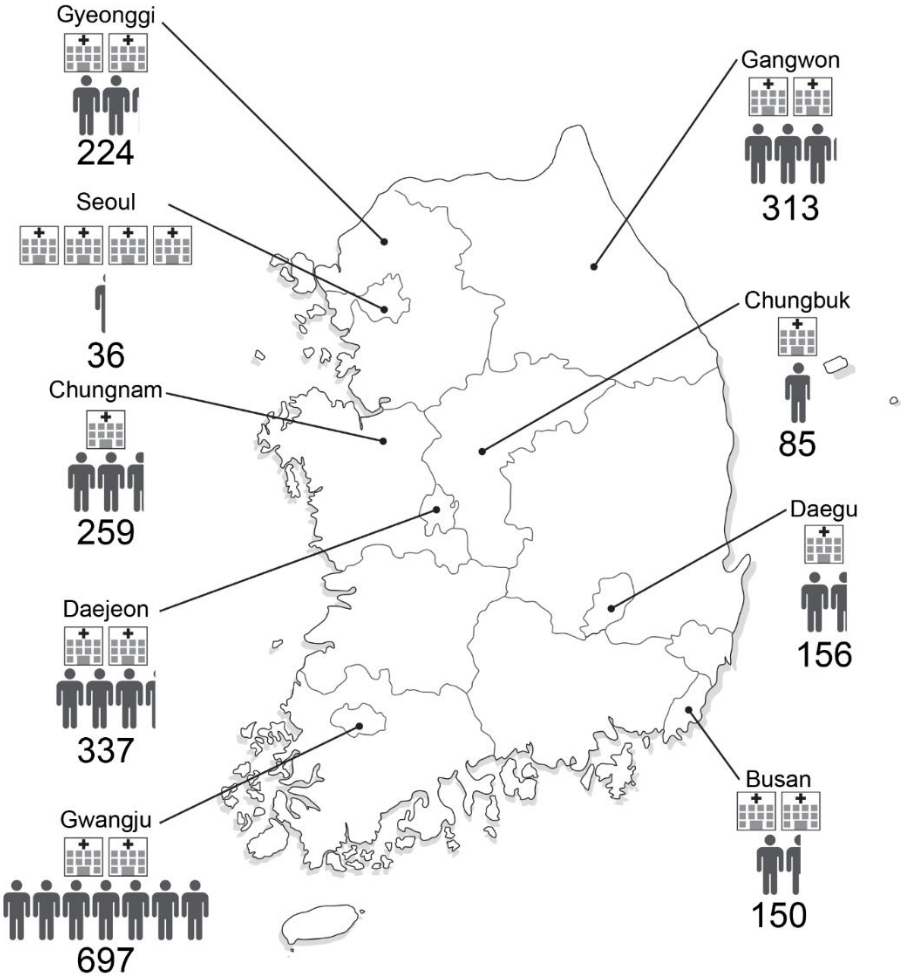

Figure 1. Regions of participating hospital and the number of enrolled patients

III. RESULTS

Total of 2,257 patients was enrolled as study subjects and consisted of a higher number of male (90.9%). Their mean age was 59.8 ± 16.1 years. Among the patients, the number who intentionally ingested herbicides were 1,794 (79.4%), and the number of poisoning cases was highest in Gwangju, followed by Daejeon, Gangwon province, in that order (Figure 1). The products that patients were exposed were paraquat 1,056 (46.8%), glyphosate 629 (27.9%), glufosinate 176 (7.8%), and there were 366 cases (16.2%) involving other agents including 30 mixed poisonings. During the study period it was summarized by separating each year to evaluate the changes in each herbicide poisoning (Figure 2). The 60% of patients was classified to the period of "before paraquat ban". The other epidemiological findings of the enrolled patients are shown in Table 1. The average patient mortality rate was 40.6%. The mortality rates for each herbicide were 73.0%, 13.8%, and 9.6%, for paraquat, glyphosate, and glufosinate, respectively (Table 1). Total herbicide mortality were 48.8% and 30.1% before and after paraquat ban, respectively. Among the patients with paraquat poisoning, the mortality rate was decreased from 74.9% in the before period to 67.3% in the after period (p=0.041, Table 2). The proportion of intentional poisoning was significantly decreased after paraquat ban (78.8% vs 70.3%, p=0.004, Table 2). There were significant differences in age, region, herbicide type, period, coingestion, exposure route, estimated dose, and intentionality between the survival and the mortality groups (Table 3). The multivariable logistic regression analysis confirmed that the "after paraquat ban" was associated with lower herbicide mortality (OR 0.738, p=0.035, Table 4).

To compare the pattern of change, the total number of mortalities by suicide and unintentional exposure to poison was depicted together between January 2010 and December 2014 was surveyed from the KOSIS (Figure 4).

Table 1. Epidemiological characteristics of enrolled patients with herbicide intoxication

		Paraquat	Glyphosate	Glufosinate	Mixed	Others	Total	%*
Case		1,056	629	176	30	366	2,257	
Sex								
	M	951 (90.1%)	577 (91.7%)	167 (94.9%)	29 (96.7%)	329 (89.9%)	2,053	91.0
Age		60.8±16.8	59.7±15.2	59.0±15.3	60.4±18.6	57.1±16.0	59.8±16.1	
Intentionality								
	Yes	809	521	151	25	288	1794	79.5
	No	247	108	25	5	78	463	20.5
Region								
	Gwangju	319	222	32	3	121	697	30.9
	Daejeon	153	110	28	2	44	337	14.9
	Gangwon	190	46	43	6	28	313	13.9
	Chungnam	136	77	21	0	25	259	11.5
	Gyeonggi	115	55	20	0	34	224	9.9
	Daegu	65	58	10	0	23	156	6.9
	Busan	42	31	10	14	53	150	6.6
	Chungbuk	25	13	10	4	33	85	3.8
	Seoul	11	17	2	1	5	36	1.6
Mortality (%)		73.0	13.7	9.7	10.0	10.1	40.6	

*Percentage by column **Sorted by number per region

In the Bayesian change point analysis, a major increase in the change rate of herbicide mortality was observed in February 2012, approximately 3 months after the paraquat ban was enforced, which correlates with a prominent decrease in the mortality rate. Subsequently, the mortality rate decreased slightly and then stabilized until November 2013, when it dropped by a wide margin. This resulted in another major increase in the change rate that was higher than the previous change was. This was approximately 1 year after the complete sales ban (Figure 2).

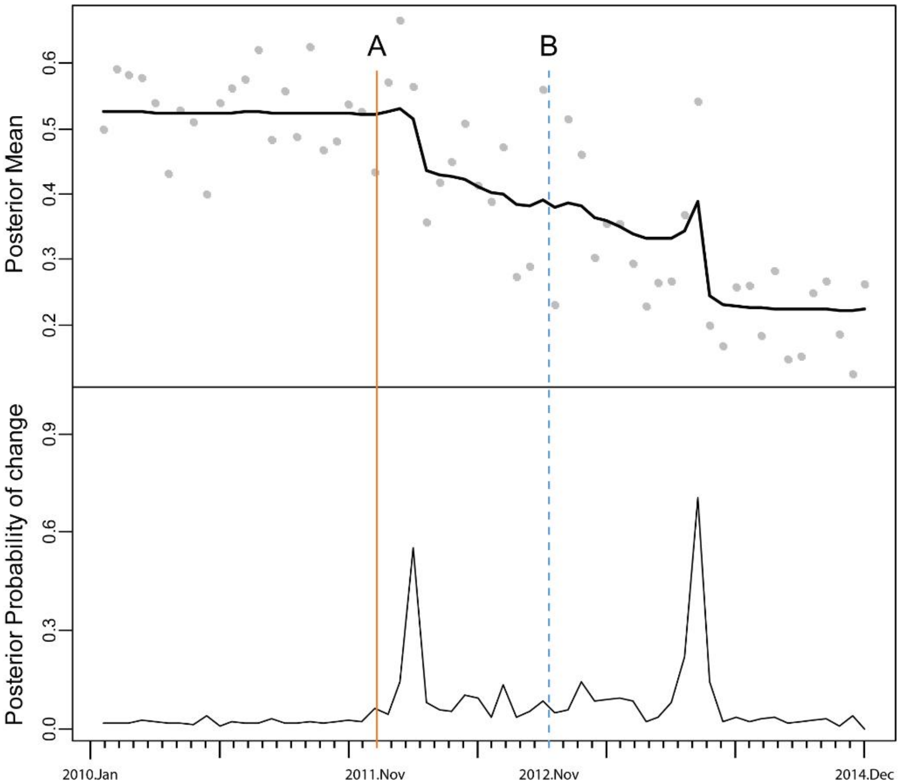

Figure 2. Bayesian change point analysis of herbicide mortality. Posterior mean is a trend line of herbicide mortality, posterior probability of change means that it reflects the amount of change of herbicide mortality.

A: Production ban, B: Distribution ban

Table 2. Demographics by survival and death

	Total (N=2,257)	Survival (N=1,341)	Death (N=916)	P-value*
Region				0.024
Gwanju	697 (30.9)	403 (30.1)	294 (32.1)	
Daejeon	337 (14.9)	189 (14.1)	148 (16.2)	
Gangwon	313 (13.9)	188 (14.0)	125 (13.6)	
Chungnam	259 (11.5)	137 (10.2)	122 (13.3)	
Gyeonggi	224 (9.9)	142 (10.6)	82 (9.0)	
Daegu	156 (6.9)	100 (7.5)	56 (6.1)	
Busan	150 (6.6)	99 (7.4)	51 (5.6)	
Chungbuk	85 (3.8)	56 (4.2)	29 (3.2)	
Seoul	36 (1.6)	27 (2.0)	9 (1.0)	
Age	59.8±16.1	56.4±15.4	64.6±15.9	<0.001
Herbicide type				<0.001
Paraquat	1,056 (46.8)	285 (21.3)	771 (84.2)	
Glyphosate	629 (27.9)	543 (40.5)	86 (9.4)	
Glufosinate	176 (7.8)	159 (11.9)	17 (1.9)	
Others	396 (17.5)	354 (26.4)	42 (4.6)	
Paraquat ban				<0.001
Before†	1,362 (60.3)	697 (52.0)	665 (72.6)	
After‡	895 (39.7)	644 (48.0)	251 (27.4)	
Sex				0.474
Male	2,053 (91)	1,215 (90.6)	838 (91.5)	
Female	204 (9)	126 (9.4)	78 (8.5)	
Co ingestion				0.007
None	1,789 (79.3)	1,039 (77.5)	750 (81.9)	
Alcohol	419 (18.6)	265 (19.8)	154 (16.8)	
Other herbicide	34 (1.5)	23 (1.7)	11 (1.2)	
Oral pill	15 (0.7)	14 (1.0)	1 (0.1)	
Exposure route				<0.001
Mouth	2,186 (96.9)	1,278 (95.3)	908 (99.1)	
Others	71 (3.2)	63 (4.7)	8 (0.9)	
Estimated dose (ml)				<0.001
<50	322 (14.3)	237 (17.7)	85 (9.3)	
50-100	540 (23.9)	349 (26.0)	191 (20.9)	
>100	796 (35.3)	474 (35.3)	322 (35.2)	
Unknown	599(26.5)	281(21.0)	318(34.7)	
Intention				0.001
Yes	1,794 (79.5)	1,033 (77.0)	761 (83.1)	
No	463 (20.5)	308 (23.0)	155 (16.9)	

* Independent two sample t-test, chi-square test
† January 2010- October 2012, ‡November 2012-December 2014

Table 3. Change of characteristics in paraquat intoxication before and after ban paraquat.

Variables	Total (N=1,056)	Before paraquat ban* (N=787)	After paraquat ban† (N=269)	P-value‡
Age	60.8±16.8	60.6±17.1	61.2±15.9	0.618
Sex				0.595
Male	951 (90.1)	711 (90.3)	240 (89.2)	
Female	105 (9.9)	76 (9.7)	29 (10.8)	
Herbicide type				0.626
Gramoxone	973 (92.1)	727 (92.4)	246 (91.5)	
Gramoxone inteon	83 (7.9)	60 (7.6)	23 (8.6)	
Exposure route				0.156
Mouth	1,006 (95.3)	754 (95.8)	252 (93.7)	
Others	50 (4.8)	33 (4.2)	17 (6.3)	
Intention				0.004*
Yes	247 (23.4)	167 (21.2)	80 (29.7)	
No	809 (76.6)	620 (78.8)	189 (70.3)	
Outcome				0.041*
Survival	285 (27.0)	197 (25.0)	88 (32.7)	
Death	771 (73.1)	590 (75.0)	181 (67.3)	

* January 2010- October 2012, †November 2012-December 2014, ‡Chi-square test

Table 4. Univariable logistic regression and multivariable logistic regression by survival and death

	Univariable logistic regression		Multivariable logistic regression	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age (years)	1.034 (1.028-1.04)	< 0.0001	1.048 (1.04-1.056)	< 0.0001
Gender (female)	0.898 (0.668-1.206)	0.474		
Herbicide type				
Paraquat	1 (reference)		1 (reference)	
Glyphosate	0.059 (0.045-0.076)	< 0.0001	0.039 (0.029-0.053)	< 0.0001
Glufosinate	0.04 (0.024-0.066)	< 0.0001	0.028 (0.016-0.048)	< 0.0001
Others	0.044 (0.031-0.062)	< 0.0001	0.031 (0.021-0.046)	< 0.0001
Paraquat ban (after)	0.409 (0.341-0.489)	< 0.0001	0.766 (0.598-0.982)	0.0352
Co-ingestion				
None	1 (reference)		1 (reference)	
Alcohol	0.805 (0.646-1.003)	0.053	1.63 (1.156-2.299)	0.0053
Other herbicides	0.663 (0.321-1.367)	0.266	0.959 (0.37-2.485)	0.9321
Other Med*	0.099 (0.013-0.754)	0.026	0.215 (0.024-1.893)	0.1662
Exposure route				
Ingestion	1 (reference)		1 (reference)	
Others	0.179 (0.085-0.375)	< 0.0001	0.099 (0.043-0.228)	<0.0001
Intentionality (yes)	1.464 (1.181-1.814)	0.0005	2.417 (1.711-3.416)	<0.0001

*Other medication

IV. DISCUSSION

After paraquat ban, the number of paraquat poisoning gradually but distinctly decreased while that of glyphosate, glufosinate, and other agents increased slightly (Figure 3). Similar results were reported by Lee et al.[8], who discovered a significant trend of increased annual number of suicides and proportion of suicide induced by glyphosates and glufosinates versus total herbicide. Another study revealed there was only a slight decrease in paraquat-related mortalities after its sale was banned in Europe from July 2007.[6]

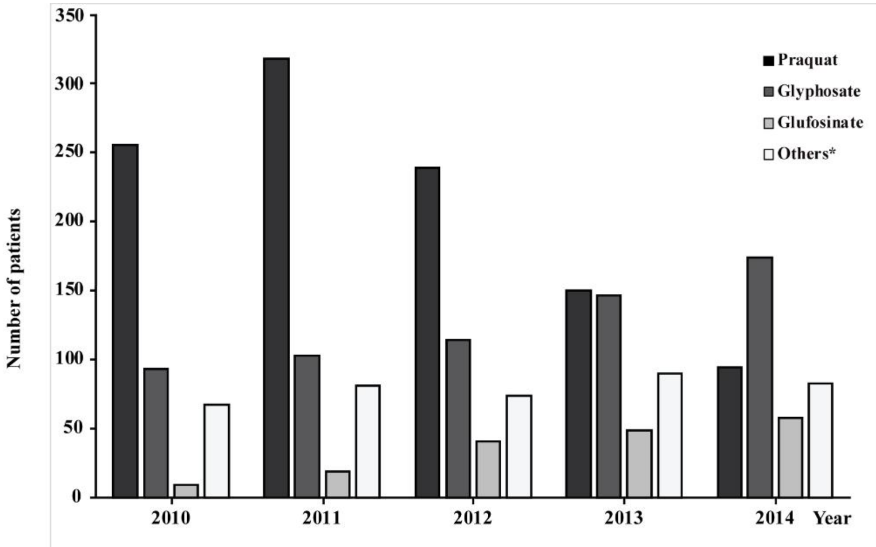

Figure 3. Change in the number of deaths due to herbicide poisoning

*Others : substances such as benrazone sodium, 2-methyl-4-chlorophenoxyacetic acid (MCPA) and mixtures of various agents were grouped together

In this study, it was observed paraquat intoxication group characteristics changes on before and after paraquat ban. There is significant difference in intention (P=0.004) and outcome (P=0.04) (Table 3). The multivariate logistic regression model revealed that the paraquat ban showed a significance to affect herbicides mortality (p = 0.032). Therefore, it appears that after the paraquat ban the death rate tends to decline (Table 4). In this study, it was confirmed that the number of intentional suicide dropped after paraquat ban. It is evident that the paraquat ban contributed to the decline of the total number of suicide even though the proportion of herbicide poisonings of the total suicide was relatively small. Similar results were reported by Myung et al. who found a marked decrease in the suicide population by poisoning with herbicide after the paraquat ban was reported.[11]

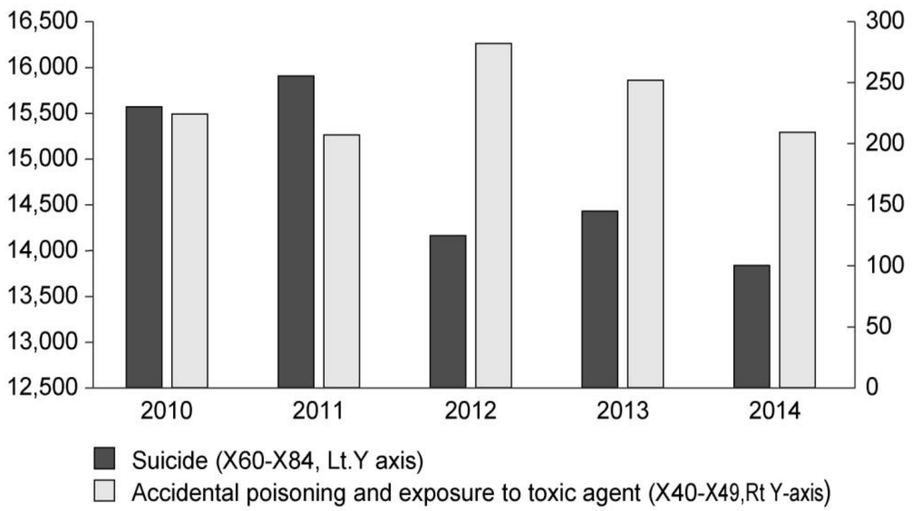

Figure 4. Frequency of deaths from suicide, accidental poisoning, and exposure to toxic agents. Data were thoroughly examined, and verified by the Korea National Statistical Office (KNSO, http://kostat.go.kr/portal/english)

We also analyzed the KOSIS data including the number of mortalities associated with all attempted suicides and unintended exposure to poison during the study period as well as unintended exposure to poison between January 2010 and December 2014. The number of mortalities from herbicide poisoning was lower than that of overall suicides. However, considering that the number of mortalities from unintended exposure to poison exhibited similar values during the study period, it was suspected that the paraquat ban decreased the number of mortalities from overall suicide to a certain extent (Figure 4). According to the multivariate logistic regression analyzed in this study, intentionality and herbicide type were expected to affect death from herbicide poisoning. Intentional ingestion was reduced from 78.8% to 70.3% after the sales ban. Therefore, it is suggested that intentionality affected the mortality rate of paraquat.

A previous study by Cha et al.[7] reported that the ban on paraquat had an influence in lowering the pesticide suicide rate from 2011–2012. The study had limitations such as short study period and enrollment of suicide patients only, but the results were similar to those of our study.

The Bayesian change point analysis was performed to determine the point when the statistically significant changes of herbicide-related mortality occurred.[10,12] There were 2 time points with a wide amplitude change of posterior probability, which can be considered as a significant change point of herbicide-related mortality. The first change point was between December 2011 and February 2012, which was approximately 3 months after the ban on production. After the mortality rate had dropped it was maintained at that level and a period of stabilization was observed. The changes in mortality rate at this point may be attributable to poor accessibility to paraquat because production was banned but existing inventory was still on sale. Therefore, depending on the inventory consumed on small farms, the accessibility of paraquat reduced with time. However, the existing stock in certain sales outlets was still being used and, hence, the mortality rate did not attain the level seen in the latter parts. The second change point was around November 2013, which was approximately 1 year from the implementation of the sales ban. At this point, another drop in mortality rate was observed, followed by a period of stabilization. It is believed that the most paraquat was used, which had been on hand since the production ban, decrease drastically, and relatively less toxic substances were used as substitutes, which resulted in a drop in the herbicide-related mortality remained at a low level.

The present study has several limitations that are worth mentioning. First, this was a retrospective study, and some information provided by the patients such as intentionality or estimated ingestion dose may be inaccurate or insufficient. Second, this study was a multicenter study and, threrfore, regional and institutional differences may have influenced the results.

V. CONCLUSION

This study suggests that the paraquat ban is associated with a reduced mortality rate of herbicide poisoning. After the paraquat ban, the number of associated poisonings decreased while that of the other less toxic herbicides poisonings increased. It may also have resulted from decreased intentional ingestion. Furthermore, a certain timeframe may be required for the effect of the regulatory measures to result in reduced mortality.

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ABSTRACT (IN KOREAN)

파라콰트 판매금지가 제초제 중독의 사망률에 미치는 영향

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고 동 률

서론

파라콰트는 독성이 강하며 다양한 노출 경로를 통해 중독을 일으킬 수 있는 위험한 제초제이다. 우리 나라에서는 2011년 11월부터 생산을 전면 금지하였으며, 2012년 11월부터 판매 자체를 금지하였다. 우리나라의 제초제를 이용한 사망률은 2011년 에서 2013년 까지 10만명당 5.26명에서 10만명당 2.67명으로 줄어드는 추세를 보였으며, 이후 우리나라에서 2011년부터 2014년까지 일개 병원에서 진행한 연구에 따르면 전체 제초제를 이용한 자살 시도자의 수가 감소하였고 이중에서 파라콰트를 이용한 자살 시도자의 수는 63.4%에서 24.5로 감소하였음을 확인하였다. 이 논문의 목적은 우리나라에서 파라콰트 판매금지가 제초제 관련 사망률에 어떤 변화를 일으켰으며, 어떤 영향을 주었는지에 대해 알아보고자 한다.

방법

2010년 1월 1일부터 2014년 12월 31일까지 제초제 중독을 주소로 내원한 환자를 대상으로 하였으며 전국의 응급의료기관을 대상으로

하여 9개 지역 18개 응급진료센터에 내원한 환자 중 제초제 중독(ICD-10 code, T60.3)을 주 진단으로 내원한 환자를 대상으로 하였다. 이때 의무기록을 조사하여 상품명을 모르고 제초제 혹은 농약이라고만 한 경우는 제외하였으며, 노출 경로는 모든 경로를 포함하였다. 환자 군의 자료의 분석은 Statistical analysis software version 9.2 (SAS Institute, Cary, NC, USA)를 이용하여 연구 기간 동안의 사망률을 백분율로 계산하여 기록하였으며, 남녀 성비, 의도성 여부, 각 지역별 중독 환자수 역시 백분율을 계산하여 기록하였다. 판매금지 전후의 생존 수, 사망 수를 나누어 정리하였으며 이를 토대로 각각 제초제에 따른 생존 수, 사망 수를 기록하고 사망률을 백분율로 나타내었다. 생존, 사망 시 각 약물 별로 계산된 사망률을 토대로 Chi-square test 를 분석하였으며 P값이 0.05 미만일 때 통계적으로 유의하다고 해석하였다. 기간에 따른 사망률의 변화를 관찰하기 시간에 따라 각 제초제 중독 수를 Bar graph로 나타내었다. 시간에 따른 사망률의 변화가 어떤지를 살펴보고 의미 있는 변화 시점을 알아보기 위해 사망률의 변화를 Bayesian change point 분석을 시행하였다.

결과

전체 환자는 2,257명 이었으며 남성이 더 높은 비율을 나타내었다(N=2,053, 90.9%). 전체 연구기간 동안 생존 군과 사 망군에서 성별을 제외한 통계적으로 유의한 차이가 관찰되었으며 일변량 로지스틱 회귀분석에 따르면 두 군에서 나이, 제초제 종류, 노출 경로, 파라콰트 판매 금지 여부, 성별, 함께 먹은 물질, 용량, 의도성 여부에 통계학적 차이를 보였으며, 다변량 로지스틱 회귀분석에 따르면 파라콰트 판매 금지 여부와 노출 경로에서는 뚜렷한 차이를 보이지

않았다. 제초제 사망률의 통계학적 변화를 확인하기 위해 Bayesian change point analysis를 시행하였으며 두 번에 걸쳐 사망률의 큰 변화가 관찰되는데, 생산 금지 시점부터 약 3개월 뒤인 2012년 2월 큰 폭으로 사망률이 떨어져 이후 안정된 추세를 보이다가 2012년 11월 판매가 금지된 이후 약 1년 후인 2013년 10월~11월경 한 차례 더 큰 폭으로 떨어진 후 유지되고 있는 것이 관찰되었다.

결론

본 연구에 따르면 파라콰트 판매 금지에 따라 제초제 중독 의도성의 변화가 있었으며, 이것은 제초제 중독에 따른 사망률에 영향을 미치는 인자로 보인다. 따라서 파라콰트 판매 금지가 따라 제초제 연관 사망률이 떨어지는데 영향을 주었다고 생각할 수 있을 것이다. 또한 change point analysis의 결과로 볼 때 판매 금지와 같은 정책의 변화가 실제로 영향력을 보여주는 것에는 상당한 시간이 필요함을 확인할 수 있었다. 파라콰트 판매금지에도 불구하고 여전히 높은 사망률을 확인할 수 있었으며, 이에 따라 지속적인 관찰이 필요할 것으로 생각된다.

핵심되는 말 : 파라콰트 판매 금지, 제초제, 중독