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The Burden of Acute Pesticide Poisoning and Pesticide Regulation in Korea

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ABSTRACT

Background: This study aimed to estimate the burden of acute pesticide poisoning and to determine its trend with recently implemented pesticide regulations.
Methods: Disability-adjusted life-years (DALYs) were calculated as the sum of years of life lost (YLLs) and years lived with disability (YLDs) due to acute pesticide poisoning using the methods of the Global Burden of Disease Study 2013. The values of YLLs, YLDs, and DALYs were stratified by sex, age groups, intentionality of poisoning, and causative agents.
Results: From 2006 to 2014, DALYs decreased by 69% (from 69,550 to 21,742). The decreasing tendency of DALYs was especially marked from 2011. The total burden of acute pesticide poisoning was mainly caused by YLLs and intentional pesticide poisoning. The highest DALYs due to acute pesticide poisoning occurred in those in their 40s and 50s; however, the decreased rates of DALYs were higher in those aged 10–49 years than in those aged more than 50 years. Herbicides including paraquat contributed to the largest proportion of total DALYs.
Conclusion: As this is the first study to quantify the burden of acute pesticide poisoning using DALYs, our results provide comprehensive evidence of the importance of using strict regulations to prevent public health hazards due to acute pesticide poisoning.

Keywords: Agrochemicals; Burden of Illness; Paraquat; Poisoning; Suicide

INTRODUCTION

Acute pesticide poisoning is an important public health issue worldwide.[1] Approximately 350,000–440,000 annual suicides by means of deliberate pesticide poisoning have been estimated to occur worldwide,[2] and the numbers of victims of non-fatal pesticide poisoning are assumed to be much greater. However, pesticide poisoning can be prevented and minimized by proper interventions such as regulatory legislation, safety education, and improving patient care.[3]

In the Korea, previous epidemiologic studies have reported a 5.4 per 100,000 persons age-standardized pesticide poisoning death rate during 2006–2010,[4] an annual pesticide-related hospitalization rate of 17.8 per 100,000 persons during 2004–2006,[5] a 26.8 per 100,000 persons annual average rate of emergency department visits due to pesticide poisoning during 2006–2009,[6] and 24.7% of acute occupational pesticide poisoning among male

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farmers in 2010.[7] Recently, a remarkable decrease in suicide deaths from herbicide poisoning following the legislative ban of paraquat has been reported.[8]

The Global Burden of Disease (GBD) Study introduced a summary measure to quantify the burden of disease and injury, the disability-adjusted life-years (DALYs), to establish objective and comparative evidence in an effort to set priorities in public health policy and to evaluate the effectiveness of public health interventions.[9] The GBD has been reported with updated methodology and extended scope for various diseases[10,11]; however, no study has focused on pesticide poisoning.

Estimating the burden of acute pesticide poisoning at a national level would provide scientific evidence regarding the overall disease burden, as well as support future strategies for decreasing incidence rates of acute pesticide poisoning. Therefore, the objectives of the present study were to estimate the burden of acute pesticide poisoning and to determine its trends with recent pesticide regulations implemented in Korea.

METHODS

Data source

Data regarding mortality due to acute pesticide poisoning during 2006–2014 were obtained from Statistics Korea (http://www.kostat.go.kr). Underlying causes of death are coded using the International Classification of Disease, 10th Revision (ICD-10).[12] Thus, acute pesticide poisoning was identified using the ICD-10 code, T60.0–T60.9, which was subdivided by the toxic effect of pesticides, herbicides and fungicides (T60.3), insecticides (T60.0–T60.2), other pesticides (T60.4, T60.8), and unspecified pesticides (T60.9). Cases of intentional and unintentional pesticide poisoning were categorized according to the code for external causes of injury, intentional self-poisoning (X68), accidental poisoning (X48), assault (X87), or intent undetermined poisoning (Y18).

Prevalence data were obtained from the Korea National Health Insurance claims data from the National Health Insurance Service during 2006–2014. A prevalent case was defined as an individual episode classified with the ICD-10 code T60.0–T60.9 as the primary diagnostic code. Among information included in the National Health Insurance claims data, we used sex, age group, type of care received, and days of hospital stay or outpatient visits in the analysis. Acute pesticide poisoning by causative agents was differentiated in the same manner as that by mortality. External cause of injury codes contained in the claims data are mostly missing; therefore, we assumed that 72.1% of inpatients with acute pesticide poisoning were considered cases of intentional poisoning, based on a previous study.[5]

The information on regulated pesticide items such as the active ingredient, concentration, year of regulation, chemical category, and amount sold was obtained from the Korea Rural Development Administration (http://www.rda.go.kr), Agrochemical Year Book published by Korea Crop Protection Association, and by searching the Internet. Overall, 51 pesticide items were regulated between 2006 and 2014 (**Supplementary Table 1**).

Statistical analysis

Age-standardized rates of the mortality due to and prevalence of acute pesticide poisoning were directly standardized in 5-year age groups using the 2000 world standard population.[13]

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The population serving as a denominator was the sex- and age-stratified mid-year populations of registered residents used yearly by Statistics Korea. We also examined relative changes in age-standardized rates of the mortality and prevalence between 2006 and 2014.

We calculated DALYs for acute pesticide poisoning using the methods described in the GBD Study 2013.[11] DALYs aggregate mortality and morbidity by the time lost due to premature death (i.e., YLLs) and time lived with disability (i.e., YLDs). DALYs due to acute pesticide poisoning was the sum of YLLs and YLDs, and one DALY represented one lost year of healthy life. YLLs were calculated by the number of acute pesticide poisoning deaths multiplied by the standard expected years remaining at the age of death according to the Korean standard life tables from 2006–2014 (http://kosis.kr). YLDs were computed by multiplying the number of prevalent cases of acute pesticide poisoning by the relevant disability weight (0.163 for short-term health state of poisoning) from the GBD Study 2013.[14] In this study, we obtained the mean durations of acute pesticide poisoning for inpatients (7.6 days) and outpatients (1.3 days) from the National Health Insurance claims data. Values for the YLLs, YLDs, and DALYs were stratified by sex, 10-year age groups, intentionality of poisoning, and causative agents. Each analysis is also presented with the relative change in values between 2006 and 2014. Sensitivity analysis was performed by using the disability weight of poisoning separately for unintentional (0.546) and intentional (0.614) poisoning, according to a recent Korean study.[15] All analyses were performed using Stata 13.0 software (StataCorp, College Station, TX, USA).

Ethics statement

This study analyzed publicly available data for mortality and health care utilization data without any personal identifiers; thus, protocol review and informed consent were unnecessary. This study was exempt from the Institutional Review Board of Korea University (KU-IRB-16-EX-132-A-1).

RESULTS

The age-standardized rate of mortality due to acute pesticide poisoning decreased from 5.8 per 100,000 persons in 2006 to 1.6 per 100,000 persons in 2014, and the age-standardized prevalence rate decreased from 15.0 per 100,000 persons in 2006 to 8.1 per 100,000 persons in 2014 (**Table 1**). Mortality and prevalence rates noticeably decreased from 2011. The mortality rate decreased by 72.4% between 2006 and 2014, which was 1.5 times higher than the decrease in the prevalence rate (46.0%). Cases of acute pesticide poisoning and age-standardized rates were higher in men than in women.

From 2006–2014, the DALYs decreased from 69,550 to 21,742, yielding a 69% decrease (**Table 2**). The decreasing tendency of DALYs, corresponding with the rate of mortality due to acute pesticide poisoning, was observed from 2009, and it was especially marked from 2011. The overall burden of acute pesticide poisoning was mainly caused by YLLs (69,533 [99.98%] in 2006 and 21,729 [99.94%] in 2014). Although YLDs accounted for a very small portion of total DALYs, a proportion of YLDs in the total burden of acute pesticide poisoning increased fractionally. The average proportion of DALYs due to acute pesticide poisoning in men among the total DALYs was 65% from 2006–2014. Results of sensitivity analysis using Korean disability weights by intentional or unintentional poisoning to calculate YLDs were similar (**Supplementary Table 2**).

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Table 1. Mortality due to and prevalence of acute pesticide poisoning by sex in Korea, 2006–2014

Year	Mortality						Prevalence					
	Men		Women		Overall		Men		Women		Overall	
	No.	ASR[a]	No.	ASR	No.	ASR	No.	ASR	No.	ASR	No.	ASR
2006	2,115	8.8	1,086	3.6	3,201	5.8	4,778	19.5	3,395	11.7	8,173	15.0
2007	2,201	9.0	1,087	3.4	3,288	5.8	5,255	20.7	3,490	11.7	8,745	15.6
2008	2,207	8.7	1,089	3.3	3,296	5.6	5,577	21.3	3,688	12.1	9,265	16.1
2009	2,113	8.0	1,057	3.0	3,170	5.2	5,702	21.0	3,741	12.0	9,443	15.9
2010	2,208	8.1	998	2.7	3,206	5.0	4,913	17.4	3,135	9.6	8, 048	13.0
2011	1,998	7.0	915	2.5	2,913	4.4	4,219	14.5	2,671	8.0	6,890	10.8
2012	1,615	5.5	784	2.0	2,399	3.4	4,052	13.6	2,562	7.5	6,614	10.1
2013	1,120	3.7	538	1.3	1,658	2.3	3,656	11.8	2,308	6.5	5,964	8.8
2014	829	2.6	380	0.9	1,209	1.6	3,458	10.8	2,119	5.9	5,577	8.1
% change	−60.8	−70.5	−65.0	−75.0	−62.2	−72.4	−27.6	−44.6	−37.6	−49.6	−31.8	−46.0

ASR = age-standardized rate.
[a]ASRs per 100,000 persons using the 2000 world standard population.

Table 2. YLLs, YLDs, and DALYs due to acute pesticide poisoning by sex in Korea, 2006–2014

Year	YLLs			YLDs			DALYs			DALYs per 100,000
	Men	Women	Overall	Men	Women	Overall	Men	Women	Overall	
2006	44,455	25,078	69,533	10	7	17	44,465	25,085	69,550	142
2007	44,656	23,393	68,049	10	7	17	44,666	23,400	68,066	139
2008	45,428	24,479	69,907	11	7	18	45,439	24,486	69,925	142
2009	42,504	23,135	65,639	12	8	20	42,516	23,143	65,659	132
2010	42,492	20,344	62,836	11	7	18	42,503	20,351	62,854	126
2011	37,927	20,575	58,502	10	6	16	37,937	20,581	58,518	117
2012	28,820	16,051	44,871	10	6	16	28,830	16,057	44,887	89
2013	19,706	9,959	29,665	9	5	14	19,715	9,964	29,679	59
2014	14,761	6,968	21,729	8	5	13	14,769	6,973	21,742	43
% change	−66.8	−72.2	−68.8	−20.0	−28.6	−23.5	−66.8	−72.2	−68.7	−69.9

YLLs = years of life lost, YLDs = years lived with a disability, DALYs = disability-adjusted life-years.

The highest DALYs due to acute pesticide poisoning occurred in those aged 40–49 years from 2006–2010 followed by those aged 50–59 years, 60–69 years, and 30–39 years; then those aged 50–59 years had the highest DALYs since 2011 (**Table 3**). The old age groups accounted for a large number of DALYs; however, the decreased rates of DALYs from 2006–2014 were greater in those aged 10–49 years (80%–92%) than in those aged more than 50 years (19%–67%). Regarding the age distribution of acute pesticide poisoning between age-specific mortality rates and DALYs, the mortality rates increased with age in men and women, whereas DALYs were the highest in the 30–69-year-old age group in 2006 and 50–79-year-old age group in 2014 (**Fig. 1**).

Regarding burden separated by the intentionality of poisoning, 87% of the total DALYs (60,595 DALYs) in 2006 was due to intentional pesticide poisoning, and this value slightly increased to 91% (19,700 DALYs) in 2014 (**Fig. 2**). DALYs from intentional and unintentional pesticide poisoning decreased from 2006–2014. Additionally, the fraction of intentional or unintentional poisoning and the decreasing trend was similar between men and women.

Herbicides including paraquat contributed to the largest proportion of total DALYs from 44,163 (64%) in 2006 to 12,492 (58%) in 2014, followed by unspecified pesticide, insecticides, and other (**Table 4**). The order of causative agents was maintained from 2006–2014; however, the percentage of DALYs due to herbicides decreased with the largest reduction rate (71.7%), whereas that of insecticide poisoning increased from 10% in 2006 to 17% in 2014 of the total DALYs, which was remarkable since 2011. The distribution of YLLs by causative agents was similar to that of DALYs, whereas YLDs due to herbicides increased

Table 3. DALYs due to acute pesticide poisoning by age groups in Korea, 2006–2014

Year	Age groups, yr									Total
	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	> 80	
2006	155 (0.2)	574 (0.8)	3,808 (5.5)	10,944 (15.7)	16,966 (24.4)	13,773 (19.8)	13,098 (18.8)	7,847 (11.3)	2,385 (3.4)	69,550 (100)
2007	0.2 (0.0)	513 (0.8)	3,415 (5.0)	9,155 (13.4)	15,947 (23.4)	13,391 (19.7)	13,336 (19.6)	9,819 (14.4)	2,491 (3.7)	68,067 (100)
2008	223 (0.3)	647 (0.9)	3,462 (5.0)	10,246 (14.7)	16,564 (23.7)	13,571 (19.4)	12,569 (18.0)	9,747 (13.9)	2,896 (4.1)	69,925 (100)
2009	0.2 (0.0)	613 (0.9)	2,789 (4.2)	7,807 (11.9)	14,563 (22.2)	14,428 (22.0)	11,992 (18.3)	10,393 (15.8)	3,072 (4.7)	65,657 (100)
2010	158 (0.3)	190 (0.3)	1,733 (2.8)	7,639 (12.2)	13,371 (21.3)	12,668 (20.2)	12,393 (19.7)	11,238 (17.9)	3,465 (5.5)	62,855 (100)
2011	160 (0.3)	391 (0.7)	2,546 (4.4)	5,698 (9.7)	11,323 (19.4)	14,151 (24.2)	11,093 (19.0)	10,092 (17.2)	3,060 (5.2)	58,514 (100)
2012	0.1 (0.0)	450 (1.0)	850 (1.9)	3,681 (8.2)	8,488 (18.9)	10,631 (23.7)	8,396 (18.7)	9,534 (21.2)	2,854 (6.4)	44,884 (100)
2013	227 (0.8)	60 (0.2)	234 (0.8)	1,772 (6.0)	5,116 (17.2)	7,449 (25.1)	5,586 (18.8)	6,818 (23.0)	2,414 (8.1)	29,676 (100)
2014	0.1 (0.0)	69 (0.3)	300 (1.4)	1,363 (6.3)	3,372 (15.5)	5,500 (25.3)	4,348 (20.0)	4,846 (22.3)	1,943 (8.9)	21,741 (100)
% change	−99.9	−88.0	−92.1	−87.5	−80.1	−60.1	−66.8	−38.2	−18.5	−68.7

Values are presented as number (%).
DALYs = disability-adjusted life-years.

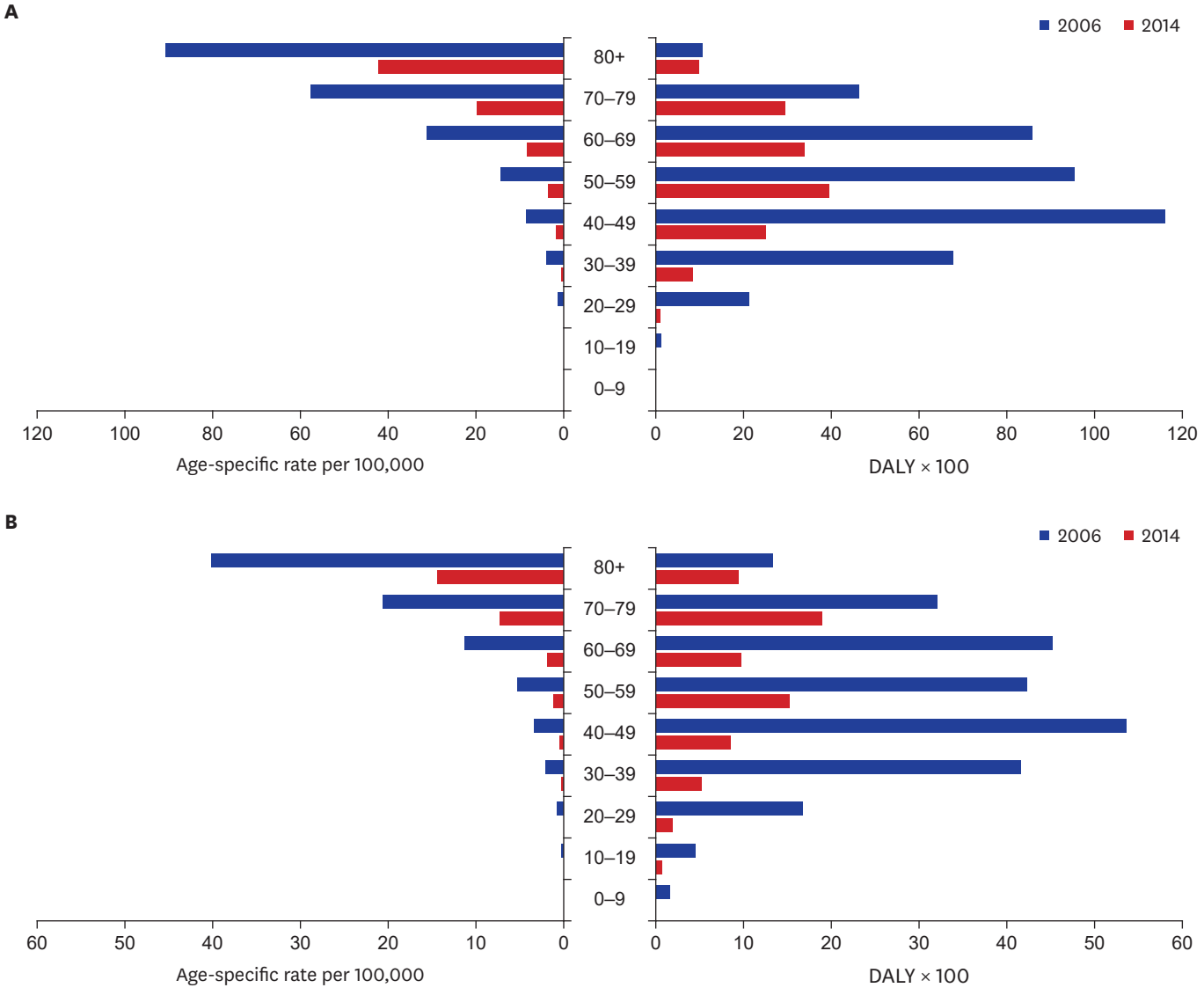

Fig. 1. Changes in the age-specific mortality rate and DALYs in Korea (2006 and 2014). (**A**) Men, (**B**) Women.
DALYs = disability-adjusted life-years.

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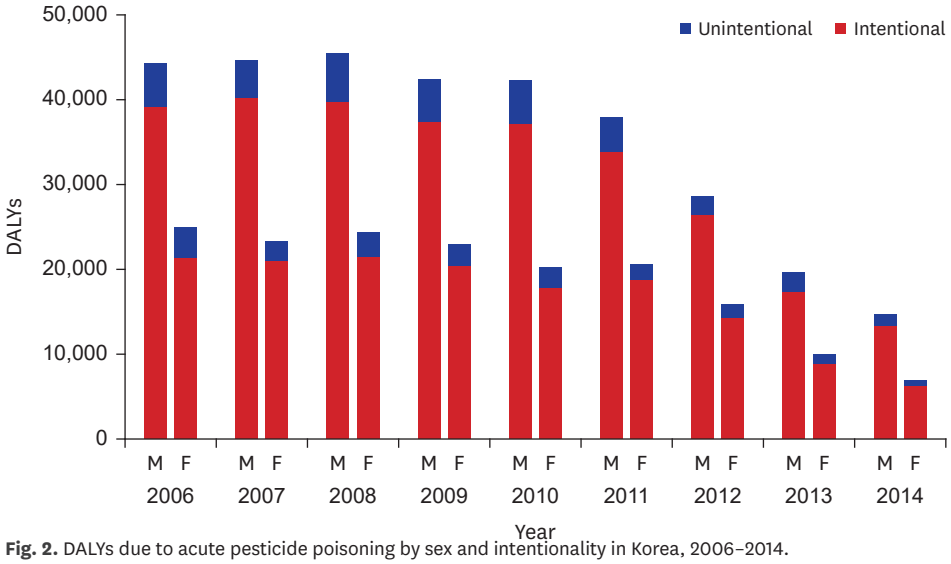

Fig. 2. DALYs due to acute pesticide poisoning by sex and intentionality in Korea, 2006–2014.
DALYs = disability-adjusted life-years, F = female subjects, M = male subjects.

and those from insecticides decreased during the study period. The overall trend of DALYs by substances was not appreciably different by sex (**Supplementary Table 3**).

DISCUSSION

We estimated the burden of acute pesticide poisoning, which was 69,550 DALYs in 2006 and 21,742 DALYs in 2014. YLLs related to premature mortality were the main contributor closely linked to fatal pesticide self-poisoning. The total burden was mostly contributed by those in their 50s to 70s, which accounted for more than 60% of total DALYs in 2014. Acute pesticide poisoning involving herbicides had the highest DALYs, which substantially decreased after 2011. The effective regulations on pesticides, cancellation of the re-registration of paraquat, were followed by the remarkable decrease in burden from acute pesticide poisoning. As this is the first study to quantify the burden of acute pesticide poisoning with DALYs, our results provide comprehensive evidence to prevent public health hazards due to acute pesticide poisoning by presenting the scale of burden and identifying specific populations with a high burden.

When compared to GBD studies,[16] the DALYs of acute pesticide poisoning in 2006 were equivalent to 0.68% of total DALYs of Korea in 2005, which is similar to the burden due to motorcyclist-related road injuries (66,352 DALYs), and they greatly decreased to 0.26% of the total burden of disease in 2013. The amount of burden in 2013 is comparable to that of prostate cancer (29,978 DALYs) and kidney cancer (28,925 DALYs); yet, it was greater than that of peptic ulcer disease (24,583 DALYs), chronic kidney disease due to diabetes mellitus (23,323 DALYs), and gall bladder and biliary diseases (23,476 DALYs). Despite the limitations of direct comparison due to different data sources and methods used for the GBD calculation, these findings indicate that the burden of acute pesticide poisoning is not negligible; however, it has not been attracting considerable attention compared to relatively well-known diseases that cause nearly the same amount of the burden. Therefore, additional effort is required from public and policymakers to increase awareness of the intensive management of pesticide poisoning.

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Table 4. YLLs, YLDs, and DALYs due to acute pesticide poisoning by substances in Korea, 2006–2014

Year	Causative agents				Total
	Herbicides	Insecticides	Other	Unspecified	
YLLs					
2006	44,156 (63.5)	7,013 (10.1)	1,764 (2.5)	16,601 (23.9)	69,534 (100)
2007	45,492 (66.9)	8,831 (13.0)	1,101 (1.6)	12,625 (18.6)	68,049 (100)
2008	47,785 (68.4)	9,271 (13.3)	1,093 (1.6)	11,757 (16.8)	69,906 (100)
2009	45,244 (68.9)	6,500 (9.9)	789 (1.2)	13,105 (20.0)	65,638 (100)
2010	44,011 (70.0)	8,051 (12.8)	928 (1.5)	9,847 (15.7)	62,837 (100)
2011	41,953 (71.7)	7,755 (13.3)	962 (1.6)	7,831 (13.4)	58,501 (100)
2012	29,741 (66.3)	6,814 (15.2)	603 (1.3)	7,714 (17.2)	44,872 (100)
2013	17,680 (59.6)	5,889 (19.9)	553 (1.9)	5,543 (18.7)	29,665 (100)
2014	12,487 (57.5)	3,706 (17.1)	499 (2.3)	5,036 (23.2)	21,728 (100)
% change	−71.7	−47.2	−71.7	−69.7	−68.8
YLDs					
2006	6.2 (37.5)	5.7 (34.1)	1.2 (7.4)	3.5 (21.0)	16.6 (100)
2007	7.0 (39.4)	5.6 (31.8)	1.5 (8.3)	3.6 (20.5)	17.7 (100)
2008	7.6 (40.5)	6.0 (32.1)	1.6 (8.4)	3.6 (19.0)	18.7 (100)
2009	8.4 (43.9)	5.6 (29.4)	1.5 (8.0)	3.6 (18.7)	19.0 (100)
2010	7.0 (41.3)	5.1 (30.1)	1.4 (8.1)	3.5 (20.5)	17.0 (100)
2011	6.5 (44.6)	4.4 (30.2)	1.1 (7.9)	2.5 (17.3)	14.5 (100)
2012	5.9 (42.7)	4.4 (31.9)	1.1 (7.9)	2.4 (17.5)	13.9 (100)
2013	5.2 (41.3)	4.1 (32.7)	1.1 (9.0)	2.1 (17.0)	12.5 (100)
2014	5.0 (43.0)	3.7 (31.8)	1.0 (8.5)	1.9 (16.7)	11.6 (100)
% change	−19.5	−34.7	−18.9	−44.3	−29.8
DALYs					
2006	44,163 (63.5)	7,018 (10.1)	1,766 (2.5)	16,604 (23.9)	69,551 (100)
2007	45,499 (66.8)	8,836 (13.0)	1,103 (1.6)	12,628 (18.6)	68,066 (100)
2008	47,793 (68.3)	9,277 (13.3)	1,095 (1.6)	11,760 (16.8)	69,925 (100)
2009	45,252 (68.9)	6,505 (9.9)	791 (1.2)	13,108 (20.0)	65,656 (100)
2010	44,018 (70.0)	8,056 (12.8)	930 (1.5)	9,850 (15.7)	62,854 (100)
2011	41,959 (71.7)	7,760 (13.3)	963 (1.6)	7,834 (13.4)	58,516 (100)
2012	29,747 (66.3)	6,819 (15.2)	604 (1.3)	7,716 (17.2)	44,886 (100)
2013	17,685 (59.6)	5,894 (19.9)	554 (1.9)	5,545 (18.7)	29,678 (100)
2014	12,492 (57.5)	3,709 (17.1)	500 (2.3)	5,038 (23.2)	21,739 (100)
% change	−71.7	−47.2	−71.7	−69.7	−68.7

Values are presented as number (%).
YLLs = years of life lost, YLDs = years lived with disability, DALYs = disability-adjusted life-years.

A larger proportion of YLLs in total DALYs due to acute pesticide poisoning was similar to the finding on burden of self-harm from the global burden of injury study.[17] Deliberate self-poisoning was identified as the main cause of pesticide poisoning deaths (86%) in Korea,[4] and this may explain our overwhelming proportion of YLLs and cases of intentional pesticide poisoning in the total DALYs due to acute pesticide poisoning. Based on these findings, the overall management of pesticides needs to be focused on prevention of pesticide-related suicides.

Our results indicate a discrepancy between the most prominent age group that contributed to the burden of and the rate of mortality due to acute pesticide poisoning. This discrepancy has been reported by the YLLs of suicide which were predominant in middle-aged groups, whereas the highest suicide rate was observed in the elderly in Hong Kong[18] and Taiwan,[19] because YLLs weigh on deaths occurring in younger age groups when considering the expected years remaining at the age of death. Identifying specific populations requiring attention by evaluating the burden could provide new insight for prioritizing target groups to avert the burden. However, it is also important to consider the burden and traditional epidemiologic measures (i.e., mortality, incidence, or prevalence rates) equally to avoid discrimination against specific populations in public health strategies and research.[20]

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Although YLDs accounted for less than 1% of total DALYs due to acute pesticide poisoning, it should not be overlooked that a proportion of YLDs in the total burden of acute pesticide poisoning increased fractionally. This may be explained by a relative increase in suicide attempts involving the ingestion of less toxic pesticides, which resulted in nonfatal cases of pesticide poisoning after the ban on paraquat,[21] and the continuously reported pesticide poisoning accidently occurring in childhood.[22] Hence, measures to reduce cases of nonfatal pesticide poisoning are also needed.

Our results showed remarkable decreases in total DALYs due to acute pesticide poisoning and DALYs due to intentional poisoning since 2011 (i.e., after the major regulation of pesticides). It is also noteworthy that the burden of overall self-harm increased by 14.2% between 2005 and 2013 (435,808 DALYs in 2005 and 497,566 DALYs in 2013), based on GBD studies,[16] whereas that of pesticide self-harm decreased between 2006 and 2013 by 56.6% (60,595 DALYs in 2006 and 26,301 DALYs in 2013) in our study. These results indicate that the remarkable reduction in the burden of acute pesticide poisoning after 2011 was related with a number of regulations, especially on the herbicide paraquat. The largest decrease in DALYs from herbicide poisoning provides support that the legislative ban is the most effective method to regulate pesticides. Although some pesticides regulations have worked since 2008, a relatively small number of pesticides were banned before 2010, and these pesticides were not frequently used at the time of the regulation. The highly hazardous or commonly used pesticides such as paraquat and mancozeb were regulated in 2010 and 2011 (**Supplementary Table 1**). The largely decreased YLLs due to acute pesticide poisoning in our study suggests that these regulations of pesticides were effective in preventing fatal pesticide poisoning.

Regarding the ban on hazardous pesticides, legislative managements related to public health are very important for preventing diseases and injuries. For instance, the revision of Road Traffic Act in Korea in 1999 and additional traffic safety policies were followed by a reduction in the burden due to traffic accidents.[23] Additionally, a tax on sugary drinks could reduce the prevalence of obesity, which may result in decreases in DALYs due to obesity-related diseases.[24] Therefore, ultimately the matters that have a huge impact on public health, including pesticides, need mandatory regulations.

This study has some limitations. First, it is possible that our results underestimate the burden from acute pesticide poisoning due to the limited data sources. Using National Health Insurance claims data, we could only include persons who visited a hospital after pesticide poisoning. The registered death data is that suicide, the main external cause of pesticide poisoning, is likely to be misclassified as an accidental or undetermined death.[25] Additionally, a recent study reported that the causative substance of poisoning deaths is often recorded as unspecified chemicals even when a pesticide is strongly considered the cause of death.[26] Second, we confined the health effect of pesticides to acute poisoning states. However, if the chronic health effects of pesticide poisoning and long-term complications of pesticide poisoning were considered, the estimation of burden from pesticide poisoning would be greatly increased. However, additional data are needed to assess the entire range of health effects from pesticide poisoning such as the population attributable risk for pesticide exposure; thus, this endeavor may be premature at this stage. Third, to estimate DALYs, disability weight is one of the key components, and we used generalized disability weight from the GBD study.[14] However, disability weight can be different according to the severity of a specific condition,[27] and we conducted sensitivity analysis of YLDs by separating disability weights by the intentionality of poisoning. Although YLDs multiplied by two different

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disability weights from the Korean burden of disease study were three to four times higher than those in the main analysis that use a single disability weight from the GBD study, the magnitudes of DALYs for acute pesticide poisoning were very similar between the main and sensitivity analyses owing to the very small proportion of YLDs at total DALYs.

In conclusion, this study is the first to estimate the burden due to acute pesticide poisoning by presenting the amount of DALYs, and it shows the importance of implementing compulsory regulation, which may be associated with a reduction in the burden of acute pesticide poisoning. Although the burden of acute pesticide poisoning decreased during 2006–2014, it remains an issue, and further efforts are required to prevent pesticide poisoning.

SUPPLEMENTARY MATERIALS

Supplementary Table 1

Regulated pesticide products in Korea, 2006–2014

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Supplementary Table 2

YLLs, YLDs, and DALYs due to acute pesticide poisoning (Korean disability weights), 2006–2014

Click here to view

Supplementary Table 3

DALYs due to acute pesticide poisoning by sex and substances in Korea, 2006–2014

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