



# **Trends in UK deaths associated with abuse of volatile substances, 1971-2009**

**Hamid Ghodse  
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**Report 24**

**Volatile Substance Abuse  
(VSA) Mortality Project  
International Centre for  
Drug Policy (ICDP)  
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## Acknowledgements

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## Executive summary

This is the twenty-fourth annual report of the Volatile Substance Abuse (VSA) Mortality Project, and has been produced by the International Centre for Drug Policy based at St. George's, University of London. This report outlines the current trends, examines the nature of the problems, and identifies the factors associated with deaths from abuse of volatile substances occurring in the United Kingdom (UK) in 2009. It also identifies emerging issues and possible changes in solvent abuse.

There were 46 deaths associated with volatile substance abuse in 2009 (38 in 2008). The cumulative total of VSA deaths in the UK since 1971 now stands at 2,390. Since 1992 there has been a significant fall in deaths which appears to have decreased further in recent years. During the last decade (2000-2009), age at death ranged from 15 to 66 years (mean = 30.2, Standard Deviation (SD) 11.6), and one-third (32.9%) of deaths occurred in the under-20 years age-group. Compared to earlier years, there is a shift to older age-groups. Four-fifths (78.5%) of deaths were male, and in 2009 deaths from volatile substance abuse accounted for 1.1% of all-cause deaths in males aged 15-19 years, and 0.7% of females of the same age in the UK.

Standard Mortality Ratios (SMRs) differed significantly across countries and Government Office Regions in England: the highest SMRs were Northern Ireland (179) and Scotland (172), and the lowest in the South East region of England (37). Gas fuels continue to be associated with the majority of deaths; over 67% in 2009.

A decrease in suicides associated with the inhalation of a volatile substance occurred during the last two years. However, this fall appears to have been off-set by a rapid increase in suicides involving the inhalation of helium. As with VSA deaths in general, the majority (86%) of suicides using helium involved males. This phenomenon merits further investigation.

Volatile substance abuse remains an important problem in the UK, especially in terms of causing premature death amongst young people. This challenging issue still needs to be addressed through substance abuse education programmes and other initiatives, as well as examination of appropriate preventative measures and treatment provision, if required.

### Key findings for deaths in 2009:

- There were 46 deaths (including 17 in Scotland) associated with VSA in 2009, bringing the total number of such deaths in the UK since 1971 to 2,390.
- Since 1992 there has been a significant fall in deaths, from an average of 89 per year in 1990-1999, to an average of 54 per year in 2000-2009.
- Gas fuels continue to be associated with the majority of deaths. In 2009, butane from all sources, including aerosol propellants, accounted for 74% of VSA deaths (34 out of 46 deaths).
- In under-18 year olds there were seven VSA deaths in 2009 compared with five in 2008. Of these seven deaths, two were associated with butane cigarette lighter refills, the sale of which to under-18s is prohibited by legislation, and three were associated with aerosols.
- VSA deaths overall continue to be more common among males than females. In 2009, there were 34 deaths among males as compared to 12 deaths among females, a ratio of 2.8:1; in under-18 year olds this ratio was 2.5:1.
- Of the 46 deaths in 2009, five were suicides in males involving the inhalation of a volatile substance. All of these deaths were of adults, aged from 22 to 49 years.
- In 2009 there were five deaths (two in 2008) associated with the inhalation of nitrous oxide, which had been obtained for non-medical purposes.
- Although, as an inert gas, helium is not a volatile substance, previous reports have provided some basic information on this gas. The number of helium-related deaths has risen since 2001, but at an increasing rate in the last three years, standing at 26 in 2008 and 46 in 2009.
- During 2001-9, the majority (93%) of helium cases were suicides. Most deaths were among males, those aged 20-59 years, and caused by asphyxia (including plastic bag over head).

## Introduction

This report is an annual statistical summary of data on trends in deaths associated with the deliberate inhalation of volatile substances. It has been produced by the International Centre for Drug Policy (ICDP) at St. George's, University of London, which took over responsibility for this work from 2009. Data for deaths occurring in 2009 are analysed in this report, together with updated information for earlier years. Therefore, this report supersedes all previous ones. There is a necessary delay of more than twelve months between the end of a calendar year and publication of the annual report. This is to allow time for details to become available from HM Coroners, ONS, the National Records of Scotland, and the General Register Office for Northern Ireland.

Volatile Substance Abuse (VSA) has been a global issue for several decades according to the World Health Organisation (1993, 1999), though the substances are not usually considered to be illegal. In contrast to the situation with respect to illicit drugs, in most countries there is little or no criminal involvement in the supply of products used for VSA. Compounds such as diethyl ether, chloroform and nitrous oxide have been deliberately inhaled for recreational purposes since the early 1800s. Many of the substances which have been abused by inhalation remain in widespread use.

The first modern reports of VSA started to appear in the 1950s (Ramsey *et al.*, 1989), involving petrol, glues and solvent-based thinning agents, initially in the United States, and then Western Europe, particularly Scandinavia. Volatile substance abuse is not automatically linked to gender, race or class, the substance abuse is often a group activity and peer-group influence may be a factor in encouraging the persistence of the practice (Flanagan *et al.*, 1997). Abuse of volatile substances is an issue that can affect anyone, anywhere.

For example, research indicates that the main issues underlying volatile substance abuse for indigenous youth in inner Brisbane, Australia, include: unstable living situations, lack of involvement with school, low levels of meaningful activity and boredom, existence of a substance-using peer group, lack of belonging to a culture, and high levels of mental health concerns (Butt, 2004). The results of the 2009 National Survey on Drug Use and Health in the USA show that the

average age at first use among recent inhalant initiates aged 12 to 49 was 16.3 years (Substance Abuse and Mental Health Services Administration, 2011). Another study held among young Native Indians in the USA indicates that the typical user of these substances is an adolescent male with low self-esteem and a family background of alcoholism and physical aggression (Howard *et al.*, 1999). In the 2004 Canadian Addiction Survey, the majority of individuals (67%) reported first using inhalants between 12 and 16 years of age; 13% used before the age of 12 and 19% at age 17 or older (Adlaf *et al.*, 2005).

In the UK there was a steady increase in VSA deaths from the early 1960s onwards, with deaths peaking in the early 1990s at over 150 per year (Field-Smith *et al.*, 2004).

Data from the Office for National Statistics (ONS) reveal that the trends in prevalence and death from VSA continue to be serious substance-related issues, certainly for the younger teenage population in the UK (Harris, 2006). A survey of school children in England aged 11 to 15 years in 2009 found that 5.5% of pupils had used volatile substances in the previous 12 months; this compares to 7.1% in 2001. Use of these substances increases with age; from 3.3% of 11 year-olds to 7.2% of 15 year-olds (Fuller and Sanchez, 2010). In Northern Ireland last year use of such substances by 12-16 year olds fell from 4.5% in 2007 to 4.3% in 2010 (NISRA, 2011).

According to the National Advisory Committee on Drug (NACD) survey conducted in the Republic of Ireland in 2006/07, the proportion of the adult population who reported using a solvent or volatile inhalant in their lifetime was higher and more common for men than women (National Advisory Committee on Drugs and Alcohol Information and Research Unit, 2008).

Results from the 2009/10 sweep of the British Crime Survey show that in England and Wales last year use amongst 16-59 year-olds of amyl nitrite was 1.1% and solvents 0.2%; the rates for those aged 16-24 years were 3.2% and 0.7% respectively. These figures translate into an estimated using population in the previous 12 months of 351,000 aged 16-59 years for amyl nitrite and 57,000 for solvents; the corresponding figures for those

aged 16-24 years were 210,000 and 44,000 (Hoare and Moon, 2010).

The monitoring of deaths from deliberate inhalation of volatile substances is made difficult by the variety of substances abused, the various modes by which death may occur, and the lack of an appropriate code under the International Classification of Diseases (Anderson, 1990). In addition, international data collection systems on VSA vary from country to country. For example, a systematic information collection programme on inhalant-related deaths in the USA has been maintained by the North Carolina Office of the Chief Medical Examiner (Hall *et al.*, 2010), another retrospective study of inhalant deaths collected information from autopsy examinations reported since 1983 by the Office of Forensic Science in South Australia (Wick *et al.*, 2007).

Information on all ascertained deaths associated with VSA in the UK was systematically collected by the Division of Community Health Sciences at St. George's University of London from 1983 to 2009. Research by that team demonstrated that knowledge of, and interest in, the problem had grown, and there had probably been a real increase in the number of deaths (Anderson *et al.*, 1985). Since 2009 data has been collected by the ICDP (Ghodse *et al.*, 2010a).

Various efforts have been made to prevent solvent abuse and reduce the risk of premature death among abusers. Many of these attempts, however, do not affect the scale of the problems, the pattern of substances abused, or the risk of accidental death among those abusing volatile substances. The most notable exception was the Department of Health's advertising

campaign in February 1992 aimed at parents; this led to a fall from an all-time peak of 152 deaths in 1990 to 67 in 1994.

There has been a continuing programme of health education, along with personal and social education in schools, addressing the issue of volatile substance abuse. Guidance has been published on how to approach this within the National Curriculum (Department for Education and Skills, 2004; Stradling *et al.*, 2009). The Welsh Government (2011) has also published guidance on best practice for the prevention and education of volatile substance abuse (VSA), which provides advice and information to parents, schools, youth services, the police and retailers. The document details different intervention approaches for young people and provides good practice guidance for substance misuse education for young people as part of a whole organisation approach within schools, colleges and youth services. Re-Solv continues to play an important role in providing UK-wide advice, information, research and other resources (<http://www.re-solv.org/>).

Recent reports in this series have noted that gas fuels continue to be associated with the majority of deaths, both for adults and children. In particular, the single product of butane gas lighter refills is responsible for over one-quarter of deaths from volatile substance abuse, usually in the home (Ghodse *et al.*, 2010a).

This report is intended to inform policy-making and service provision at local and national level. It will also be of interest to health professionals, academics, and other stakeholders.

## Definitions

The terms 'glue sniffing' and 'solvent abuse', which were commonly used in connection with the abuse of volatile substances, have for some years been inadequate to describe the problem, hence the adoption of the term 'Volatile Substance Abuse' or 'VSA'. Other terms widely used are 'inhalant abuse' and 'huffing'. VSA has been defined by this project since 1983 as: "the deliberate inhalation of a volatile substance (gas, aerosol propellants, solvents in glue and other solvents) to achieve a change in mental state".

Solvents are a diverse group of substances whose chemical vapours can be inhaled to produce psychoactive or mind-altering effects (National Institute on Drug Abuse, 2007). Descriptions and examples of the most commonly abused substances are given in the Appendix. Inhaled volatiles produce a similar effect to hypnotics/sedatives or ethanol with hedonic (pleasurable) effects such as euphoria and distortion of consciousness (dissociation) being experienced within seconds from a low dosage (Flanagan and Ives, 1994; Steffee *et al.*, 1996). Users employing high dosages report

more euphoria, talkativeness, and grandiosity than when using low dosages. However, they also report aversive experiences such as chest pain, depressed mood, and suicidal ideation (Garland and Howard, 2010).

Death may occur from the direct toxic effects of the inhaled substances or from trauma. Fatalities often occur very quickly, and there is usually no opportunity to intervene medically and thus to prevent death. Mortality associated with the abuse of volatile substances is related

to many factors, including the chemical nature of the substance itself, the product containing it, the method of inhalation, use setting, and the prevalence of abuse.

In this report, in the context of volatile substance abuse, the term 'substance' is used to denote the generic category within which 'products' are grouped. Thus, for example, the aerosol 'substance' includes 'products' such as deodorants, air fresheners, and fly sprays.

## Methods and procedures

The historic dataset includes cases where there is no direct toxicological proof, but circumstantial evidence of varying grades suggesting that these deaths were associated with volatile substance abuse. The data also include suicides where a volatile substance was deliberately inhaled. All such cases are coded accordingly so that they can be reviewed if necessary. When further cases or additional data for previous years come to notice they are added to the dataset. For example, this report contains two additional cases for 2008. Deaths can also be removed from the dataset if subsequent information puts them outside the case criteria. For 2009 deaths there were 47 cases ascertained initially, but one was later excluded from analysis after receipt of autopsy and toxicological reports and discussions with relevant pathologists and forensic toxicologists.

The Project continues to employ both active and passive case-ascertainment approaches. The active approach involves: the use of press-clipping services, Google and other Internet searches of regional and national newspapers, as well as other media sources, to identify cases. Regular visits are made to the Medical Toxicology Laboratory at Guy's and St Thomas' Hospital Trust, and the Forensic Toxicology Service at St George's, University of London, and a number of coroners' offices to check their records for possible cases. For the passive approach, information on deaths associated with VSA in England and Wales is provided by HM Coroners. For Scotland, information is supplied by the Crown Office and the National Records for Scotland (now incorporating the General Register Office for Scotland). Details of Northern Ireland deaths are provided by the State Pathologist's Department, the Coroners Service for Northern Ireland, and the Northern Ireland Statistics & Research Agency on behalf of the General Register Office for Northern Ireland. The Deputy Viscount in Jersey, HM Greffier in Guernsey, and the High Bailiff in the Isle of Man

supply information for their areas. Data on 'all-cause' mortality and population estimates are supplied by the Office for National Statistics, the National Records of Scotland and the Northern Ireland Statistics & Research Agency.

To enable comparison with various national and international datasets all causes of death have been coded according to the International Classification of Diseases version 10. This is an international standard for the classification of diseases and health-related problems published by the World Health Organisation. The current on-line (2007) version is employed by this Project (World Health Organization, 2007).

The method of data collection used by this project has been stable and systematic since 1983. The process of confirming cause of death is undertaken by reference to the case definition criteria; each case is critically checked against information provided by the Coroner or Procurator Fiscal, including toxicological information, autopsy reports, incident reports or witness statements, and other documents.

Information from these sources is entered into coding sheets by two separate team members and any discrepancies reconciled, before being entered into the database. Deaths associated with VSA in 2009 and deaths occurring in any previous years have been added to the historic dataset. All data held, whether electronic or paper, is stored securely and treated as confidential. Access is restricted to project staff; only aggregated and anonymous data are released to third parties and only with the prior written consent of the relevant data-provider.

This report has been produced following analysis of all available information in a cumulatively updated database. Data-cleaning

for a separate research project indicated that some relevant cases had been omitted and other non-relevant cases included in the historic database. As a result, a few of the numbers for some earlier years may be slightly different to those previously published.

For some analyses all deaths have been used. For examining time trends, the period of stable data collection has been used (1983-2009), whilst for others the most recent ten-year period

has been employed. All tables have been designed using uni- and bi-variate tabulation formats, and related graphs/charts have also been drawn up using these tables. Statistical analysis was undertaken using IBM® SPSS® Statistics for Windows Release 18 (based on the previous EPI Info and Stata® programs used for reports on deaths up to and including 2007). The presentation of complex statistical techniques has been kept to a minimum to facilitate ease of reading.

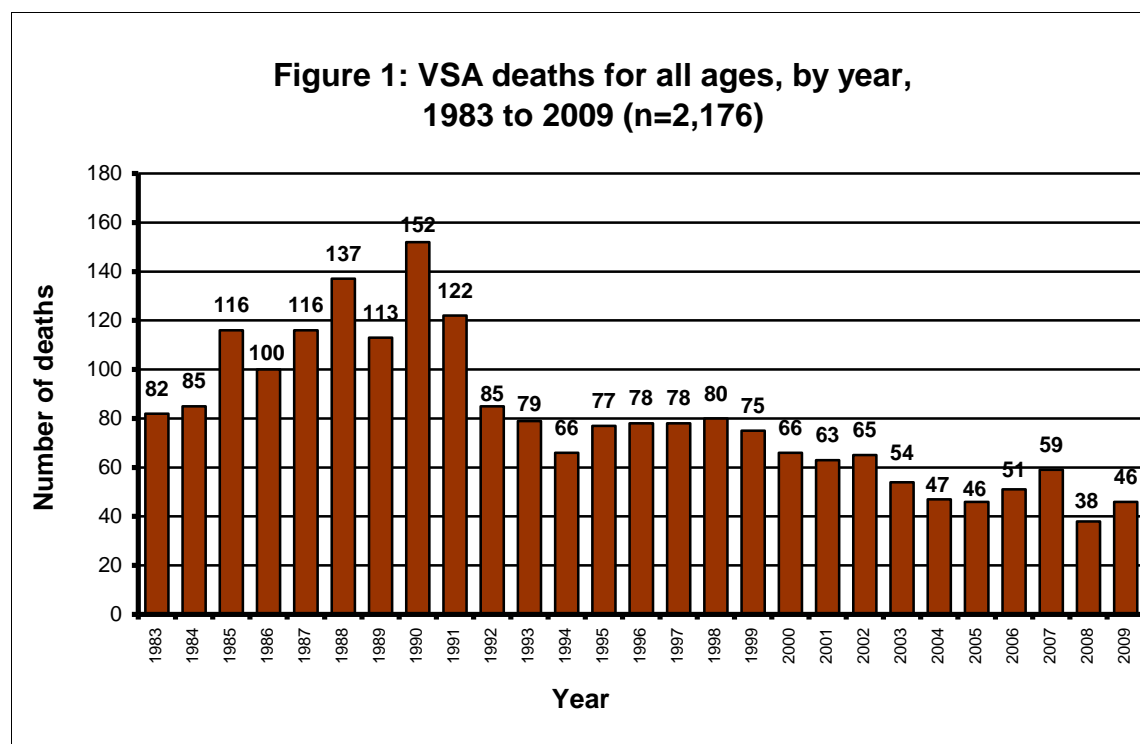
## Trends in total VSA deaths

The total number of deaths between 1971 and 2009 was 2,390; during 2009 there were 46 deaths. Figure 1 gives the total number of deaths from 1983, when the methods of data collection became stable and systematic, to 2009. The Figure shows that there was a steady increase between 1985 and 1991 followed by a more gradual decline.

A commonly-used technique is 'smoothing' which, when properly applied, reveals more clearly the underlying trend. The 'moving average' method is one of these techniques, which can smooth a data-series and make it easier to spot trends. It is routinely employed with time-series data to smooth out short-term fluctuations and highlight longer-term trends.

In Figure 2, the three-year moving average method was used to examine the underlying trend in VSA deaths for all ages between 1983 and 2009.

An increasing upward trend in deaths is discernible during the 1980s, followed by a sharper decline in the early 1990s. This was followed by a period of stability, with a more gradual fall from the late 1990s. The decline since the peak around 1990 reflects the impact of the publicity campaign by the Department of Health in 1992. There are no noteworthy variations between 1997 and 1999 as well as in later periods, when the average number ranges from about 50 to 75 deaths per year.







## Death by age

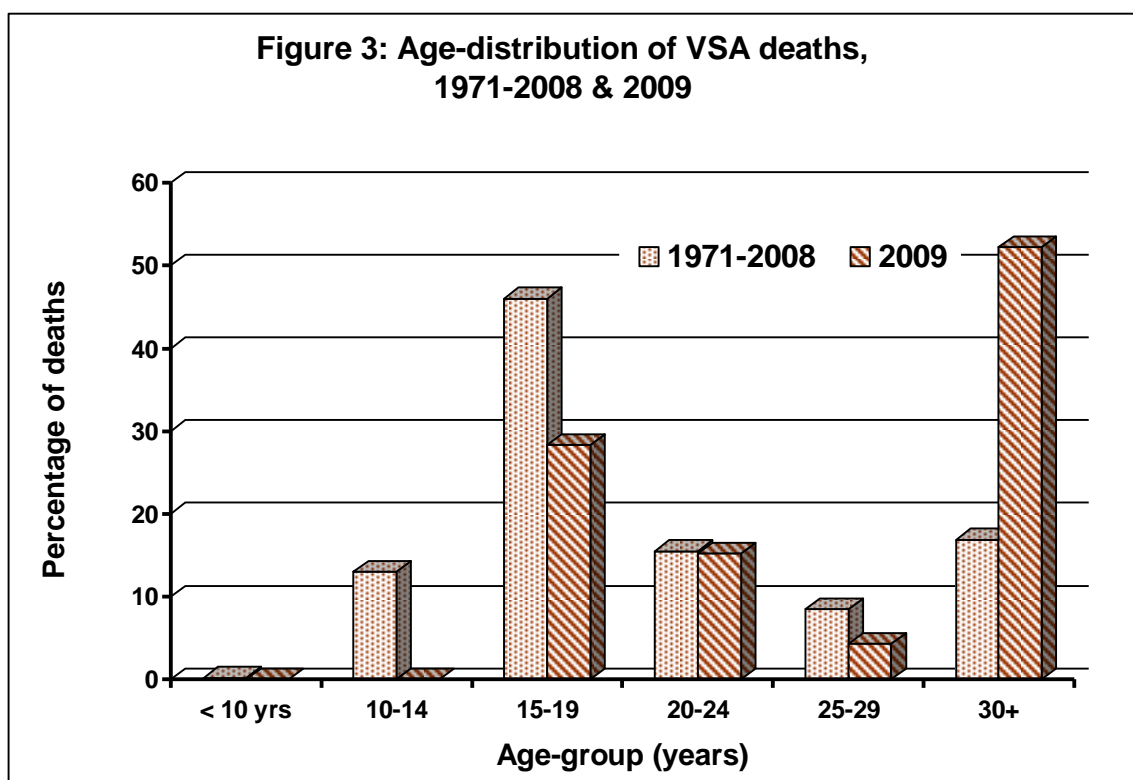
Table 1 presents the age-distribution of VSA deaths in 1971-99 and during the last 10 years. In 2009 the youngest person to die was aged 15 years and the oldest was aged 66 years. This table also shows that the fall in deaths since 1971 was predominantly among adolescents (<15 years) with a gradual decline among older teenagers (15-19 years). Just under half (47.9%) of VSA deaths occurred in the under-20 years age-group during the early part of this decade, falling to 23.1% in recent times. The proportion of deaths accounted for by adults (20 years and over) remained stable until about 2005. Since that time, this proportion has increased significantly.

Changes in the age-distribution are illustrated in several ways, e.g. those aged 15-19 years

have been declining, whereas those aged 25 years or more have seen a sharp increase and those aged 20-24 years have remained stable. However, the proportion of teenagers and youths are more likely than those in other age-groups in the general population to die from abuse of volatile substances. Figure 3 shows a smaller proportion of deaths among teenagers (10-14 years) but less so for youths (15-19 years) as compared to their counterparts in both historic data (1971-2008) and in 2009. This Figure also shows a shift in the distribution of deaths towards higher age-groups when 2009 is compared with historic data. This shift is highly statistically significant ( $p < 0.001$  in the Mann-Whitney U test where all deaths were included).

**Table 1: Age-distribution (%) of VSA deaths, 1971-99 & each year to 2009**

Age Group (years)	Year											All 1971-09
	1971-99	00	01	02	03	04	05	06	07	08	09	
7	0.1	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1
9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
10	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
11	0.3	0.0	0.0	1.5	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.4
12	1.3	4.5	0.0	3.1	1.9	2.1	0.0	0.0	0.0	2.6	0.0	1.4
13	3.3	0.0	3.2	7.7	0.0	4.3	0.0	0.0	0.0	0.0	0.0	3.0
14	9.2	3.0	7.9	6.2	3.7	0.0	6.5	2.0	0.0	0.0	0.0	7.8
15	13.6	9.1	7.9	9.2	1.9	10.6	4.3	5.9	0.0	0.0	4.3	11.8
16	13.5	4.5	14.3	6.2	3.7	6.4	0.0	2.0	6.8	7.9	2.2	11.8
17	10.7	4.5	6.3	3.1	5.6	4.3	4.3	3.9	6.8	2.6	8.7	9.5
18	8.2	6.1	9.5	6.2	0.0	4.3	2.2	5.9	3.4	7.9	8.7	7.6
19	5.2	9.1	6.3	4.6	5.6	4.3	2.2	2.0	1.7	2.6	4.3	5.0
20-24	15.6	16.7	12.7	15.4	24.1	10.6	17.4	7.8	13.6	18.4	15.2	15.5
25-29	8.1	9.1	6.3	6.2	14.8	2.1	19.6	11.8	13.6	7.9	4.3	8.4
30-39	5.5	21.2	14.3	16.9	27.8	31.9	23.9	35.3	35.6	28.9	30.4	10.1
40-49	2.3	4.5	6.3	6.2	5.6	8.5	4.3	11.8	10.2	10.5	19.6	3.7
50-59	1.6	6.1	3.2	6.2	3.7	8.5	8.7	5.9	3.4	5.3	0.0	2.4
60-69	0.8	0.0	1.6	1.5	0.0	2.1	4.3	3.9	1.7	0.0	2.2	1.0
70+	0.2	1.5	0.0	0.0	0.0	0.0	0.0	2.0	3.4	5.3	0.0	0.4
<b>Total</b>	<b>1855</b>	<b>66</b>	<b>63</b>	<b>65</b>	<b>54</b>	<b>47</b>	<b>46</b>	<b>51</b>	<b>59</b>	<b>38</b>	<b>46</b>	<b>2390</b>

**Figure 3: Age-distribution of VSA deaths, 1971-2008 & 2009**

## Death in young people (10-19 years)

Figures 4 and 5 show the mortality rates per million populations for each year from 2000 to 2009, respectively for the 10-14 years and 15-19 years age-groups by gender. These rates were calculated by taking into account any possible changes over time in the general population. In both age-groups the mortality rates for females are generally lower than those for males. A few exceptions were observed in the 10-14 years age-group.

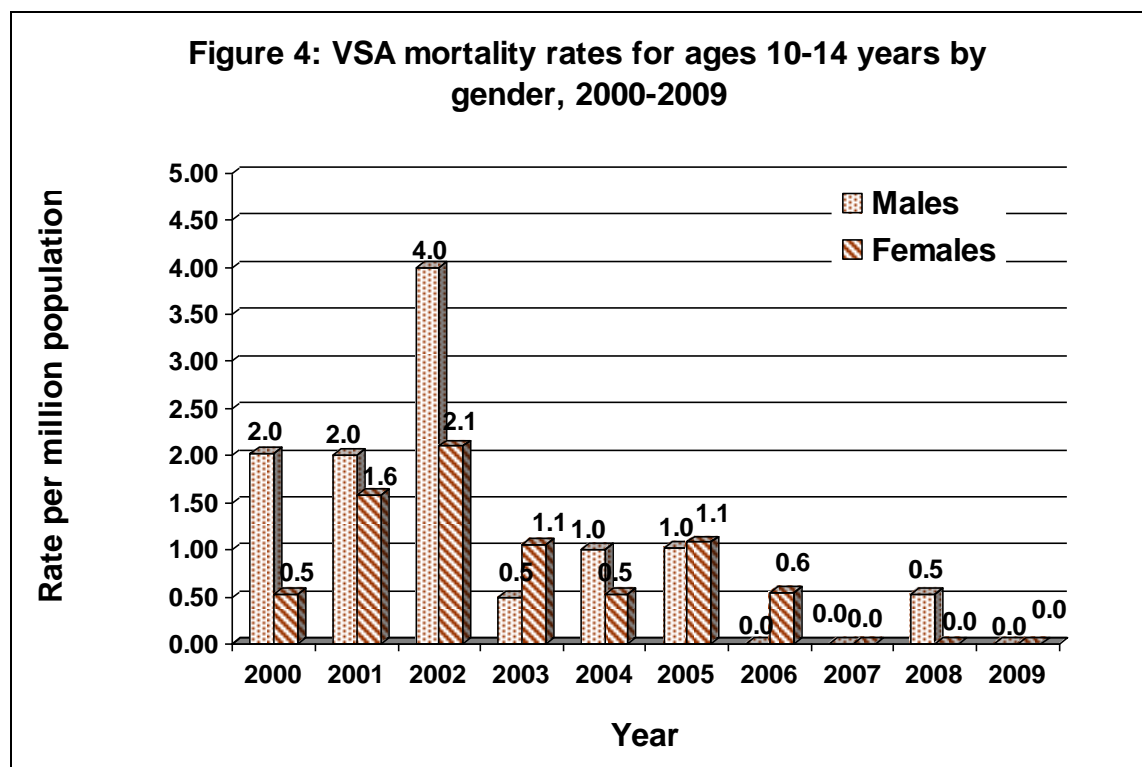
Table 2 presents a comparison of deaths from VSA, from drug misuse (defined as deaths where the underlying causes is poisoning, drug abuse or dependence and where any of the substances controlled under the Misuse of Drugs Act 1971 are involved), from transport accidents and from all causes among the 10-14 and 15-19 years age-groups in the UK for 2009. Mortality data for all causes, transport accidents and drug misuse are for deaths registered in 2009, whereas those for VSA are those occurring in the calendar year.

It should be noted that all drug misuse death numbers are collated by registration year, and that in England and Wales VSA deaths are ascribed to ICD 10 code F18; where an illicit

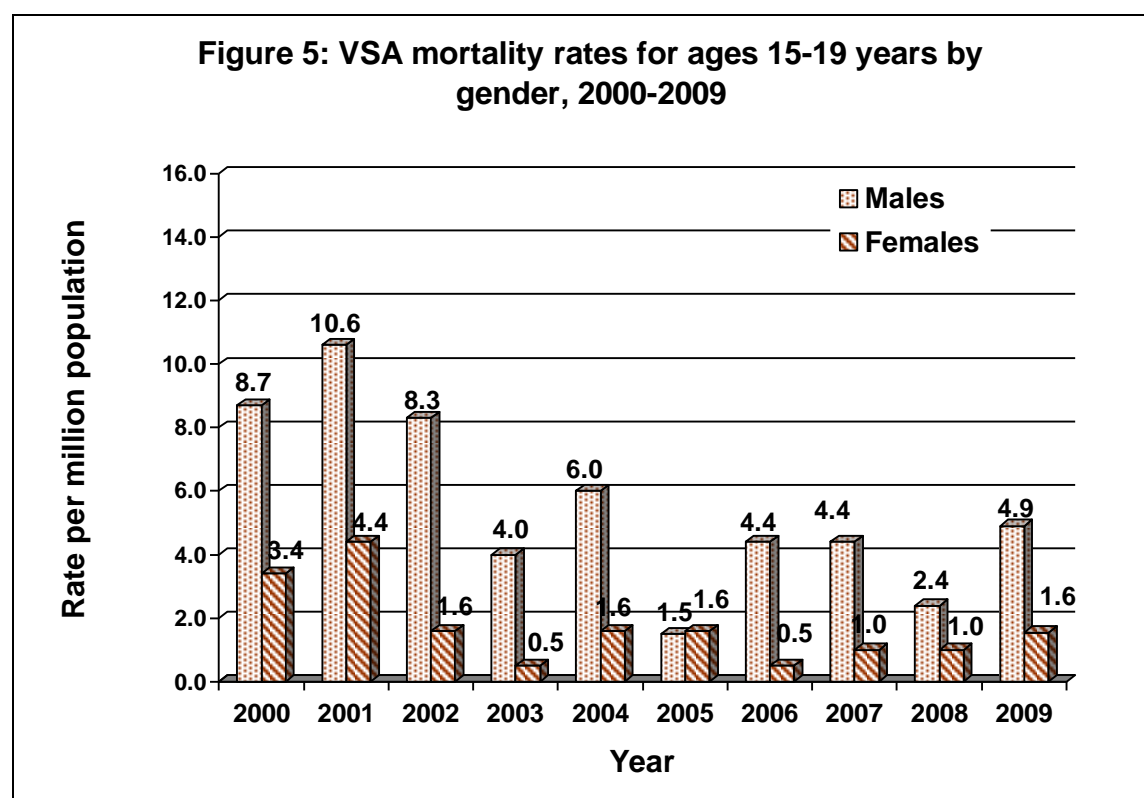
drug is mentioned on the death record it is included in the drug-related death figures.

In 2009 there was no death in the 10-14 years age-group, but at the 15-19 years age-group VSA deaths accounted for 1.0% of deaths from all causes. In the same year, transport accidents (which are by far the most frequent cause of death), accounted for 11.9% of all deaths at age 10-14 years and 25.0% of all deaths at age 15-19 years. Deaths associated with drug misuse accounted for 0.5% of all deaths in the 10-14 years age-group and 4.5% of all deaths in the 15-19 years age-group.

Looking more closely at individual age data for England and Wales for 2000 to 2008, the ratio of VSA to drug misuse deaths appears to cross over between the ages of 14 and 15 years. In the 10-14 year age-group there were 36 VSA deaths over the nine-year period compared with 15 deaths related to drug misuse. In the same period, at age 15 years there were 28 VSA deaths and 34 deaths related to drug misuse. At age 16 years there were 29 VSA deaths and 64 deaths related to drug misuse. This pattern continues into 2009.







**Table 2: Number of deaths in the UK for the 10-14 and 15-19 years age-groups, by cause of death, 2009**

Cause of death	Age (years)			
	10-14		15-19	
	No.	% of all causes	No.	% of all causes
All causes*				
Male	216	53.5	925	69.8
Female	188	46.5	401	30.2
<b>Total</b>	<b>404</b>	<b>100.0</b>	<b>1326</b>	<b>100.0</b>
Transport accidents*				
Male	29	13.4	263	28.4
Female	19	10.1	68	17.0
<b>Total</b>	<b>48</b>	<b>11.9</b>	<b>331</b>	<b>25.0</b>
Drug misuse*				
Male	1	0.4	42	4.5
Female	1	0.5	18	4.5
<b>Total</b>	<b>2</b>	<b>0.5</b>	<b>60</b>	<b>4.5</b>
Volatile Substance Abuse				
Male	0	0.0	10	1.1
Female	0	0.0	3	0.7
<b>Total</b>	<b>0</b>	<b>0.0</b>	<b>13</b>	<b>1.0</b>

\* Deaths registered in 2009.

Sources of data for death from all causes, transport accidents and drug misuse:

England and Wales: Office for National Statistics

Scotland: National Records of Scotland

Northern Ireland: Northern Ireland Statistics and Research Agency, for General Register Office for Northern Ireland

## Death by gender

Table 3 shows the gender-distribution of deaths associated with volatile substances. In 2009, 12 female deaths were recorded (26.1%) while male deaths numbered 34 (73.9%). Over the past ten years males have accounted for an average of 79.5% of deaths across all age-groups. There have been slight year-to-year fluctuations in this proportion.

Figures 6 and 7 shows the percentage of deaths among males and females aged under 18 years and in persons aged 18 years and over respectively, for 1971-1999 and each year to 2009. In 2009 there were seven deaths (two female) in the under-18 years' age-group (Figure 6); there were 39 deaths (10 female) in the 18 years and over age-group (Figure 7).

To compare the difference in proportions of males and females in the two age-groups in 2009, a statistical test was employed (Chi-square test with Yates correction) which showed no marked gender differences ( $X^2 = 0.026$ , 1df,  $p = 0.8709$ ) in both those aged under 18 and those aged 18 and above. Again, over time there have also been significant differences in gender for both those

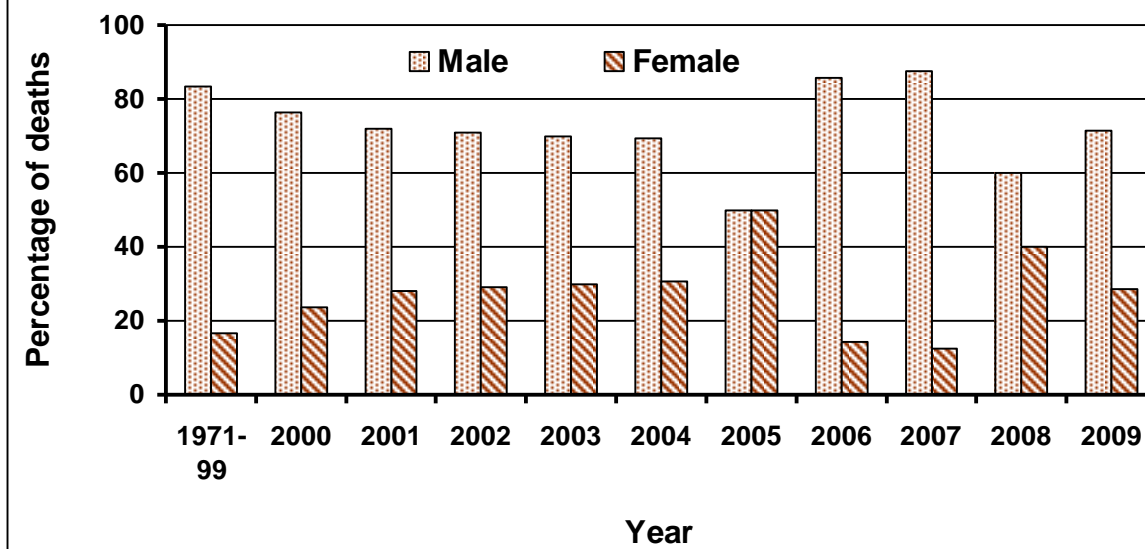
aged under 18 years and for those aged 18 years and over. This shows a significantly lower proportion of females to males were observed over time in both age-groups.

Figure 5 shows a higher percentage of deaths for males compared to a lower percentage for females. A survey of secondary schoolchildren aged 11-15 years in England in 2009 was carried out for the National Centre for Social Research and the National Foundation for Educational Research. This found that 5.4% of male pupils in this age-range used volatile substances in the 12 months prior to the survey compared to 5.6% of female pupils (Fuller and Sanchez, 2010). The European School Survey Project on Alcohol and other Drugs (ESPAD) 2007 found that there was no gender difference in lifetime inhalant use among 16-year olds in the majority of countries surveyed, although a gender difference was evident for the UK (Hibell *et al*, 2009). Although there is greater use of volatile substances by girls, the number of deaths is higher amongst boys. This indicates that boys are at higher risk of dying from VSA.

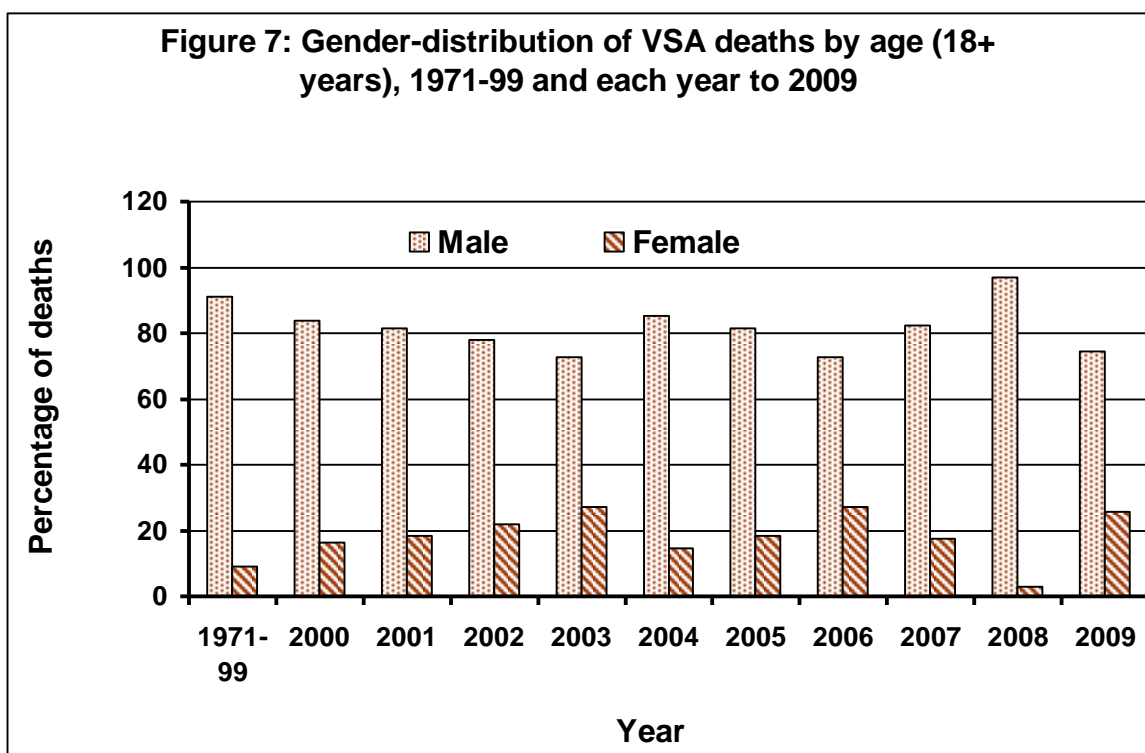
**Table 3: Gender distribution of VSA deaths, 1971-1999 & each year to 2009**

Year	Gender					
	Male		Female		All persons	
	No.	%	No.	%	No.	%
1971-99	1614	87.0	241	13.0	1855	100.0
2000	54	81.8	12	18.2	66	100.0
2001	49	77.8	14	22.2	63	100.0
2002	49	75.4	16	24.6	65	100.0
2003	39	72.2	15	27.8	54	100.0
2004	38	80.9	9	19.1	47	100.0
2005	35	76.1	11	23.9	46	100.0
2006	38	74.5	13	25.5	51	100.0
2007	49	83.1	10	16.9	59	100.0
2008	35	92.1	3	7.9	38	100.0
2009	34	73.9	12	26.1	46	100.0
<b>Total</b>	<b>2034</b>	<b>85.1</b>	<b>356</b>	<b>14.9</b>	<b>2390</b>	<b>100.0</b>

**Figure 6: Gender-distribution of VSA deaths by age (<18 years), 1971-99 and each year to 2009**



**Figure 7: Gender-distribution of VSA deaths by age (18+ years), 1971-99 and each year to 2009**



## Regional variation

Table 4 shows the numbers of deaths by country and by Government Office Region in England. In 2009, there were 25 deaths in England, one in Wales, three in Northern Ireland, and 17 deaths in Scotland. There were no deaths in the Channel Islands or Isle of Man.

Table 5 and Figure 9 give the Standardised Mortality Ratios (SMRs) for each Region and country averaged across the period 2000-2009. SMRs are used to compare geographical areas taking account of any differences in the age and gender distribution of the population. The whole of the UK has an average SMR of 100. Countries and regions where the SMR is higher than 100 have more deaths than

expected and those where the SMR is less than 100 have lower deaths than expected.

SMRs differ significantly across countries and Government Office Regions ( $P < 0.001$  with 11 df). For the period 2000–2009 Northern Ireland (179) and Scotland (172) had the highest SMRs and South East England had the lowest SMR (37). In general, there were more deaths than expected in Northern Ireland, Scotland, North East, Yorkshire and Humber, East and West Midlands, and the South West. The North West, London, South East, East, and Wales exhibited lower death rates than expected.

**Table 4: Number of VSA deaths by Government Office Region (England) and Country, 1971-99 & each year to 2009**

Region or Country	Year											Total
	71-99	00	01	02	03	04	05	06	07	08	09	
<b>England:</b>												
North East	119	3	3	6	4	1	2	2	3	2	3	148
North West	242	10	4	4	5	6	1	3	2	4	5	286
Yorkshire/Humber	172	5	10	7	4	6	4	4	5	3	3	223
East Midlands	121	5	9	5	3	7	6	4	6	2	2	170
West Midlands	163	7	5	10	5	3	3	5	7	5	2	215
East	117	7	5	2	4	4	4	5	5	2	4	159
London	223	4	6	2	8	6	8	4	5	5	3	274
South East	183	7	4	10	8	5	7	5	8	4	3	244
South West	110	4	3	5	1	3	1	2	3	3	0	135
<b>Total England</b>	<b>1450</b>	<b>52</b>	<b>49</b>	<b>51</b>	<b>42</b>	<b>41</b>	<b>36</b>	<b>34</b>	<b>44</b>	<b>30</b>	<b>25</b>	<b>1854</b>
WALES	77	1	1	5	1	4	1	5	2	2	1	100
SCOTLAND	250	9	9	8	6	1	4	9	10	4	17	327
N. IRELAND	70	2	4	1	5	1	5	3	3	2	3	99
CHANNEL ISLANDS	6	1	0	0	0	0	0	0	0	0	0	7
ISLE OF MAN	2	1	0	0	0	0	0	0	0	0	0	3
<b>Total UK and Island</b>	<b>1855</b>	<b>66</b>	<b>63</b>	<b>65</b>	<b>54</b>	<b>47</b>	<b>46</b>	<b>51</b>	<b>59</b>	<b>38</b>	<b>46</b>	<b>2390</b>

**Table 5: Standardised Mortality Ratios for Govt. Office Region (England) and Country, adjusted for age and gender, 2000-2009**

Region or Country	Deaths		SMR	95% confidence interval
	Observed	Expected		
<b>ENGLAND</b>				
North East	29	22.5	129	89 to 184
North West	44	60.5	73	54 to 97
Yorkshire/Humber	51	45.6	112	85 to 147
East Midlands	49	37.9	129	97 to 171
West Midlands	52	47.0	111	84 to 145
East	42	47.5	89	65 to 119
London	51	72.6	70	53 to 92
South East	26	70.8	37	25 to 53
South West	60	42.5	141	109 to 100
<b>Total England</b>	<b>404</b>	<b>446.7</b>	<b>90</b>	<b>82 to 100</b>
WALES	23	25.3	91	59 to 135
SCOTLAND	77	44.8	172	137 to 214
N. IRELAND	29	16.2	179	123 to 256
<b>Total UK*</b>	<b>533</b>	<b>533</b>	<b>100</b>	

<b>Crude Mortality Rates</b> per million population per year	<b>Male = 1.43</b>	<b>Female = 0.38</b>	<b>All persons = 0.89</b>
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\* Channel Isles and Isle of Man are not included

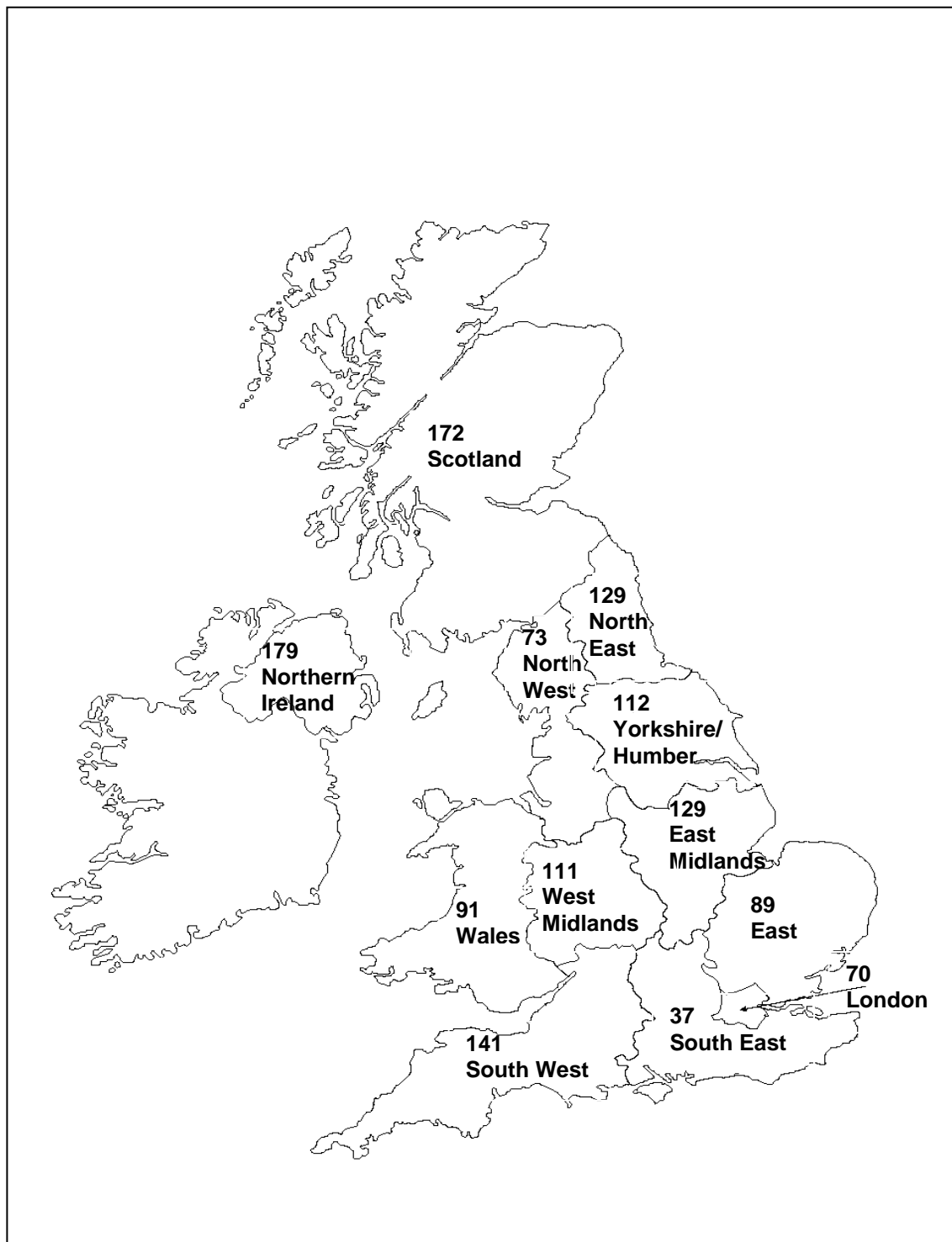
Sources of population data (Average of censuses updated mid-year estimates for 2004 and 2005)

England and Wales: Office for National Statistics

Scotland: National Records of Scotland

Northern Ireland: Northern Ireland Statistics and Research Agency, for General Register Office for Northern Ireland

**Figure 8: Standardised Mortality Ratios for Govt. Office Region (England) and Country, adjusted for age and gender, 2000-2009**



## Substances abused

The main substances abused by all age-groups between 2000 and 2009 are shown in Table 6. Butane intended for fuel use and butane used as a propellant in aerosols are classified separately. The highest proportion of deaths is associated with only one volatile substance - butane. In 13 (2%) deaths over this 10-year period, two volatile substances in combination were known to be involved. Table 6 and Figure 9 show the number of times each substance was associated with death.

Over the time-period 1971 to 2009 there was a notable change in the proportions of specific substances abused. In 2009 the total number of cases associated with gas fuels was 30, similar

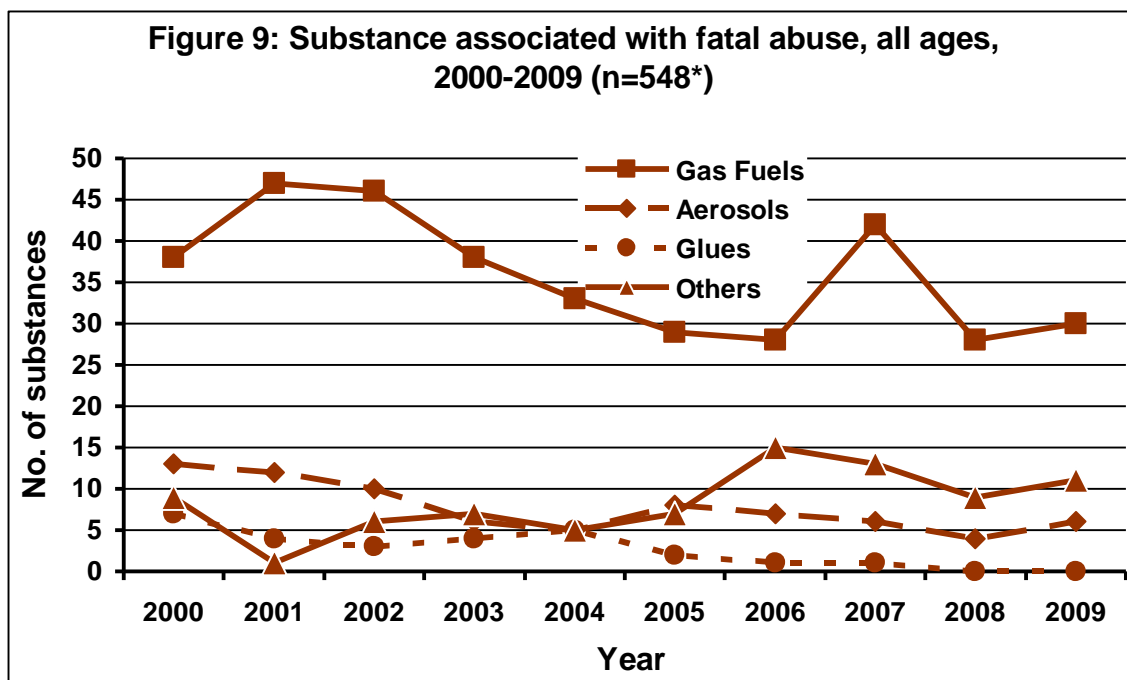
to 2008. The declines in aerosol-related deaths in recent years and declines in glue-related deaths over time are more pronounced.

Figure 10 gives the same information for those aged less than 18 years for the number of times each substance was associated with death. Changes in the proportion of substances abused in this age-group are also notable, with marked fluctuations observed in different periods between 2000 and 2009. In 2009 deaths associated with gas fuels sharply increased compared to 2008; whereas deaths associated with aerosols remained stable. Overall, there has been a fall over time in the number of such cases.

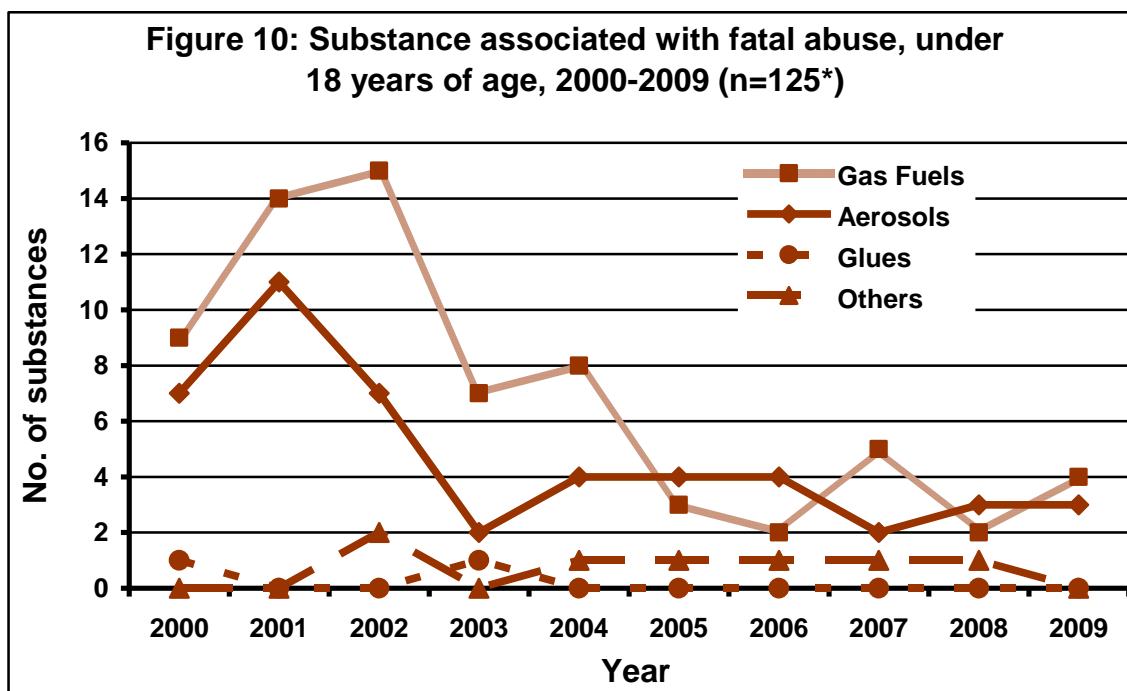
**Table 6: Substance abused, all ages, 1971- 99 & each year to 2009 (n=2495\*)**

Substance	Year											Total
	1971 - 99	00	01	02	03	04	05	06	07	08	09	
<b>Gas fuels</b>	844	38	47	46	38	33	29	28	42	28	30	1202
%	45.5	56.7	72.3	70.8	69.1	68.8	63.0	54.9	66.7	68.3	63.8	48.2
<b>Aerosols</b>	356	13	12	10	6	5	8	7	6	4	6	428
%	19.2	19.4	18.5	15.4	10.9	10.4	17.4	13.7	9.5	9.8	12.8	17.2
<b>Glues</b>	323	7	4	3	4	5	2	1	1	0	0	350
%	17.4	10.4	6.2	4.6	7.3	10.4	4.3	2.0	1.6	0.0	0.0	14.0
<b>Other</b>	361	8	1	6	7	5	7	15	12	8	9	440
%	19.5	11.9	1.5	9.2	12.7	10.4	15.2	29.4	19.0	19.5	19.1	17.6
<b>Fire Extinguishers</b>	58	0	0	0	0	0	0	0	0	0	0	58
%	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
<b>Not known</b>	12	1	0	0	0	0	0	0	1	1	2	17
%	0.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.4	4.3	0.7
<b>All substances</b>	<b>1855</b>	<b>67</b>	<b>65</b>	<b>65</b>	<b>55</b>	<b>48</b>	<b>46</b>	<b>51</b>	<b>63</b>	<b>41</b>	<b>47</b>	<b>2495</b>

\* Number of substances is greater than the number of deaths as all substances associated with a death are included.



\* All substances associated with a death are included.



\* All substances associated with a death are included.



## Products abused

Table 7 shows products abused by substance for 2009. This also gives the type of products implicated in death, showing them as percentages of substances used, rather than as percentages of the total number of deaths. There were no multiple product fatalities in 2009. However, in previous years there were some instances of more than one product being involved and thus deaths can appear more than once in the table. Butane gas lighter fuel was associated with 17% of all substances fatally abused in 2009. In addition, unspecified butane (including butane gas can), some of which is likely to have been lighter fuel, accounted for another 35% of all substances in the same year.

In 2009 there were five deaths (two in 2008) associated with the inhalation of anaesthetic agents. All cases involved nitrous oxide, supplied for non-medical use as cylinders or as caplets designed to be employed with cream-whipping devices, and were the result of asphyxiation where the nitrous oxide had been inhaled using a plastic bag over the head. The supply, other than by a registered pharmacist, of nitrous oxide for inhalation is an offence under Section 52 of the Medicines Act 1968. In addition one death was associated with the inhalation of chloroform and two deaths involved the inhalation of alkyl nitrites ('poppers'). The supply of chloroform and one form of alkyl nitrite, isobutyl nitrite, is now controlled by legislation, The Dangerous Substances and Preparations (Safety) Regulations 2006, which came into full effect in August 2007.

Table 8 gives similar information for the period 1971 to 2009. This shows the wide variety of products that has been abused within the broad substance categories. Since 1971, butane gas lighter fuel has been associated with a little lower than 80% of fatal abuses of gas fuel, and 38% of all substances fatally abused. Deodorants and anti-perspirants have been associated with 47% of fatal abuses of aerosols, and 8% of all substances, and contact adhesives with 54% of fatal abuses of glue, also 8% of all substances. Since 1995 there have been no deaths from text-correction fluid or pain-relief sprays and only one death from a fire extinguisher (involving an old product).

Table 9 shows deaths associated with butane cigarette lighter refills in the time-period 1971-

1999 and for each year from 2000 to 2009 by gender for those aged under-18 years of age. Amongst those in this age-group, there were two deaths in 2009, as in 2008, compared with 4 in 2007 and 2 in both 2006 and 2005. Legislation which banned the sale of these items to under-18 year olds came into effect in October 1999 [The Cigarette Lighter Refill (Safety) Regulations 1999]. In this age-group the number of deaths associated with lighter fuel fell from an average of 19.8 per year between 1990 and 1999 to 6.2 per year between 2000 and 2009. The difference between these two periods is statistically significant ( $\chi^2=20.7$ , 1df,  $p<0.001$ ). The number of such deaths amongst those aged less than 18 fell from a peak of 40 in 1990 to 15 in 1999, and to 2 in recent years. About two-thirds of the fall in deaths occurred after the coming into force of these regulatory provisions. These changes provide evidence to suggest that the change in legislation had some beneficial impact. However, detailed analysis will be needed to evaluate the impact of changes in legislation over time.

The coming into force of a European Union Directive (2005/95/EC) which restricted the use of toluene and trichlorobenzene in products harmful to man and the environment on 15 December 2006, together with the introduction of the first phase of provisions on 1 January 2007 of the Volatile Organic Compounds (VOCs) in Paints, Varnishes and Vehicle Refinishing Products Regulations 2005, as well as changes by industry anticipating the introduction of more stringent controls in the second phase from 1 January 2010, may have contributed to the low level in recent years of deaths involving the deliberate inhalation of products containing these substances.

New commercial products, as well as ones which have been around for a long time, have the potential to emerge as substances of abuse due to their containing propellants. In the last year or so, the inhalation of computer cleaning duster sprays (Hahn *et al.*, 2006; Garland and Howard, 2010; Hall *et al.*, 2010; Howard *et al.*, 2011), and air conditioner fluid in residential or commercial premises (Brady *et al.*, 1994; Phatak and Walterscheid, 2010) have given rise to concern amongst health professionals and medical examiners in the USA.

**Table 7: Substance abused, by product, 2009 (n=46\*)**

<b>Substance and product</b>	<b>No.</b>	<b>% of substance group</b>	<b>% of all substances</b>
<b>GAS FUELS</b>			
Lighter fuel	8	25.8	17.4
Calor gas/domestic gas	2	6.5	4.3
Propane	2	6.5	4.3
Butane gas can	3	9.7	6.5
Butane unspecified	16	51.6	34.7
<b>TOTAL OF GAS FUELS</b>	<b>31</b>	<b>100.0</b>	<b>67.4</b>
<b>AEROSOLS</b>			
Deodorant	5	100.0	10.9
<b>TOTAL OF AEROSOLS</b>	<b>5</b>	<b>100.0</b>	<b>10.9</b>
<b>OTHER</b>			
Chloroform	1	12.5	2.2
Alkyl nitrites	2	25.0	4.3
Nitrous oxide (anaesthetic)	5	62.5	10.9
<b>Total of Other</b>	<b>8</b>	<b>100.0</b>	<b>17.4</b>
Substance not known	2	100.0	4.3
<b>All Substances</b>	<b>46</b>	<b>-</b>	<b>100.0</b>

\* No multiple substances associated with a death

**Table 8: Substance abused, by product, 1971-2009 (n=2,488)**

<b>Substance and product</b>	<b>No.</b>	<b>% of substance group</b>	<b>% of all substances</b>
Lighter fuel	947	78.9	38.1
Calor gas/domestic gas	114	9.5	4.6
Propane	39	3.3	1.6
Acetylene	3	0.3	0.1
Butane gas can	49	4.1	2.0
Butane unspecified	48	4.0	1.9
<b>TOTAL OF GAS FUELS</b>	<b>1200</b>	<b>100.0</b>	<b>48.2</b>
Deodorant	205	46.9	8.2
Pain relief spray	63	14.4	2.5
Air freshener	51	11.7	2.0
Hair spray	33	7.6	1.3
Cleaning fluid	16	3.7	0.6
Fly spray	9	2.1	0.4
Paint spray	8	1.8	0.3
Aerosol glue	2	0.5	0.1
Other aerosols	50	11.4	2.0
<b>TOTAL OF AEROSOLS</b>	<b>437</b>	<b>100.0</b>	<b>17.6</b>
Contact adhesive	186	53.8	7.5
Puncture repair glue	11	3.2	0.4
Model glue	3	0.9	0.1
Other glues	146	42.2	5.9
<b>TOTAL OF GLUES</b>	<b>346</b>	<b>100.0</b>	<b>13.9</b>
Typewriter correction fluid	112	26.1	4.5
Chloroform	41	9.6	1.6
Unspecified trichloroethylene	38	8.9	1.5
Petrol	37	8.6	1.5
Paint thinners	15	3.5	0.6
Domestic cleaner-unspecified	19	4.4	0.8
Industrial solvent	18	4.2	0.7
Carbon tetrachloride	12	2.8	0.5
Nitromors paint stripper	6	1.4	0.2
Alkyl nitrites	23	5.4	0.9
Refrigerant gases	5	1.2	0.2
Ether	5	1.2	0.2
Benzene	1	0.2	0.0
Nitrous oxide (anaesthetic)	52	12.1	2.1
Misc other	45	10.5	1.8
<b>TOTAL OF OTHERS</b>	<b>429</b>	<b>100.0</b>	<b>17.2</b>
Fire extinguishers	58	100.0	2.3
Substance not known	18	100.0	0.7
<b>TOTAL OF ALL SUBSTANCES</b>	<b>2488</b>	<b>100.0</b>	<b>100.0</b>

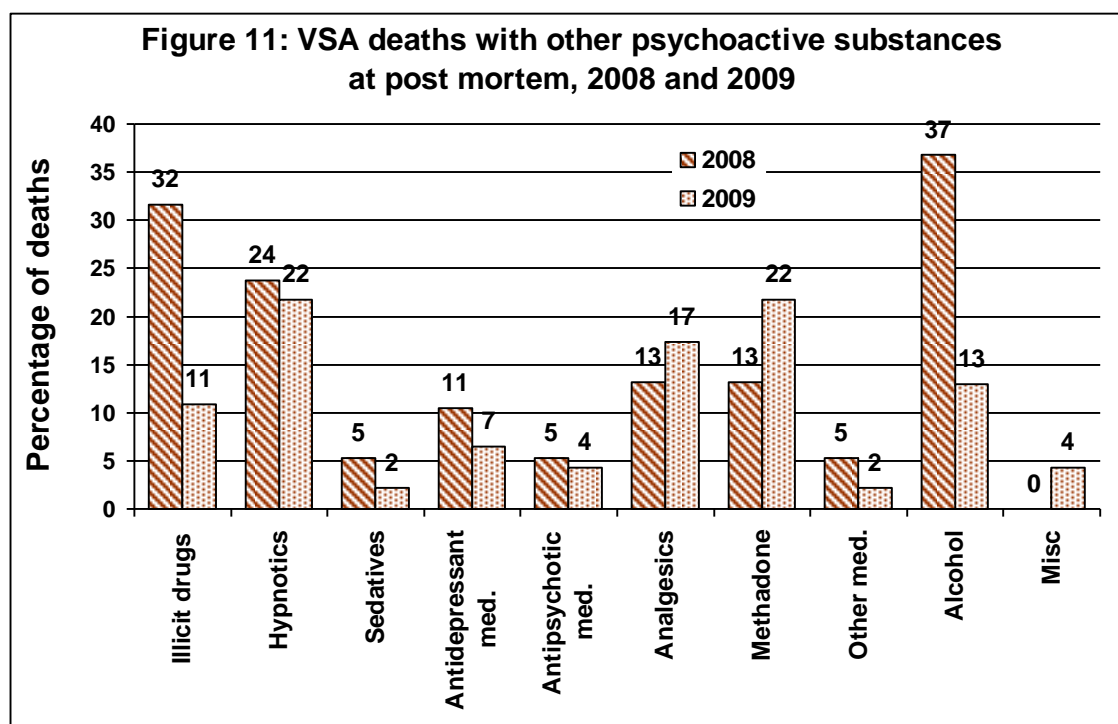
**Table 9: Deaths associated with cigarette lighter refills, in persons under 18 years of age, 1971-1999 & each year to 2009**

Gender	Year											Total
	71-99	00	01	02	03	04	05	06	07	08	09	
Male	332	7	12	13	4	6	1	2	3	2	1	383
Female	59	1	3	2	2	2	1	0	1	0	1	72
<b>All persons</b>	<b>391</b>	<b>8</b>	<b>15</b>	<b>15</b>	<b>6</b>	<b>8</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>455</b>
VSA deaths (All)	974	17	25	24	10	13	8	7	8	5	7	1098
% all VSA deaths	40.1	47.1	60.0	62.5	60.0	61.5	25.0	28.6	50.0	40.0	28.6	41.4

### Other psychoactive substances associated with VSA deaths

Figure 11 shows that other psychoactive substances, including alcohol, were also present in the post mortem toxicology of VSA fatalities. This does not mean that they necessarily caused, or contributed to, death. Drugs were mentioned in 24 (54%) cases in 2009 and 25 (66%) cases in 2008. In 2009, methadone and hypnotics (such as benzodiazepines) were both recorded in 22% of cases, followed by analgesics (pain-killers) (17%), alcohol as a sole additional substance

(13%), and illicit drugs (11%). On the other hand, alcohol featured in 37% of cases in 2008, followed by illicit drugs (32%), and hypnotics (24%). The presence of methadone was also evident in both years: 13% in 2008, and 22% in 2009. These findings underline the continuing emergence of polysubstance abuse. Combining the use of psychoactive substances increases the risk of overdose and death (Ghodse *et al.*, 2010b).



## Method of administration

Methods of administration of volatile substances are given in Table 10; Table 11 gives this information by product. Over the last ten years, the highest proportion of deaths occurred after substances were discharged directly into the mouth, followed by substances sniffed from plastic bags. The predominant method of abuse of butane lighter refills is believed to be by discharge directly into the mouth. In the absence of evidence to the

contrary, lighter fuel abuse has been coded to this method. The most common method of administration for aerosols used to be sniffing from a cloth covering the breathing passages ('huffing'), but more recently has been by spraying through a cloth ('tooting'), and for glues has been by inhalation of the fumes or vapours from plastic bags ('bagging').

**Table 10: Methods of administration of main substances, 1971-1999 & each year to 2009**

Method	Year											Total
	1971-99	00	01	02	03	04	05	06	07	08	09	
Directly into mouth	661	31	40	35	34	25	18	27	31	20	23	945
Sniffed from container	133	4	1	7	6	4	4	2	3	3	6	173
Sniffed from/through cloth	190	5	7	8	4	2	3	4	2	5	1	231
Sniffed from plastic bag	296	3	3	3	1	2	0	1	0	2	2	313
Plastic bag over head	206	10	3	7	5	10	12	13	15	2	5	288
Mask or padding over face	47	2	2	1	1	3	5	3	7	3	2	76
Other	24	0	0	0	0	0	0	0	0	1	0	25
Not known	298	11	7	4	3	1	4	1	1	2	7	339
<b>Total</b>	<b>1855</b>	<b>66</b>	<b>63</b>	<b>65</b>	<b>54</b>	<b>47</b>	<b>46</b>	<b>51</b>	<b>59</b>	<b>38</b>	<b>46</b>	<b>2390</b>

**Table 11: Methods of administration of main substances, by product, 1971-1999 & each year to 2009 (n=2390)**

Substance and method	Year											Total
	1971-99	00	01	02	03	04	05	06	07	08	09	
<b>Gas fuels</b>												
Directly into mouth	594	31	40	35	33	25	15	22	30	19	18	862
Sniffed from container	25	2	1	2	0	0	1	0	0	2	5	38
Sniffed from cloth or sleeves	14	0	0	1	0	0	0	0	1	0	0	16
Sniffed from plastic bag	43	1	0	0	0	1	0	0	0	1	2	48
Plastic bag over head	88	3	3	6	4	5	8	5	10	0	0	132
Mask or padding over face	16	0	1	1	0	1	3	1	0	0	0	23
Other	10	0	0	0	0	0	0	0	0	1	0	11
Not known	42	1	1	1	1	1	2	0	0	2	4	55
<b>Total for gas fuels</b>	<b>832</b>	<b>38</b>	<b>46</b>	<b>46</b>	<b>38</b>	<b>33</b>	<b>29</b>	<b>28</b>	<b>41</b>	<b>25</b>	<b>29</b>	<b>1185</b>
<b>Aerosols</b>												
Directly into mouth	41	0	0	0	1	0	3	4	1	1	2	53
Sniffed from container	9	1	0	1	2	0	0	0	0	1	1	15
Sniffed from/through cloth	73	5	7	6	1	2	3	2	1	2	0	102
Sniffed from plastic bag	65	0	2	1	0	1	0	1	0	0	0	70
Plastic bag over head	35	3	0	0	0	1	1	0	3	0	2	45
Mask or padding over face	10	0	0	0	0	0	0	0	0	0	0	10
Other	2	0	0	0	0	0	0	0	0	0	0	2
Not known	86	4	3	2	1	0	1	0	0	0	1	98
<b>Total for aerosols</b>	<b>321</b>	<b>13</b>	<b>12</b>	<b>10</b>	<b>5</b>	<b>4</b>	<b>8</b>	<b>7</b>	<b>5</b>	<b>4</b>	<b>6</b>	<b>395</b>
<b>Glues</b>												
Directly into mouth	6	0	0	0	0	0	0	0	0	0	0	6
Sniffed from container	136	1	0	1	1	2	1	0	0	0	0	212
Sniffed from cloth or sleeves	3	0	0	0	0	0	0	0	0	0	0	3
Sniffed from plastic bag	150	1	1	2	1	0	0	0	0	0	0	155
Plastic bag over head	45	1	0	0	0	3	0	0	0	0	0	49
Mask or padding over face	6	0	0	0	1	0	0	0	0	0	0	7
Other	1	0	0	0	0	0	0	0	0	0	0	1
Not known	72	3	3	0	1	0	1	1	0	0	0	81
<b>Total for glues</b>	<b>299</b>	<b>6</b>	<b>4</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>324</b>
<b>Others</b>												
Directly into mouth	20	0	0	0	0	0	0	1	0	0	3	24
Sniffed from container	83	0	0	3	3	2	2	2	3	0	0	98
Sniffed from cloth or sleeves	100	0	0	1	3	0	0	2	0	3	1	110
Sniffed from plastic bag	38	1	0	0	0	0	0	0	0	1	0	40
Plastic bag over head	38	3	0	1	1	1	3	8	2	2	3	62
Mask or padding over face	15	2	1	0	0	2	2	2	7	3	2	36
Other	11	0	0	0	0	0	0	0	0	0	0	11
Not known	98	3	0	1	0	0	0	0	1	0	2	105
<b>Total for others</b>	<b>403</b>	<b>9</b>	<b>1</b>	<b>6</b>	<b>7</b>	<b>5</b>	<b>7</b>	<b>15</b>	<b>13</b>	<b>9</b>	<b>11</b>	<b>486</b>

Note: Other includes fire extinguisher and substance not known

## Mechanism of death

VSA causes death either as a result of a direct toxic mechanism or as a result of other indirect mechanisms including plastic bag asphyxia, inhalation or aspiration of stomach contents, and trauma. Where there is a possibility of an indirect mechanism this is given priority, otherwise the death is recorded as due to 'direct toxic effects'.

Table 12 and Figure 12 show the numbers of deaths due to each mechanism over the past

decade. The majority of deaths (72% overall and 80% in 2009) are due to direct toxic effects. Between 2004 and 2007 there was an increase in the proportion of deaths associated with asphyxiation, mainly by plastic bag, followed by a decrease. The proportion of trauma deaths, which historically were more common with the abuse of glue, has largely decreased over time, from an average of 5.7% (2000-2004) to an average of 2.5% (2005-2009).

**Table 12: Principal mechanism of death for all ages, 2000-2009**

Mechanism	Year										Total
	00	01	02	03	04	05	06	07	08	09	
Direct toxic effect	40	48	44	43	32	30	38	44	31	37	387
%	60.6	76.2	67.7	79.6	68.1	65.2	74.5	74.6	81.6	80.4	72.3
Asphyxia-mainly plastic bag	8	2	6	2	9	8	11	10	5	5	66
%	12.1	3.2	9.2	3.7	19.1	17.4	21.6	16.9	13.2	10.9	12.3
Inhalation of vomit	6	10	9	6	5	3	1	2	0	1	43
%	9.1	15.9	13.8	11.1	10.6	6.5	2.0	3.4	0.0	2.2	8.0
Trauma	9	3	3	1	1	4	1	1	0	0	23
%	13.6	4.8	4.6	1.9	2.1	8.7	2.0	1.7	0.0	0.0	4.3
Other	1	0	0	0	0	1	0	1	1	2	6
%	1.5	0.0	0.0	0.0	0.0	2.2	0.0	1.7	2.6	4.3	1.1
Not known	2	0	3	2	0	0	0	1	1	1	10
%	1.5	0.0	4.6	3.7	0.0	0.0	0.0	1.7	2.6	2.2	1.9
<b>Total</b>	<b>66</b>	<b>63</b>	<b>65</b>	<b>54</b>	<b>47</b>	<b>46</b>	<b>51</b>	<b>59</b>	<b>38</b>	<b>46</b>	<b>535</b>

## Previous history of solvent abuse

In 2009, for 15 (33%) of the 46 VSA deaths there was evidence of a previous history of solvent abuse; for the remaining 67%, there was no evidence of previous volatile substance abuse (9%), or the history was unknown (58%).

However, an absence of evidence should not lead to the assumption that death occurred on the first occasion, as this fact is often difficult to establish.

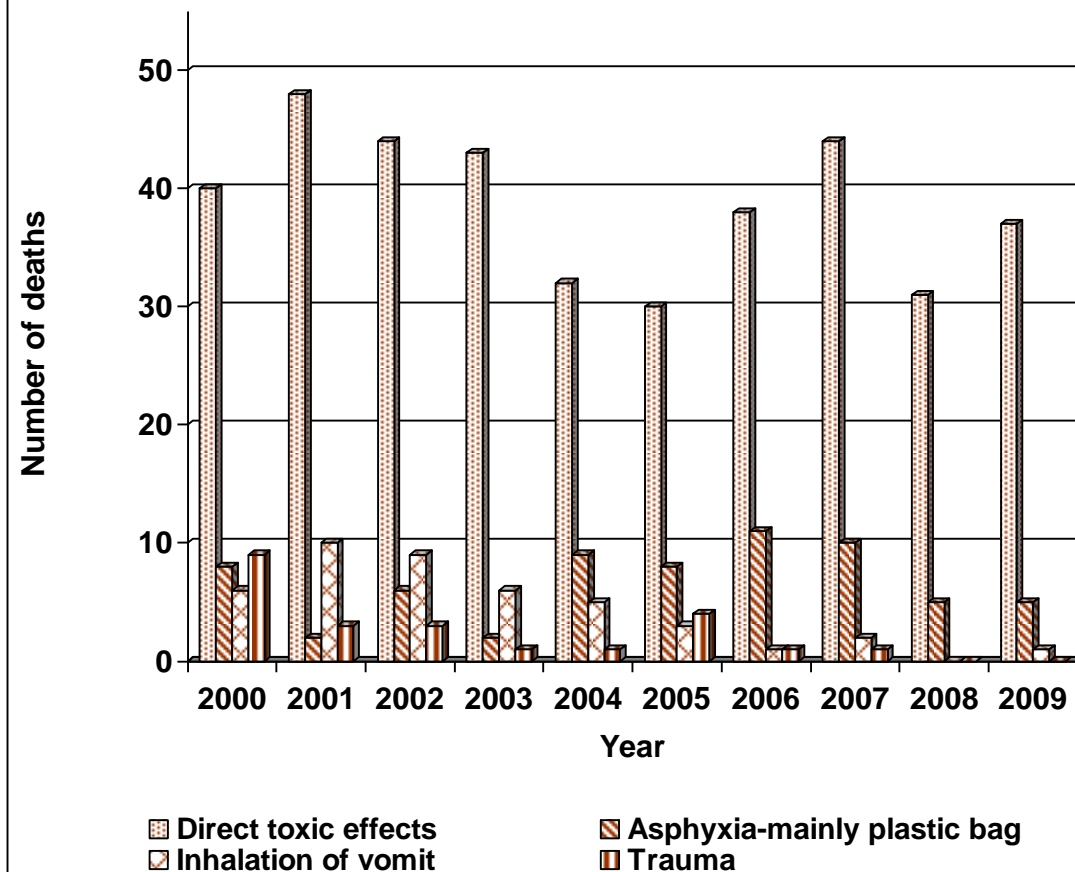
## Place of fatal abuse and death

Figure 13 shows where the fatal abuse leading to death took place. In 2009 the most common place for abuse remained the abuser's home (67%), followed by 9% in a friend's house but only 2% of abuse cases occurred in a public place such as a park, shopping centre or the street. Abuse in other places accounted for

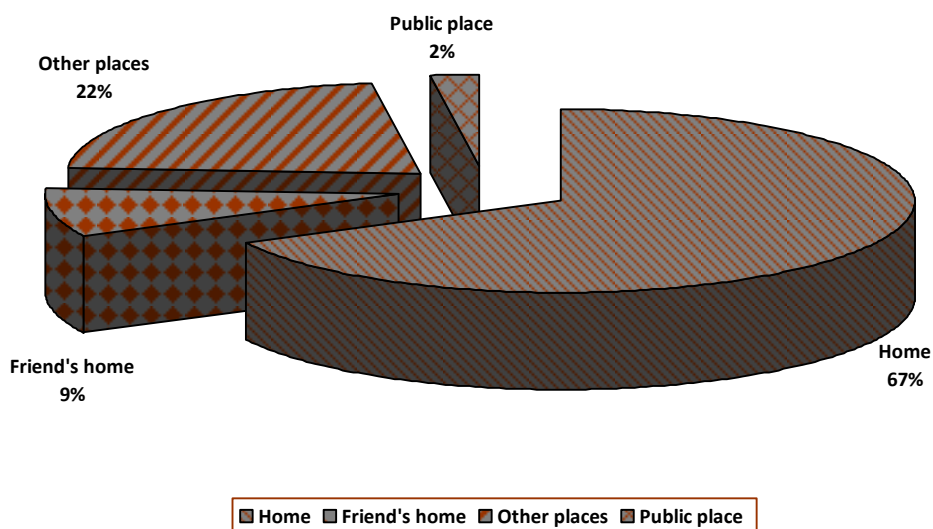
22%.

Figure 14 shows the place of fatal abuse by gender for the period 2000-2009. There was a weak statistically significant difference between males and females in the place of fatal abuse ( $X^2=7.6$ , 6 df,  $p<0.10$ ).

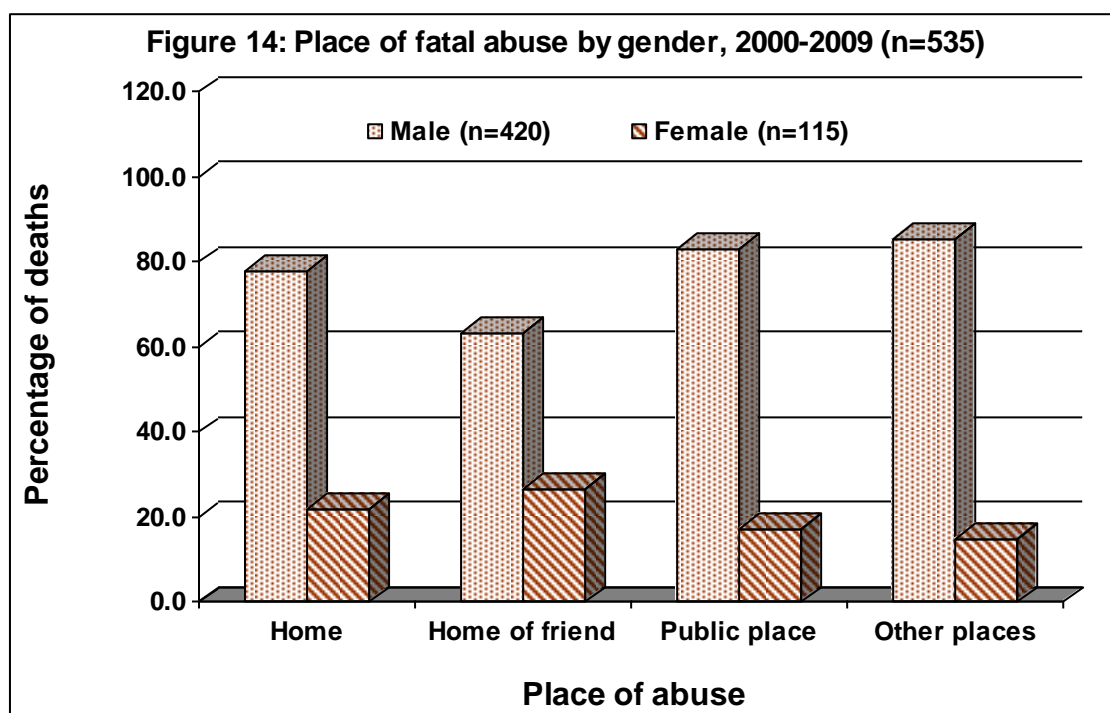
**Figure 12: Principal mechanism of VSA death for all ages, 2000-2009**



**Figure 13: Place of fatal abuse, 2009 (n=46)**





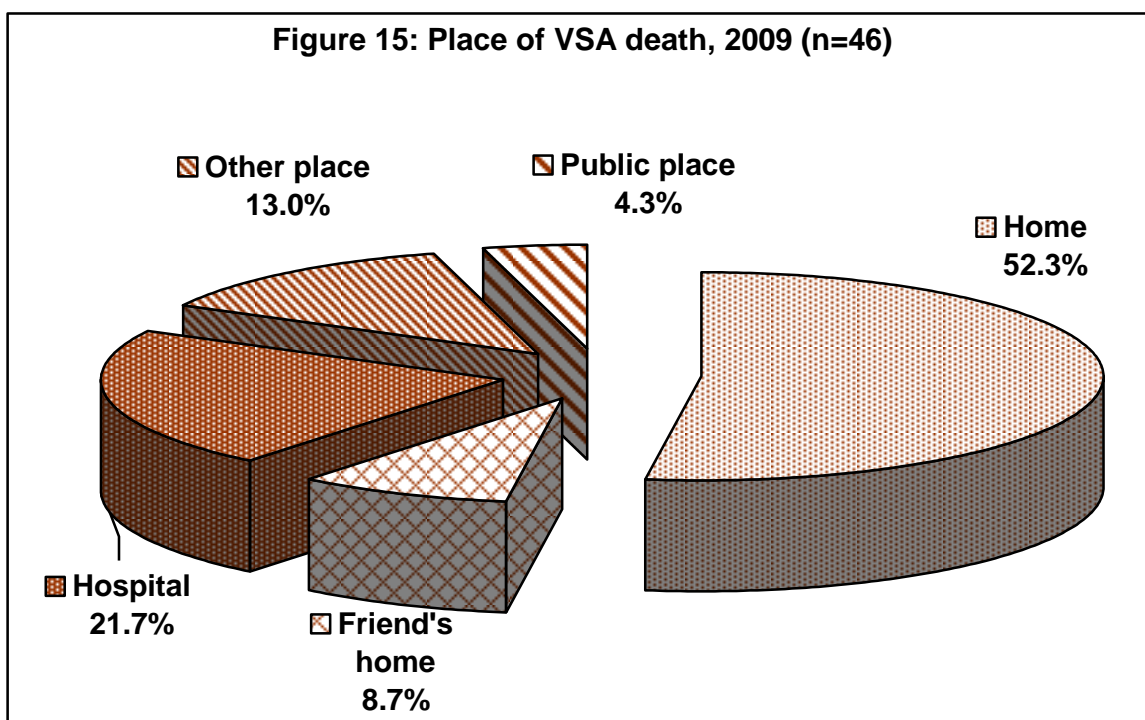


The relationship between age and place of fatal abuse is shown in Table 13. Looking at the last ten years, the most common place of fatal abuse was the person's home or the home of a friend. This proportion for those aged less than 18 years dying at home or the home of a friend was 62% and for those aged 18 years and over was 82%.

Figure 15 shows the place of VSA death in 2009. Just over half (52%) of deaths occurred at home and 22% of deaths were recorded as having occurred in hospital, or as 'dead on arrival' at hospital. Nearly nine per cent died at the home of a friend.

**Table 13: Place of fatal abuse by age-group, 2000-2009**

Age-group (Year)	Place of abuse								Total No
	Home		Home of friend		Public place		Other places		
	No.	%	No.	%	No.	%	No.	%	
< 10	1	100.0	0	0.0	0	0.0	0	0.0	1
10-14	15	41.7	3	8.3	18	50.0	0	0.0	36
15-19	80	57.1	14	10.0	34	24.3	12	8.6	140
20-24	61	75.3	6	7.4	12	14.8	2	2.5	81
25-44	172	79.3	9	4.1	22	10.1	14	6.5	217
45+	52	86.7	1	1.7	2	3.3	5	8.3	60
< 18	63	50.8	14	11.3	41	33.1	6	4.8	124
18+	318	77.4	19	4.6	47	11.4	27	6.6	411
<b>All ages</b>	<b>381</b>	<b>71.2</b>	<b>33</b>	<b>6.2</b>	<b>88</b>	<b>16.4</b>	<b>33</b>	<b>6.2</b>	<b>535</b>



## Suicide

Table 14 gives information on deaths since 2000 associated with the inhalation of a volatile substance where there was an inquest verdict or Procurator Fiscal finding of suicide. It is sometimes difficult to establish for suicides, particularly where no 'suicide note' is left (or found) (Gunnell *et al.*, 2011), what influence the inhalation of a volatile substance had on the actions of the deceased. The use of 'narrative' verdicts also poses problems for determining intent (Gunnell *et al.*, 2011).

The use of a volatile substance in combination with a plastic bag over the head often results in death by asphyxiation, which may be the intended result. However, it has to be emphasized that plastic bags can also be used to heighten sexual experience and thus death may be the result of an accident arising from impaired judgement due to lack of oxygen and/or the effects of psychoactive (including volatile) substances.

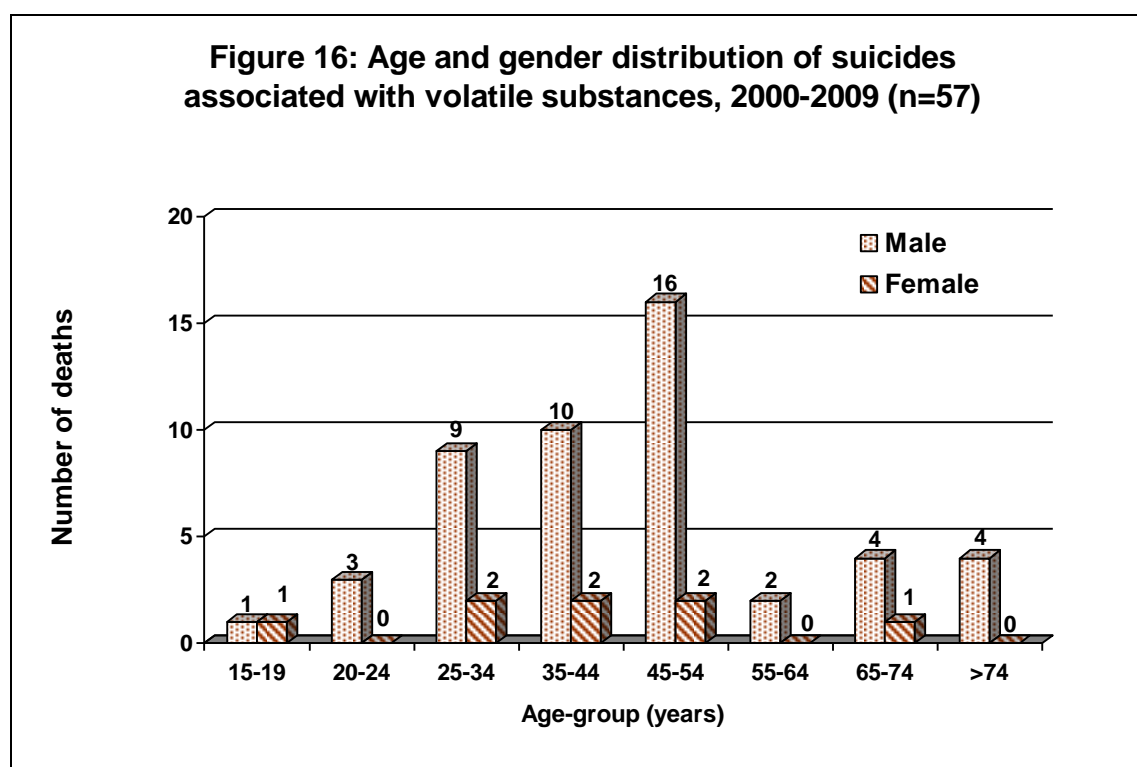
**Table 14: Number of suicides associated with a volatile substance, 2000-2009**

Year	Suicide		Total		% of VSA deaths	Median age at death
	Male	Female	Suicide	VSA		
2000	3	0	3	66	4.5	38
2001	4	0	4	63	6.4	42
2002	4	2	6	65	9.2	48
2003	3	1	4	54	7.4	45
2004	3	0	3	47	6.4	53
2005	6	3	9	46	19.5	36
2006	8	2	10	51	19.6	42
2007	9	0	9	59	15.2	36
2008	4	0	4	38	10.5	46
2009	5	0	5	46	10.9	51
<b>Total</b>	<b>49</b>	<b>8</b>	<b>57</b>	<b>535</b>	<b>10.7</b>	<b>45</b>

Table 14 gives the frequency and median age at death by year, and Figure 17 shows the age- and gender-distribution of suicides involving VSA. In 2009 there were five suicides associated with the inhalation of a volatile substance. This is similar to the level in 2008 (4 cases). To put these figures in perspective, it is worth mentioning that the total (adults aged 15 years and over) number of suicides (defined using ICD-9 and ICD-10 codes) recorded in the UK from 2000-2009 by the General Register Offices was 57,446 with a male:female ratio of 3:1 (Personal communication to the Project from

ONS, 2011).

For suicides associated with the inhalation of a volatile substance, a continuous decrease in the median age was found over time (2000-2009), with an exception in 2004. The median age of suicide was 38 years in 2000, which rose to 53 years in 2004, then fell to between 36 and 46 during 2005-8, but rising to 51 in 2009. For all suicides involving VSA since 2000, the male:female differences are more pronounced in different age-groups, particularly in those aged 20 and above (see Figure 16).



## Deaths associated with helium: a renewed warning

Whilst inert gases, like helium and nitrogen, do not strictly come under the definition of volatile substances this report series has included reference to helium-related deaths since 1999. The cylinders of helium that can be used for inflating balloons are easily available from party shops and for purchase over the Internet. It has become evident to the team that, in the last few years, there has been a rapid increase in the number of deaths, especially suicides, resulting from the deliberate inhalation of helium.

This part of the report presents a brief overview of deaths resulting from the deliberate inhalation of helium gas between 2001 and 2009. Figure 17 gives the number of such deaths during this period; the total number of such deaths in this period was 111, of which 46 occurred in 2009, and 26 in 2008. The majority (93%) of the deaths were suicides, with the remaining 7 cases (6%) being regarded as of undetermined intent, e.g. open verdict, and one as misadventure.

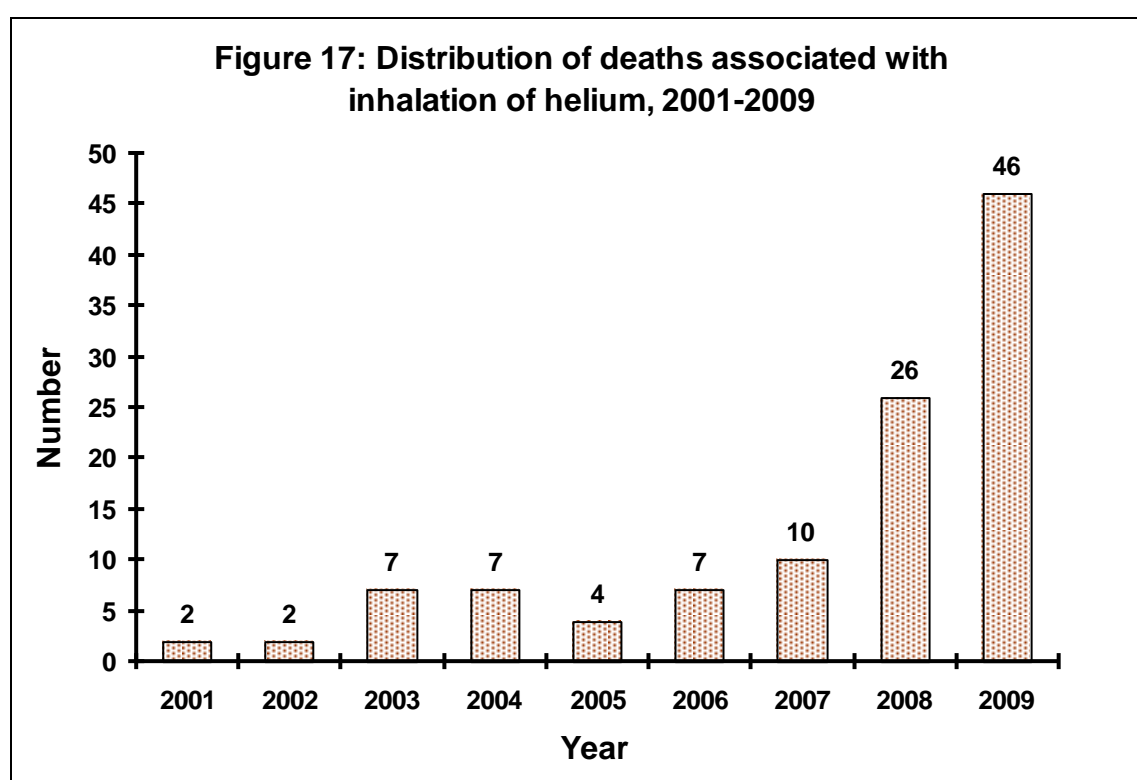


Table 15 shows the distribution of deaths associated with helium inhalation by age-group and gender. In 2009, there were 43 cases identified of those who committed suicide by inhalation of helium while there were 23 in 2008, and 36 during the previous seven years (2001-2007). Overall, the majority (71%) were male, this percentage unchanging over time. Deaths were more pronounced among the 20-39 years age-group as compared to other age-groups shown in Table 15.

Figure 18 shows causes of death due to

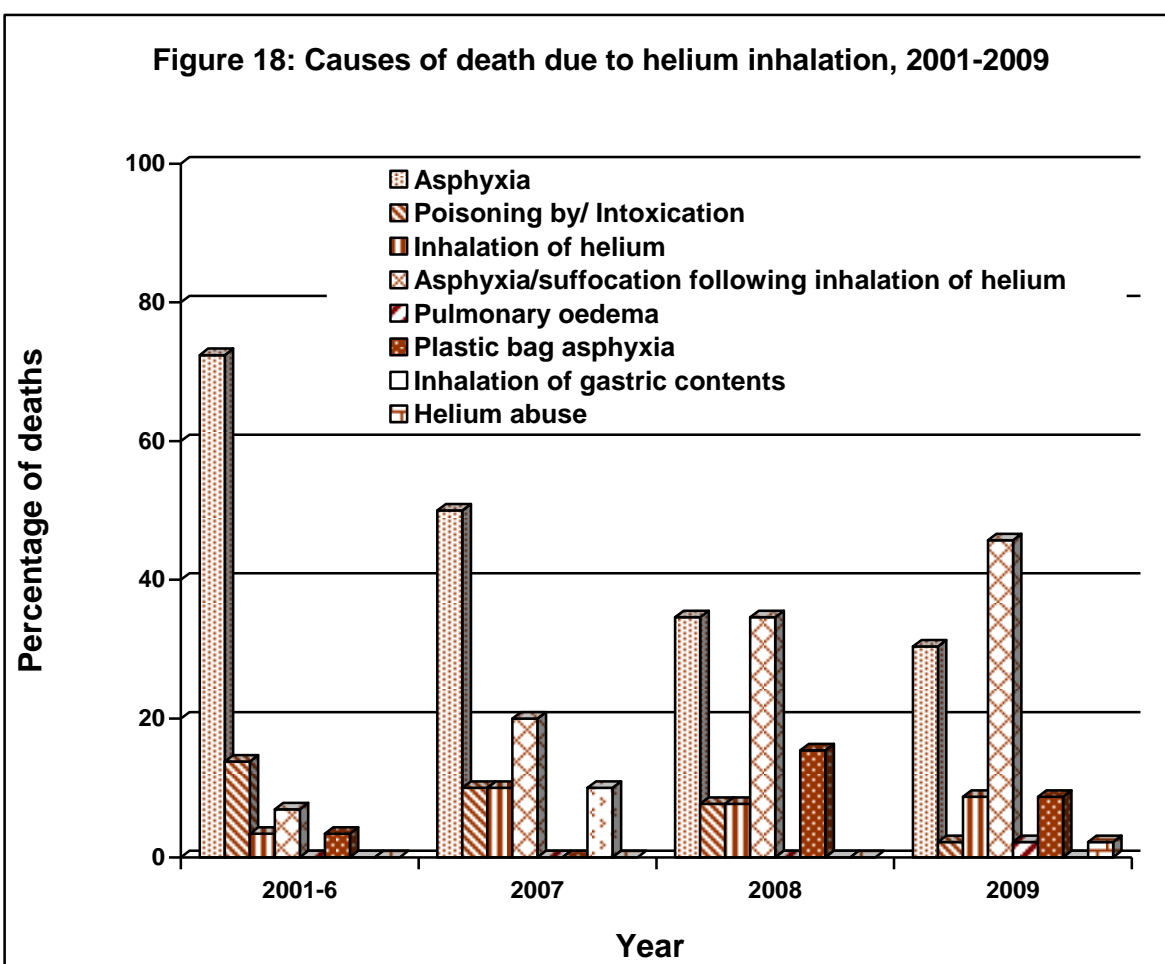
inhalation of helium between 2001 and 2009. The majority of deaths were caused by asphyxia, including plastic bag over the head, due to inhalation of the gas.

The monitoring by this project of deaths involving the deliberate inhalation of gases and vapours has allowed the identification of a rapid increase in deaths resulting from the use of helium. This figure is particularly pronounced between 2007 and 2009, and principally involves suicides. Early indications show that this trend is continuing.

Table 15: Age and gender distribution of deaths due to helium inhalation

Age group	2001-6		2007		2008		2009		2001-9	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
< 20 years	0	1	0	0	1	0	2	0	3	1
%	0.0	16.7	0.0	0.0	4.8	0.0	5.7	0.0	3.4	4.2
20-39	13	3	4	0	9	2	16	2	42	7
%	56.5	50.0	50.0	0.0	42.9	40.0	45.7	18.2	48.3	29.2
40-59	7	2	3	1	10	3	12	6	32	12
%	30.4	33.3	37.5	50.0	47.6	60.0	34.30	54.5	36.8	50.0
60 & above	3	0	1	1	1	0	5	3	10	4
%	13.0	0.0	12.5	50.0	4.8	0.0	14.3	27.3	11.5	16.7
All ages	23	6	8	2	21	5	35	11	87	24
%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Figure 18: Causes of death due to helium inhalation, 2001-2009



## Commentary

The purpose of this Project is to monitor trends in deaths associated with the abuse of volatile substances. This report reports on those trends rather than providing an exhaustive commentary. The results presented here indicate that there has been a significant overall decline in deaths from volatile substance abuse in the United Kingdom since 1992. However, this reduction appears to have stabilised in recent years. Therefore, efforts to educate people on the dangers of inhalation of volatile substances should continue, especially since young people are at greater risk of dying from VSA than from drug misuse or other causes of death.

Overall, the patterns of death associated with VSA in the UK remained fairly stable in 2009. This was true, especially in respect of the products and substances abused, the place of death, as well as the age and gender distributions. However, the main change was an increase in the number of deaths from 38 to 46.

This increase takes the number of cases back to a similar level as was reported for 2004 and 2005 but is still lower than the totals for 2006 and 2007. The decline in deaths between 2007 and 2008 reported last year would appear to be an actual decline rather than the result of changes in the project personnel. Methods of case-ascertainment have remained consistent with previous years and, if anything, made more robust through greater triangulation of sources and the use of additional information flows. However, this increase in deaths from one year to another should be seen as part of a longer-term downward trend.

Data for recent years suggests that one-third of deaths associated with volatile substance abuse still occur amongst those aged under-20 years, predominantly among males. More than half of these premature fatalities are accidental in nature. Therefore, it is important to initiate and maintain public health strategies to prevent the risk of accidental death for those abusing volatile substances. In a high proportion (54%) of such deaths in 2009 other psychoactive substances, including alcohol, were found to be present at post mortem. These findings underline the continuing emergence of polysubstance abuse and the potentially fatal role in death of combining such substances, including 'legal highs' such

as piperazines which were present at significant levels in two VSA deaths in 2009.

Deaths involving nitrous oxide and nitrites are still occurring, albeit at low levels. These still need to be monitored closely, as they are more frequent than in previous decades.

Suicide rates associated with the inhalation of a volatile substance have fallen steadily, yet continue to occur predominantly amongst males. This decline may be due, in part, to an increase in the number of deaths involving the deliberate inhalation of helium, particularly in recent years. It should be possible to reduce the number of suicides using volatile substances and gases if the availability and accessibility of such substances were more restricted. For example, there is evidence that the introduction of the Intoxicating Substances (Supply) Act 1985 had an impact on deaths involving solvents (Esmail *et al.*, 1992), as did the introduction of The Cigarette Lighter Refill (Safety) Regulations 1999 on those involving butane. If safer alternatives were in the market, there would be fewer and less easily accessible substances for committing suicide.

This report further documents, noted for the first time anywhere in last year's publication, the emerging issue of an increasing number of suicides due to deliberate helium inhalation. The numbers increased more than five-fold between 2006 and 2009, and appears to principally involve suicides. Those who committed suicide by inhalation of helium were mainly adult males, including those aged 20-39 years. This phenomenon merits further detailed research, as indications showed that this trend continued into 2011. Although helium is not a volatile substance, consideration may need to be given to raising awareness of this issue.

This report, as well as demonstrating what has happened in 2009 and previous years in terms of deaths involving volatile substances, also provides an indication of possible evolving changes in use patterns, and newly-emerging issues.

This surveillance project is the only UK-wide source of comprehensive information on the phenomena of deaths related to VSA and fatalities due to the deliberate inhalation of helium.

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## Appendix

### Description and examples of commonly abused volatile substances and solvents

This is not meant to be an exhaustive list, but it does give some examples of the substances typically abused in the UK.

Type	Description	Examples
Aerosols	Sprays containing propellants and solvents	Air fresheners Contact adhesives Deodorants Hairsprays Fabric protector sprays Insect sprays Spray paints Vegetable oil sprays Computer cleaning duster sprays
Gases	Medical anaesthetics  Gases used in household or commercial products	Chloroform, ether, halothane, nitrous oxide (laughing gas) Butane lighters, butane/propane canisters, caplets/cartridges for whipped cream dispensers, refrigerants, and home carbonation systems for soft drinks.
Nitrites	'Poppers' act primarily to dilate blood vessels and relax muscles, unlike most other volatile substances which are used to alter mood. Nitrites are used chiefly to enhance sexual experiences.	Amyl nitrite, butyl nitrite
Volatile solvents	Liquids that vaporise at room temperature. Contained in a range of cheap, easily available products used for normal domestic and industrial purposes	Paint thinners and removers /strippers Dry-cleaning fluids Degreasers Petrol and petroleum products Glues



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