Final Report to Funders

25 Years of Volatile Substance Abuse

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Addendum: Important notes on interpreting the "indoor" versus "outdoor" analysis

On the VSA database "place of sniffing" (i.e. place of fatal abuse) as opposed to "place of death" has been recorded in a consistent fashion from 1990 onwards. It is coded as:

10 - Home

15 - Home of friend

20 - Public place

30 - Institution / School

60 - Other (hotel room, vacant flat, derelict house*, industrial premises)

* unless living here when = 10

70 - Place of work

99 - Not known

In this report we created an "indoor/outdoor" variable where

"Indoors" = Home, Home of friend, Institution/School, Other, Place of work

"Outdoors" = Public place

However these are very **broad** categories in that "indoors" does not guarantee that the place of sniffing was indoors and "outdoors" does not guarantee that the place of sniffing was outdoors.

Problems:

- Institution/School includes "sniffing" in playground or on roof of school.
- In addition to the more obvious, in street, in park etc., public place includes in car, public toilets, shed/den on waste ground, shopping centre etc..

Conclusion:

- "indoors" and "outdoors" are very **broad** categories.
- "indoors" should be interpreted as "not in a public place" where "public place" is as outlined above.
- "indoors" is predominantly "home and home of a friend" (see tables a and b below).

Table a: Place of "Sniffing" by Year Group (N=1310)

Variable	1990-1992	1993-1997	1998-2002	2003-2007
Home	42.6%	53.1%	63.7%	73.3%
Home of friend	9.1%	10.4%	6.4%	7.4%
Public place	41.8%	30.1%	25.0%	14.3%
Institution/school, other, workplace	6.5%	6.5%	4.9%	5.0%
Total	100%	100%	100%	100%

Table b: Place of "Sniffing" by Age-group and Sex (N=1310)

Place of Sniffing	Child, Male	Child, Female	Adult, Male	Adult, Female
Home	33.4%	46.0%	69.5%	74.4%
Home of friend	12.4%	21.0%	4.7%	5.6%
Public Place	48.5%	28.0%	19.5%	16.0%
Institution/school, other, workplace	5.7%	5.0%	6.3%	4.0%
Total	100%	100%	100%	100%

BK BUTLAND 10/12/2012

Key Findings

Among children (<18 years) dying from VSA 1983-2007:

- A higher proportion of girls than boys were students or still at school at the time of death (87% versus 64%).
- A higher proportion of VSA deaths in girls than boys were from abuse of aerosols (47% versus 23%) whereas higher proportions of VSA deaths in boys than girls were from abuse of gas fuels (50% versus 39%) and glues (7% versus 1%).
- Nearly all gas fuel deaths in children (91%) were attributed to lighter fuel.
- A higher proportion of aerosol deaths in girls than boys were attributed to abuse of deodorants (66% versus 50%).
- 12% of children dying from VSA had at some point been 'in care'.

Among adults (≥18 years) dying from VSA 1983-2007:

- Most (82%) were single/divorced/separated or widowed, although the proportion married and/or cohabiting was higher in women (27%) than men (16%).
- A higher proportion of VSA deaths in men than women were from abuse of glues (21% versus 8%) and a higher proportion of VSA deaths in women than men were from abuse of gas fuels (74% versus 52%). Fatal abuse of aerosols was almost as common among VSA deaths in men as in women (8% versus 10%).

- Three-quarters of gas fuel deaths in adults were attributed to lighter fuel.
- Among the small number of aerosol deaths in women 43% (6/14) were attributed to abuse of hairsprays. Hairsprays were only recorded as the primary substance of abuse in 5% of aerosol deaths in men.

Among males aged 16 years and over dying from VSA 2000 -2007:

- The proportion classified as managers and/or professionals was lower than one might expect based on the results of the 2004 (second quarter) Labour Force Survey (13% versus 32%).

Among all VSA deaths1983-2007:

- Fatal abuse of aerosols (27% versus 9%), in particular deodorants (15% versus 3%), was proportionately higher among child than adult VSA deaths.
- A higher proportion of VSA deaths occurred in the Summer months compared to the Winter months (28% versus 19%) but this difference was more marked among children (30% versus 17%) than adults (26% versus 21%).
- The proportion with a reported possible/definite increase in physical or emotional activity prior to fatal abuse was higher among VSA deaths in males than females (43% versus 27%).

- Fatal abuse indoors (1990-2007) was proportionately higher among VSA deaths in adults than in children (81% versus 56%), as was fatal abuse alone (82% versus 49%).
- Fatal abuse indoors (1990-2007) was also proportionately higher among VSA deaths in females than males (79% versus 70%).

Time trends in VSA deaths 1983-2007

- The previously reported sustained fall in VSA deaths in the under 18s coincident with the 1992 Department of Health Advertising Campaign was observed among both boys and girls. Having adjusted for time trends and seasonality, it was estimated that the fall post January 1992 was 56% (36% to 70%) in boys and 64% (20% to 84%) in girls.
- There was no evidence of a sustained drop in monthly VSA deaths in the under 18s coincident with the 1999 Cigarette Lighter Refill Legislation.
- The mean age at death has increased over time in both males and females respectively from 19.8 and 16 years in 1983 to 33.5 and 27.2 years in 2007. However, there is no evidence that this change was associated with the 1992 Advertising Campaign.
- There has been a steady rise in the number of women dying of VSA from 6 in 1983-1987 to 45 in 2003-2007, a trend which may have peaked in recent years.
- Overall, there has been a marked shift over time in the distribution of deaths by age and sex from 48% boys, 11% girls, 40% men and

1% women in 1983 -1987 to 13% boys, 5% girls, 65% men and 17% women in 2003-2007.

- The percentage of deaths attributed to abuse of glues fell sharply from 24% in 1983-1987 to 12% in 1988-1992.
- The number and proportion of adult VSA deaths from abuse of gas fuels has increased over time from 53 (26% of all VSA deaths in adults) in 1983-1987 to 145 (69%) in 2003-2007, a trend which may have reached a plateau in the 21st century.

Glossary of Statistical Abbreviations

OR	Odds Ratio
RR	Relative Risk
RRR	Relative Risk Ratio
95% CI	95% Confidence Interval
Chi-sq	Chi-square test

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Objectives

Using 25 years of VSA data (1983-2007):

1. To describe the characteristics of those dying VSA-related deaths.
2. To investigate whether changes in the number of VSA deaths 1983-2007 within age-sex groups reflect well defined interventions (e.g. The Cigarette Lighter Refill (Safety) Regulations 1999)?
3. To investigate whether the average age of death has risen over time in both males and females.
4. To describe the circumstances of VSA-related deaths (e.g. indoors or outside, seasonal variations, alone/in company, etc.)
5. To investigate the changing patterns in VSA-related deaths 1983-2007 (e.g. primary substance abused in different age-sex groups)

1. Introduction

Over the past 22 years, annual reports produced by St George's have monitored trends in the mortality associated with the deliberate inhalation of volatile substances. Within these reports, deaths have been tabulated by age, sex, year, region, substance abused, product abused, method of administration, previous history of solvent abuse, place of death, place of fatal abuse and suicide. Standardised Mortality Ratios have been calculated for Government Office Regions and Countries and trends in child (under-18 year olds) and adult (≥18 years of age) deaths have been monitored over time (in months) allowing for the evaluation of public health action such as the Department of Health's advertising Campaign of February 1992 aimed at parents in England, Wales and Scotland [1-2] and the Legislation which came into effect in October 1999 banning the sale of butane cigarette lighter refills to under-18 year olds.

From the key findings of the 2009 report,[2] based on data up to and including 2007, it would appear that VSA deaths are still far more common in males than females, that currently gas fuels are associated with the majority of deaths, that the age of death is on the increase but that the total number of deaths associated with volatile substance abuse have declined since 1992.

Nevertheless there are some routinely collected data that have not thus far been fully exploited within our reports including time of death, day of death, whether 'sniffing' alone or with others, whether ever 'in care', whether both

natural parents are at home, Standard Occupational Classification (2000-2007 deaths only) and marital status. There has also been relatively little in the reports describing how characteristics/circumstances of VSA deaths and trends in VSA deaths over time differ between the four major age-sex groups i.e. boys (male: age<18), girls (female: age<18), men (male: ≥18) and women (female: ≥18) and although age at death appears to be on the increase this has not been investigated separately for males and females.

In this new analysis we therefore aim to use 25 years of VSA data (1983-2007) including some previously under-used variables and some new derived variables to describe the characteristics and circumstances of VSA deaths, to investigate patterns in VSA deaths (including changes over time) and how these patterns may differ between the 4 major age-sex groups.

1. Methods

1.1 Study Design

St George's Volatile Substance Abuse (VSA) Programme has been monitoring volatile substance abuse deaths in the UK since 1971 and has been funded by the Department of Health since the 1980s. Our information comes mainly from coroners but also from press cuttings and from death data supplied by The Office for National Statistics (ONS). Our methods of data collection have been stable and systematic since 1983 and a statistical summary of our data is published annually (available at www.vsareport.org).

1.2 Study Subjects

All study subjects are dead. The analysis funded through Re-Solv will be restricted to deaths occurring between 1/1/1983 and 31/12/2007, this being the period during which data have been collected prospectively using systematic methods.

1.3 The Data

The data are held in various forms:

1) The main study database, anonymised by the use of case numbers. This currently includes information on 2,093 VSA deaths occurring between 1/1/1983 and 31/12/2007.
2) An electronic administrative database containing names and case numbers.

3) Paper files including post-mortem reports, toxicology reports and death certificates. These contain names and case numbers.

1.4 Data security

All electronic files are held on the University computer in the password-protected accounts of Programme staff. Paper files are stored in locked filing cabinets.

1.5 Definition of Volatile Substance Abuse (VSA)

Volatile substance abuse is defined as “the deliberate inhalation of a volatile substance (gas, aerosol propellants, solvents in glue and other solvents) to achieve a change in mental state”.

1.6 Ethics

The St George’s VSA programme is a mortality monitoring programme, and only holds information on subjects who are dead. Its intent is to provide information to the public, interest groups and policy makers regarding current trends in VSA mortality and to evaluate the impact of any resulting legislation or government instigated campaign. We have been advised by the National Research Ethics Service Queries Line that the St George’s VSA programme as summarised in Appendix A1 is deemed to be service evaluation not research and as such does not require ethical approval.

1.7 Plan of Analysis – including variable description

1. In order to describe the characteristics of VSA deaths 1983-2007, the following variables will be tabulated by sex, for adults (i.e. ≥18 years of age) and children (i.e. <18 years of age) separately as appropriate.

Children & adults:

- Employment status (employed; unemployed; other (including retired, student, at school).

Children only:

- Ever in care (yes (not including on remand, in custody and on bail, on probation, subject of a Care Order or in prison); no)
- Natural parents in household (both; 1 natural+1step parent/cohabitee; 1 natural; no (including adopted, fostered))

Adults only:

- Marital status (single; married/co-habiting; divorced/separated/widowed).
- Since 2000 any information on current or past employment has been used to code VSA deaths according to the Standard Occupational Classification 2000. This information will be tabulated for male VSA deaths (2000 to 2007 inclusive) aged 16 and over and compared with SOC 2000 data (April-June 2004)

for the employed UK male population of the same age. (Source: ONS The Labour Force Survey second quarter 2004).

2. Using data for 1983 to 2007 inclusive, the number of VSA deaths per month will be calculated for each of the four main age-sex groups ("Boys" i.e. males <18 years old, "Girls" i.e. females <18 years old, "Women" i.e. females ≥18 years old, "Men" i.e. males ≥18 years old). Using a 12 month moving average to remove seasonal variation, plots illustrating trends in monthly deaths over time by sex will be produced for children and adults separately.

3. In order to estimate the magnitude of any fall in deaths occurring post the 1992 Campaign and the 1999 Legislation, beyond that predicted by underlying time trends and seasonal variation, monthly deaths will be modelled for each of the four main age-sex groups using over-dispersed Poisson regression. This type of analysis allows us to adjust for the fact that not all months contain the same number of days.[3-8]

    - Step 1: Underlying long term time trends will be represented by orthogonal polynomials of degree 1, 2, 3, 4 or 5, with the highest degree of polynomial to include in the model above a simple linear trend being chosen using forward selection and F tests.
    - Step 2: Up to two sinusoidal cycles with wavelengths chosen from the following list (12 months, 6 months, 4 months, 3 months, 2 months) will then be added to the model to represent underlying

seasonal variation. The choice of two wavelengths will be based on periodograms and the inclusion of the associated sinusoidal cycles in the final model based on forward selection and F tests.

- Step 3: Using graphs of autocorrelations, partial autocorrelations and Bartlett's periodogram-based test for white noise, the inclusion of lagged values or seasonally differenced values of monthly deaths will be considered in an attempt to remove any residual autocorrelation.
- Step 4: Binary variables representing the Campaign of February 1992 (coded 1 for Feb 1992 to December 2007) and the Legislation which took effect in October 1999 (coded 1 for October 1999 to December 2007 and 0 for January 1983 to September 1999) will then be added to the resulting model.

4. Using data for 1983 to 2007 inclusive, the average age in years at VSA death will be calculated by year for males and females separately and line plots illustrating trends in mean age over time by sex produced. For each sex, mean age by year will then be modelled using weighted multiple regression investigating both linear and quadratic time trends.

5. In order to describe the circumstances of VSA deaths 1983-2007, the following variables will be tabulated by the 4 main age-sex groups.

   (i) Fatal abuse indoors (yes; no): Information on place of sniffing and therefore fatal abuse was only routinely recorded on the VSA

database from 1990 onwards. It is recorded as “home”, “home of friend”, “public place”, “institution/school”, “other (hotel room, vacant flat, derelict house, industrial premises)” or “place of work” but for the purposes of this report it will be re-coded into outdoors (i.e. “public place”) or indoors (i.e. all other categories).

(ii) Fatal abuse alone (yes; no)

(iii) Primary substance abused (gas fuels; aerosols; glues; other)

(v) Season (Winter; Spring; Summer; Autumn)

(iv)Time of death (0700-1300; 1300-1900; 1900-0100; 0100-0700)

(v) Day of death (weekday; weekend/public holiday)

6. Tables (i) and (ii) will be extended to include a fourth dimension i.e. year group (1983-1987;1988 -1992;1993 -1997;1998 - 2002;2003 - 2007) and logistic regression models fitted in order to:

- Investigate the effect of age group (i.e. <18 years; ≥18 years), sex (male; female) and time period (1990-1992; 1993-1997; 1998-2002; 2003-2007) on fatal abuse indoors. The final model will be chosen using the process of forward selection.
- Investigate the effect of age group (i.e. <18 years; ≥18 years), sex (male; female) and 5-year time period (1983-1987; 1988-1992; 1993-1997; 1998-2002; 2003-2007) on fatal abuse alone. The final model will be chosen using the process of forward selection.
- Significance tests presented in the text for main effects will be adjusted for other main effects in the final model and significance

tests for two-factor interactions will be adjusted for other two-factor interactions in the final model.

7. Tables (iii), (iv) and (v) will be extended to include a fourth dimension i.e. year group (1983-1987;1988 -1992;1993 -1997;1998 - 2002;2003 - 2007) and multinomial regression models fitted in order to:

   - Investigate simultaneously the effect of age group (i.e. <18 years; ≥18 years), sex (male; female) and 5-year time period (1983-1987; 1988-1992; 1993-1997; 1998-2002; 2003-2007) on i) the ratio of aerosol to gas fuel deaths, ii) the ratio of glue to gas fuel deaths, and iii) the ratio of 'other substance' to gas fuel deaths. The final model will be chosen using the process of forward selection.
   - Investigate simultaneously the effect of age group (i.e. <18 years; ≥18 years), sex (male; female) and 5-year time period (1983-1987; 1988-1992; 1993-1997; 1998-2002; 2003-2007) on i) the ratio of Autumn to Summer deaths, ii) the ratio of Winter to Summer deaths, and iii) the ratio of Spring to Summer deaths. The final model will be chosen using the process of forward selection.
   - Investigate simultaneously the effect of age group (i.e. <18 years; ≥18 years), sex (male; female) and 5-year time period (1983-1987; 1988-1992; 1993-1997; 1998-2002; 2003-2007) on i) the ratio of afternoon to later morning deaths, ii) the ratio of evening to later morning deaths, and iii) the ratio of early morning to later morning

deaths. The final model will be chosen using the process of forward selection.

- Significance tests presented in the text for main effects will be adjusted for other main effects in the final model and significance tests for two-factor interactions will be adjusted for other two-factor interactions in the final model.

8. Using data for 1983-2007, the difference in death rates per 100 days between weekdays, weekends, and public holidays will be modelled using Poisson Regression. The model will adjust for country (i.e. England & Wales; Scotland; Northern Ireland) as public holidays are not the same throughout the UK. Deaths occurring in the Channel Islands or the Isle of Man will not be included in this analysis.

2. Results

2.1. Demographic Characteristics of VSA deaths 1983-2007

Between 1/1/1983 and 31/12/2007 there were a total of 2,093 deaths from volatile substance abuse (VSA) in the UK. Of these 773 (37%) were among boys (i.e. males aged <18 years), 184 (9%) were among girls (i.e. females aged <18 years), 995 (48%) were in men (i.e. males aged≥18 years) and 141 (7%) in women (i.e. females aged≥18 years).

Table 1: Demographic characteristics of children (<18 years) dying VSA-related deaths 1983-2007: by sex groups.

		Boys		Girls	
		n / N	%	n / N	%
Employment Status[¶]	Employed	148 / 746	19.8%	11 / 183	6.0%
	Unemployed	118 / 746	15.8%	13 / 183	7.1%
	Student/schoolchild	480 / 746	64.3%	159 / 183	86.9%
Ever in care [†¶]		81 / 694	11.7%	24 / 178	13.5%
Natural parents in household[¶]	Both	384 / 672	57.1%	85 / 171	49.7%
	1 natural + 1 step-parent/cohabitee	90 / 672	13.4%	22 / 171	12.9%
	1 natural	138 / 672	20.5%	49 / 171	28.7%
	No (including adopted/fostered)	60 / 672	8.9%	15 / 171	8.8%

[¶] Information on employment status, ever in care and natural parents in household was available for 97.1%, 91.1% and 88.1% of VSA deaths in the under 18s respectively.

[†] "In care" does not include on remand (in custody and on bail), on probation, subject of a care order or in prison (see A2, Appendix page IV)

From Table 1 it would appear that boys and girls differed significantly in terms of their employment status at time of VSA death (chi-sq; p<0.001; df=2) with a

lower proportion of boys than girls recorded as students or still at school (i.e. 64% versus 87%). Similar proportions of boys and girls were reported as ever having been in care (12% versus 13%) and there was no significant difference (p=0.142; df=3) between girls and boys in terms of the number of natural parents in the household. With respect to VSA deaths in adults, Table 2 illustrates that men and women differed significantly in terms of both marital status (p=0.004; df=2) and employment status (p<0.001; df=2) with higher proportions of men than women recorded as single (75% versus 61%) and employed (50% versus 27%) at the time of death.

Table 2: Demographic characteristics of adults dying VSA-related deaths 1983-2007: by sex groups.

		Men		Women	
		n / N	%	n / N	%
Marital Status[¶]	Single	609 / 816	74.6%	77 / 127	60.6%
	Married/co-habiting	132 / 816	16.2%	34 / 127	26.8%
	Divorced/separated/widowed	75 / 816	9.2%	16 / 127	12.6%
Employment Status[¶]	Employed	449 / 904	49.7%	33 / 122	27.0%
	Unemployed	387 / 904	42.8%	80 / 122	65.6%
	Other (inc. student/retired/at school)	68 / 904	7.5%	9 / 122	7.4%

[¶] Information on marital status and employment status was available for 82.9% and 90.2% of adult VSA deaths respectively.

Since the year 2000 any available information on the current or most recent occupation of VSA deaths has been coded according to the Standard Occupational Classification (SOC 2000), with students or those still at school classified according to the occupation of the head of household. Using these data Table 3 compares males aged 16 and over dying from VSA in 2000-2007

with the UK employed population of the same age and sex surveyed as part of the Labour Force Survey during the second quarter of 2004. Among VSA deaths, the proportions classified as managers and/or professionals were lower than one might expect based on the results of the Labour Force Survey (LFS) and the proportion employed in elementary occupations markedly higher. Even among the 128 males (out of the 219) who were in **current** employment at the time of VSA death, 18% were employed as managers and/or professionals (compared to 32% on the LFS) and 26% were employed in elementary occupations (compared to 12% on the LFS). However, these comparisons might change if we were able to standardise for age.

Table 3: Standard Occupational Classification of males aged 16 and over: comparison between VSA deaths in 2000-2007 and the employed UK population in April-June 2004.

Standard Occupational Classification (SOC 2000)	VSA deaths	UK[¶]
	Males (N=219)	Males (N=15,290,000)
	n (%)	(%)
Managerial	16 (7.3)	18.3
Professional	13 (5.9)	13.5
Associate Professional and Technical	18 (8.2)	13.2
Admin/Secretarial	7 (3.2)	4.8
Skilled Trades	52 (23.7)	19.6
Personal Service	6 (2.7)	2.2
Sales & Customer Service	10 (4.6)	11.9
Process, Plant & Machine Operatives	27 (12.3)	12.0
Elementary Occupations	70 (32.0)	12.0

[¶] Source: Labour Force Survey. Adapted from data from the Office for National Statistics licenced under the Open Government Licence v.1.0.
Information on Standard Occupational Classification available on 70.6% of VSA deaths in 2000-2007 among males aged 16 and over.

2.2 Changes in the age-sex distribution over time

Whereas in 1983-1987, 48% of all VSA deaths were among boys, 11% among girls, 40% among men and 1% among women, in 2003-2007 the corresponding figures were 13%, 5%, 65% and 17% respectively (Fig 1 and Table 4). Thus adults accounted for 82% of all VSA deaths in 2003-2007 compared with only 41% in 1983-1987.

Fig 1

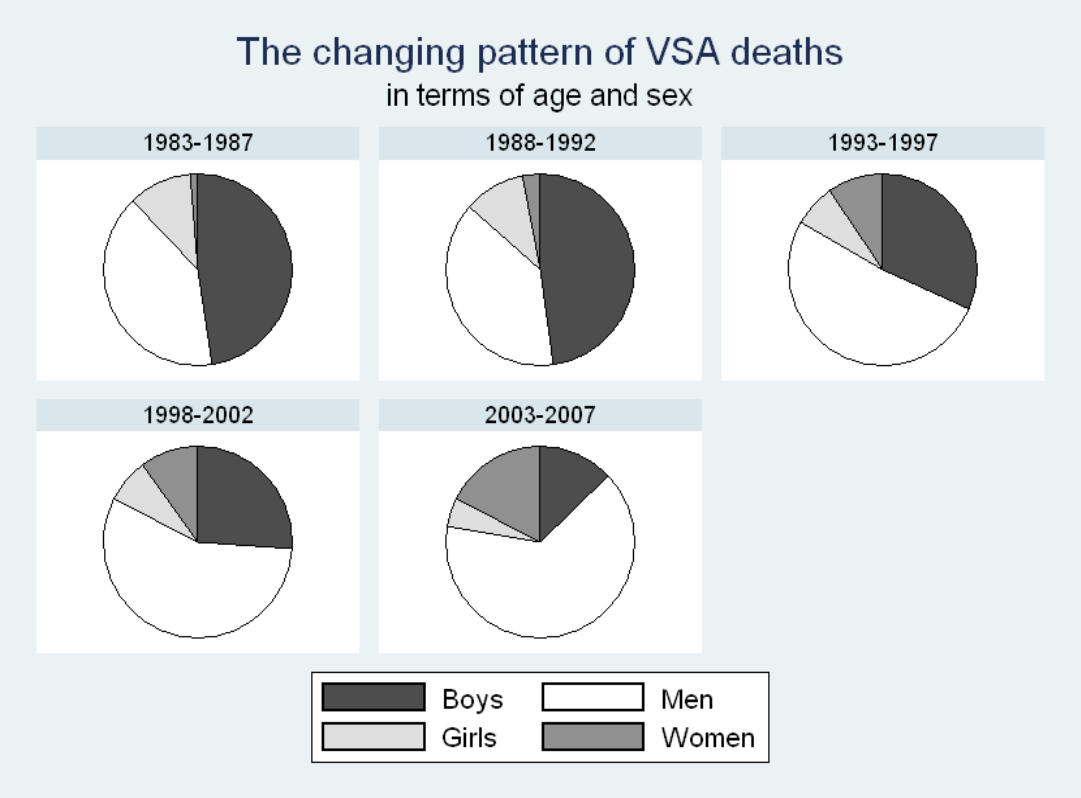


Table 4: Number of deaths in each 5 year period (1983-2007) by age-sex group.

Age	Sex	1983-1987 n (%)	1988-1992 N(%)	1993-1997 n(%)	1998-2002 n(%)	2003-2007 n(%)
<18 years	Male	238 (48%)	291 (48%)	120 (32%)	91 (26%)	33 (13%)
	Female	55 (11%)	63 (10%)	27 (7%)	26 (7%)	13 (5%)
≥18 years	Male	200 (40%)	236 (39%)	195 (52%)	197 (56)	167 (65%)
	Female	6 (1%)	19 (3%)	36 (10%)	35 (10%)	45 (17%)

Fig 2

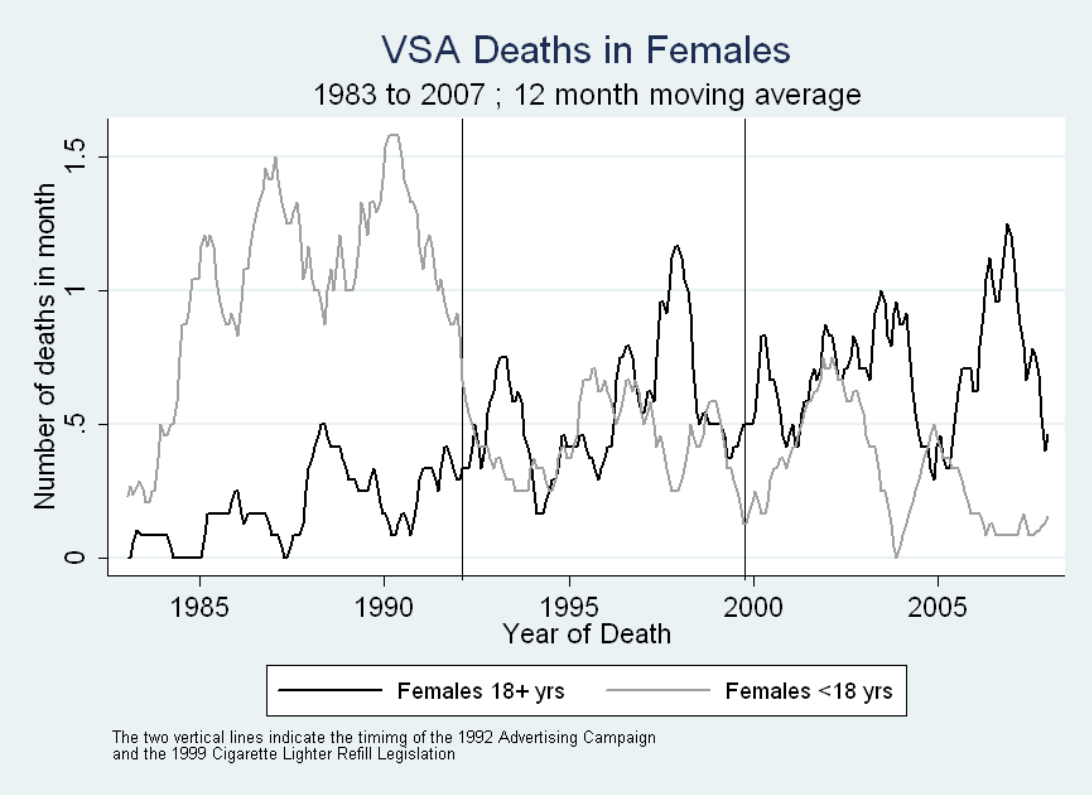
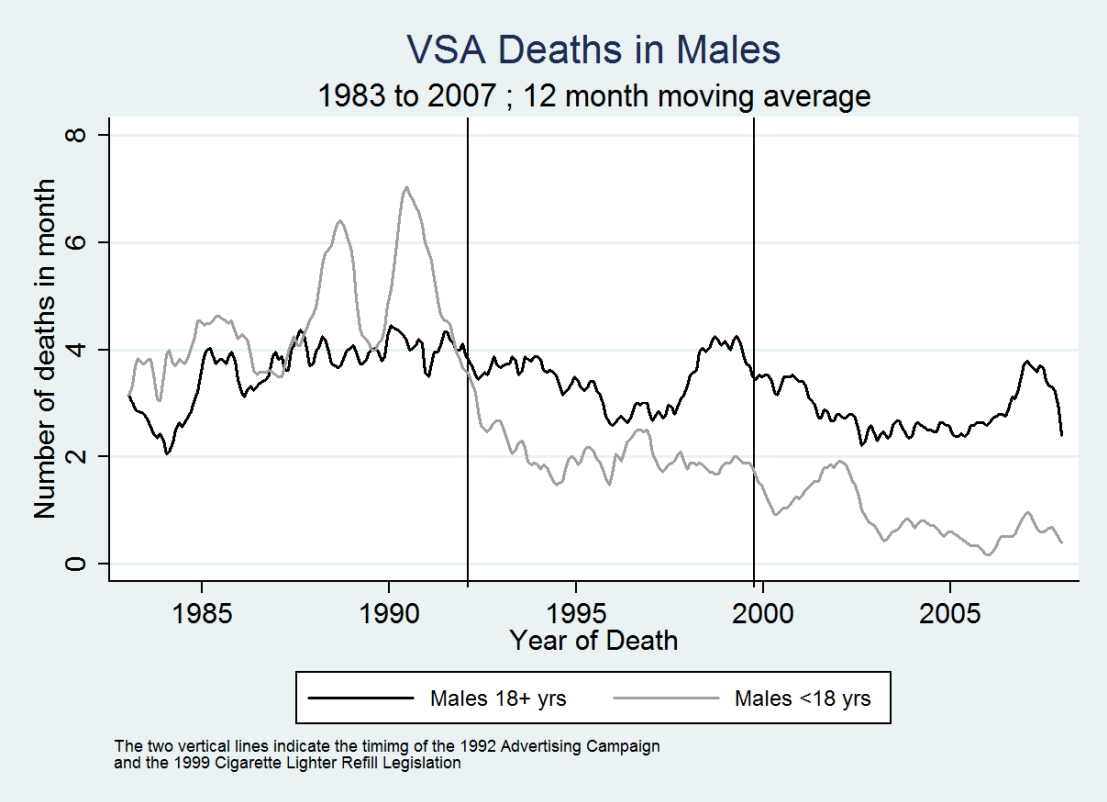

VSA Deaths in Females
1983 to 2007 ; 12 month moving average
Number of deaths in month
0
.5
1
1.5
1985
1990
1995
2000
2005
Year of Death
Females 18+ yrs
Females <18 yrs
The two vertical lines indicate the timimg of the 1992 Advertising Campaign
and the 1999 Cigarette Lighter Refill Legislation

Fig 3


VSA Deaths in Males
1983 to 2007 ; 12 month moving average
Number of deaths in month
0
2
4
6
8
1985
1990
1995
2000
2005
Year of Death
Males 18+ yrs
Males <18 yrs
The two vertical lines indicate the timimg of the 1992 Advertising Campaign
and the 1999 Cigarette Lighter Refill Legislation

2.3 Time trends in monthly VSA deaths within age-sex groups

Given the above findings, time series in monthly VSA deaths 1983 to 2007, were plotted separately for the 4 main age-sex groups.

From the resulting figures (Fig 2 and 3) it would appear that the previously reported sustained fall in VSA deaths in the under 18s coincident with the 1992 advertising Campaign, occurred and proportionately to a similar extent among both boys and girls. Having adjusted for time trends and seasonality (Table 5), it was estimated that the fall post January 1992 was 56% (36% to 70%) in boys and 64% (20% to 84%) in girls. Figures 2 and 3 also point to a continuing fall in VSA deaths among children beyond 1992.

Table 5: Investigating step changes in female and male VSA deaths (1983-2007), having adjusted for underlying time trends and seasonal variation using over-dispersed Poisson regression models.

Variable	Children (<18years of age)			Adults (≥18 years of age)		
	RR	(95% CI)	Chi-sq	RR	(95% CI)	Chi-sq
Female deaths						
1992 Campaign	0.36†	0.16 to 0.80	P=0.011	0.94¶	0.35 to 2.56	P=0.908
1999 Legislation	0.61†	0.23 to 1.63	P=0.331	0.89¶	0.44 to 1.80	P=0.752
Male deaths						
1992 Campaign	0.44§	0.30 to 0.64	P<0.001	0.80‡	0.59 to 1.08	P=0.147
1999 Legislation	0.83§	0.51 to 1.35	P=0.456	0.82‡	0.59 to 1.14	P=0.232

Adjusted for base model:

† $t + t^2 + t^3 + t^4 + \sin(2\pi t/6) + \cos(2\pi t/6) + Y_{t-1}$

¶ $t + t^2$

§ $t + t^2 + t^3 + \sin(2\pi t/6) + \cos(2\pi t/6) + \sin(2\pi t/12) + \cos(2\pi t/12) + Y_{t-2}$

‡ $t + t^2 + t^3$

where

t=time in months (t=0,….,300) and Y_t is the number of deaths in month t

These figures may be slight under-estimates as the analysis includes deaths for the whole UK whereas the advertising Campaign was targeted at those under age 18 years in Britain. However when we restricted our analysis to monthly deaths in England, Scotland and Wales, the fall post January 1992 was estimated as 56% (35% to 70%) for boys and 59% (5% to 83%) for girls. There was no evidence of a sustained drop in monthly deaths coincident with the 1999 Cigarette Lighter Refill Legislation (Table 5).

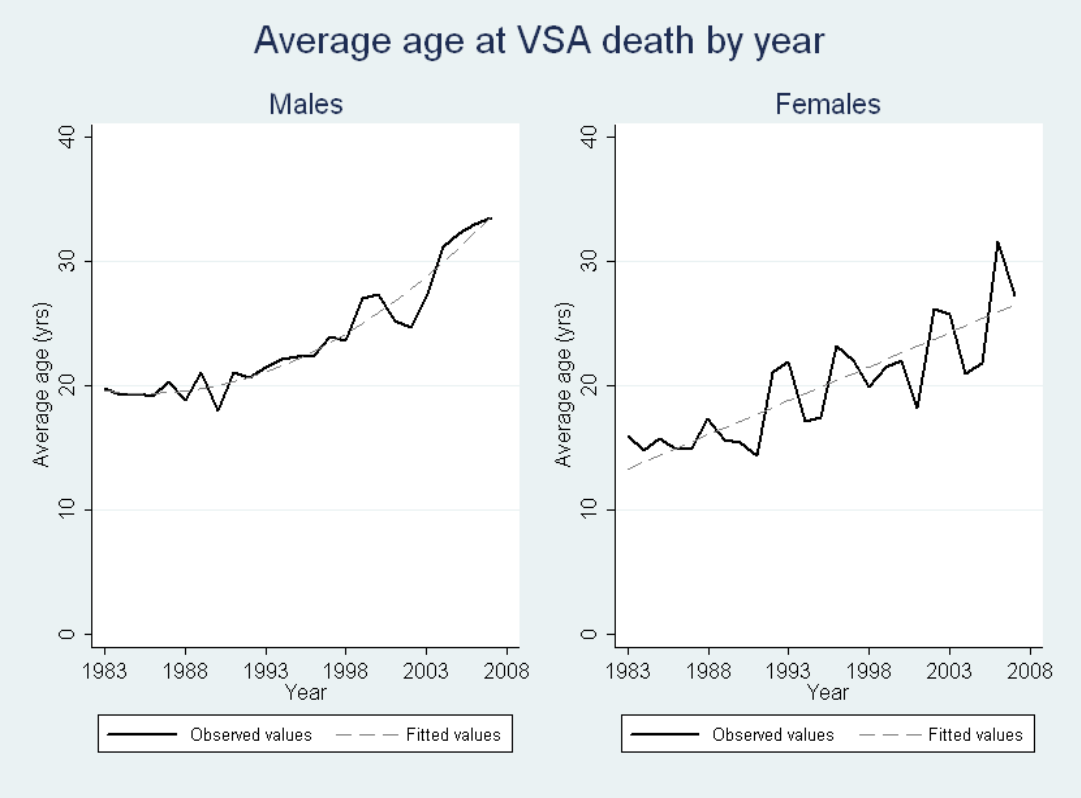
From Figure 2 it would appear that VSA deaths among women increased over time, not only in terms of the ratio of female to male VSA deaths in those aged 18 and over as reported previously,[2] but also in absolute terms. Using over-dispersed Poisson regression to model monthly VSA deaths among women, both linear ($p<0.001$) and quadratic ($p=0.018$) time trends were statistically significant indicating an increase over much of the 25 years possibly with the beginning of a slight decrease post 2003. Monthly VSA deaths in men did not follow a similar pattern (see Figure 3). There was evidence of a linear trend ($p=0.022$) but it was negative and both quadratic and cubic time trends were also statistically significant ($p=0.026$ and $p=0.010$ respectively). Having adjusted for time trends, there was no evidence of any change in monthly VSA deaths corresponding to either the 1992 Campaign or the 1999 Lighter Refill Legislation in either men or women (Table 5).

2.4 Changes in the average age at death over time

Having observed a fall in the number of VSA deaths in the under 18s coincident with the 1992 Campaign, a continued decline in such deaths

beyond 1992, and an increase in the number of VSA deaths in women, we next investigated changes in the average age at death over time for males and females separately (Fig 4). Using weighted multiple regression (Table 6) the average age of female VSA deaths was estimated to increase linearly ($p<0.001$) by just over 6 months per year (i.e. 0.55 (95% Confidence interval 0.40 to 0.70) years per year). Although there is some suggestion from Fig 4 of a step change in mean age coincident with the 1992 Campaign, when a step change term representing the Campaign was added to the model it was not statistically significant ($p=0.293$).

Fig 4



Among males the relationship between average age and time was not strictly linear and the best fitting multiple regression model included both linear ($p<0.001$) and quadratic ($p<0.001$) time trends (Table 6). The model

suggested that in males mean age changed little throughout the 1980's but started to increase rapidly from the early 1990's. Although the start of the increase was to some extent coincident with the 1992 Campaign, it did not represent the jump or step change in average age that one might have hypothesised. Thus when a step change term representing the Campaign was added to the model it was not statistically significant (p=0.558).

Figure 4 also illustrates that the mean age of VSA deaths in women tends to be lower than in men.

Table 6: Modelling year to year time trends (1983-2007) in mean age for males and females separately: Final regression models.

Explanatory variable	Dependent variable: Mean age in years				
	Coefficient (95% CI)	95% Confidence Interval	Chi-sq	Chi-sq adjusted for autocorrelation†	Percentage of variation explained by final model
Female deaths					
Linear time (year-1983)	0.550	0.397 to 0.704	P<0.001	P<0.001	69.2%
Quadratic time (year-1983)^2	Term not included in final model		¶P=0.327	¶P=0.185	
1992 Campaign	Term not included in final model		¶P=0.293	¶P=0.286	
Male deaths					
Linear time (year-1983)	-0.147	-0.414 to 0.120	P<0.001	P<0.001	91.9%
Quadratic time (year-1983)^2	0.0306	0.0193 to 0.0418	¶P<0.001	¶P<0.001	
1992 Campaign	Term not included in final model		‡P=0.558	‡P=0.326	

¶ P values adjusted for linear time trend
† P values adjusted for serial autocorrelation in residuals up to and including lag 2 using the Newey-West variance estimator.
‡ P values adjusted for linear and quadratic time trends

2.5 The Circumstances of VSA deaths 1983-2007

Table 7: Circumstances of VSA deaths 1983-2007 by major age-sex groups.

Variable		Children (<18 years of age)		Adults (≥18 years of age)	
		Boys	Girls	Men	Women
		n (%)	n (%)	n (%)	n (%)
Fatal abuse indoors[¶]		208 (51.5%)	72 (72.0%)	548 (80.5%)	105 (84.0%)
Fatal abuse alone		363 (49.1%)	87 (48.9%)	762 (83.1%)	102 (73.4%)
Exercise preceded death (definite/possible)		261 (41.8%)	41 (26.5%)	274 (43.4%)	27 (28.7%)
Primary substance abused	Gas Fuels	387 (50.3%)	71 (38.6%)	515 (52.2%)	104 (73.8%)
	Aerosols	175 (22.7%)	86 (46.7%)	83 (8.4%)	14 (9.9%)
	Glues	51 (6.6%)	1 (0.5%)	208 (21.1%)	11 (7.8%)
	Other	157 (20.4%)	26 (14.1%)	181 (18.3%)	12 (8.5%)
Season	Winter	124 (16.0%)	41 (22.3%)	213 (21.4%)	26 (18.4%)
	Spring	198 (25.6%)	47 (25.5%)	273 (27.4%)	40 (28.4%)
	Summer	244 (31.6%)	47 (25.5%)	259 (26.0%)	32 (22.7%)
	Autumn	207 (26.8%)	49 (26.6%)	250 (25.1%)	43 (30.5%)
Time of death	0700-1300	53 (8.2%)	16 (10.0%)	80 (14.2%)	12 (12.4%)
	1300-1900	223 (34.3%)	48 (30.0%)	179 (31.8%)	30 (30.9%)
	1900-0100	333 (51.2%)	84 (52.5%)	220 (39.1%)	48 (49.5%)
	0100-0700	41 (6.3%)	12 (7.5%)	84 (14.9%)	7 (7.2%)
Day of Death[†]	Weekday	531 (69.3%)	125 (68.3%)	717 (72.4%)	105 (74.5%)
	Weekend/ Public Holiday	235 (30.7%)	58 (31.7%)	273 (27.6%)	36 (25.5%)

[¶] Based on data for 1990-2007 only
[†]England, Scotland, Wales, Ireland only

2.51 Fatal abuse indoors and alone

As can be seen in part from table 7 but based on the best fitting logistic regression models (Table 8), fatal abuse indoors was significantly associated with sex ($p=0.0028$), age group ($p<0.001$) and year group ($p<0.001$). Also

from Table 7 it appeared that the association with sex differed between adults and children. However this difference fell just short of statistical significance at the 5% level (p=0.051).

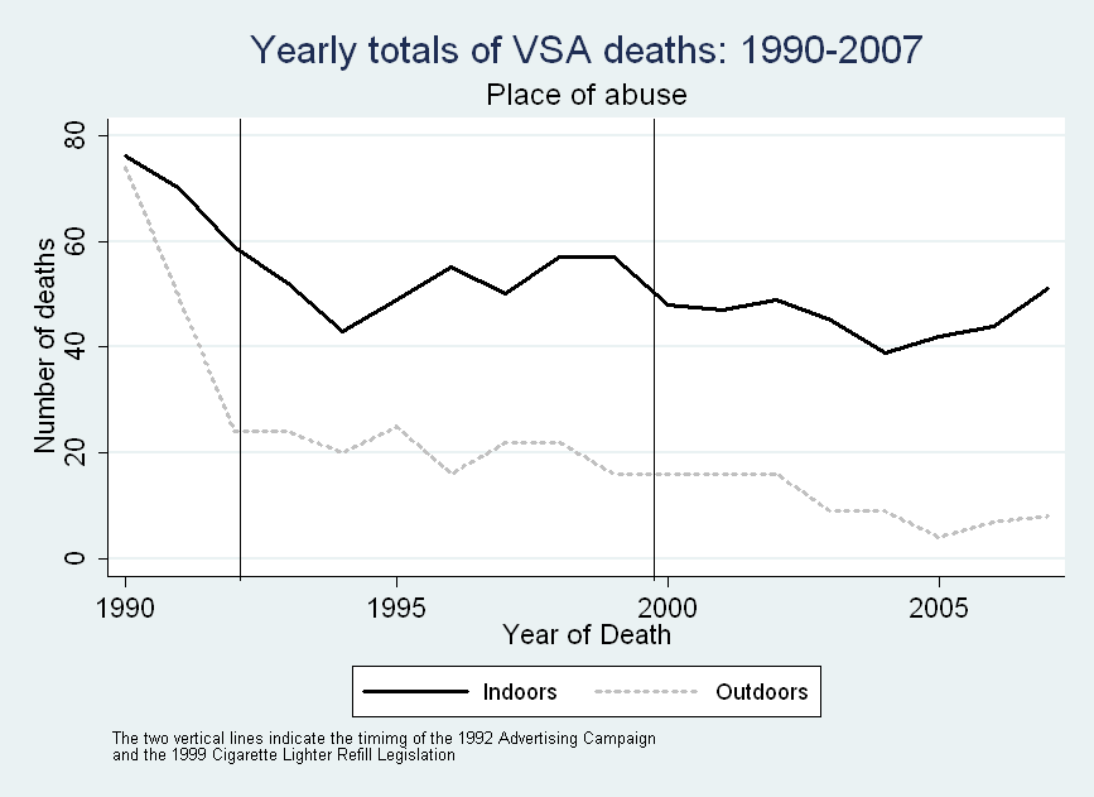
Table 8: Fatal abuse indoors and fatal abuse alone and their associations with age group, sex and year of death (grouped).

Time		Fatal abuse indoors¶	Fatal abuse alone
		OR (95% CI)	OR (95% CI)
Age Group	Children	1.00	1.00
	Adults	2.98 (2.30 to 3.87)	4.68 (3.82 to 5.73)
Sex	Males	1.00	-
	Females	1.71 (1.19 to 2.46)	
Year Group	1990-1992	1.00	-
	1993-1997	1.38 (1.00 to 1.90)	
	1998-2002	1.69 (1.20 to 2.36)	
	2003-2007	2.77 (1.81 to 4.24)	

¶ Based on data for 1990-2007 only

From Table 8 the ratio of deaths due to fatal abuse indoors versus fatal abuse outdoors (i.e. the odds) was estimated to have increased nearly three-fold between year groups 1990-1992 and 2003-2007 (Odds Ratio=2.77 (95% Confidence Interval 1.81 to 4.24)). It was also estimated to be higher in adults than children (OR=2.98 (2.30 to 3.87)) and in females than males (OR=1.71 (1.19 to 2.46)). From Fig 5, the differences between year groups appeared to be due to a more marked fall in fatal abuse outdoors than in fatal abuse indoors, with the number of VSA deaths per year attributed to fatal abuse indoors changing little post 1994.

Fig 5



Returning to Tables 7 and 8, the ratio of deaths due to abuse alone versus fatal abuse in company was also significantly higher ($p<0.001$) in adults than children (OR=4.68 (3.82 to 5.73)) but there was no evidence of any association with year group or sex.

2.52 'Exercise' preceded death

For 72% of VSA deaths recorded between 1983 and 2007, information was available as to whether the subject had 'exercised' (including sexual activity or emotional upset (e.g. a row)) prior to VSA death. Such sudden increase in physical and/or emotional activity differed significantly between age groups ($p=0.046$), year groups ($p<0.001$) and the sexes ($p<0.001$).

Table 9: VSA death preceded by 'exercise': association with age group, sex and year of death (grouped).

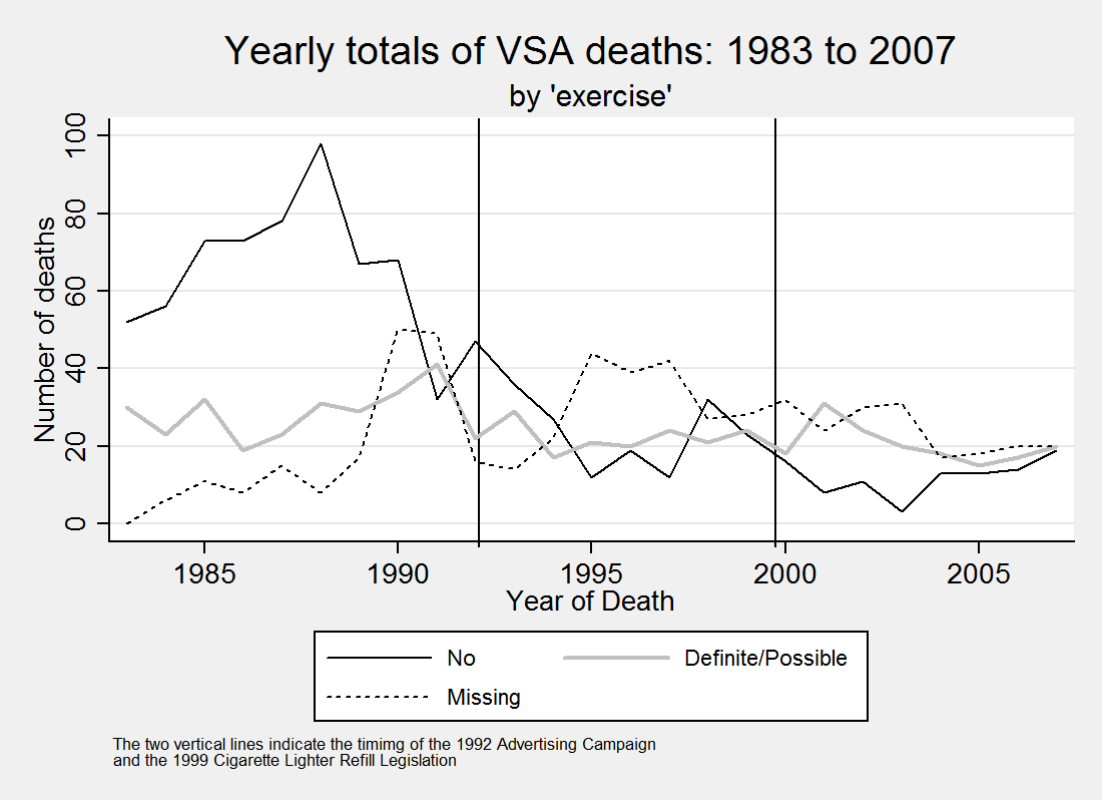
Time		VSA death preceded by 'exercise'
		OR (95% CI)
Age Group	Children	1.00
	Adults	0.79 (0.63 to 1.00)
Sex	Males	1.00
	Females	0.41 (0.30 to 0.56)
Year Group	1983-1987	1.00
	1988-1992	1.34 (1.01 to 1.78)
	1993-1997	3.05 (2.16 to 4.30)
	1998-2002	3.80 (2.67 to 5.40)
	2003-2007	4.75 (3.17 to 7.11)

Based on the best fitting logistic regression model (Table 9), the ratio of deaths definitely or possibly preceded by 'exercise' versus deaths not preceded by 'exercise' was lower in females than males (OR=0.41 (0.30 to 0.56)), slightly lower in adults than in children (OR=0.79 (0.63 to 1.00) and estimated to have increased more than four-fold between 1983-1987 and 2003-2007 (OR=4.75 (3.17 to 7.11)).

However, as can be seen from Fig 6, the level of missing information in the 'exercise' variable changes substantially over time (8% missing in 1983-1987, 23% in 1988-1992, 43% in 1993-1997, 40% in 1998-2002 and 41% in 2003-2007). Further, we suspect, based on a review of early coding notes, and despite some recent re-coding, that for VSA deaths prior to 1990 the 'exercise' variable does not include information on non-sexual emotional

activity (e.g. a row). It is therefore possible that the observed time trend is simply an artefact, reflecting changes both in the completeness and coding of information. To investigate this possibility we conducted the following sensitivity analyses.

Fig 6



2.521 Sensitivity Analysis

In our first sensitivity analysis we re-ran the final model having re-coded all subjects with missing information to 'no exercise'. As a result the association with year group became less marked but remained statistically significant ($p<0.001$) with odds ratios relative to baseline (i.e. 1983-1987) of 1.03 (0.78 to 1.35) for 1988-1992, 1.36 (1.00 to 1.85) for 1993 to 1997, 1.73 (1.27 to 2.36) for 1998-2002 and 2.01 (1.43 to 2.83) for 2003-2007. Associations with age

group and sex also persisted (both p<0.001) yielding odds ratios of 0.64 (0.52 to 0.79) for adults versus children and 0.54 (0.40 to 0.72) for females versus males.

In our second sensitivity analysis we re-ran the final model, based only on data for 1993 to 2007 and having excluded missing values. As a result, the association with year group was no longer significant (p=0.086) but associations with age group (OR=0.63, (0.44 to 0.89); p=0.009) and sex (OR=0.48, (0.32 to 0.73); p<0.001) persisted.

2.53 Primary substance of abuse

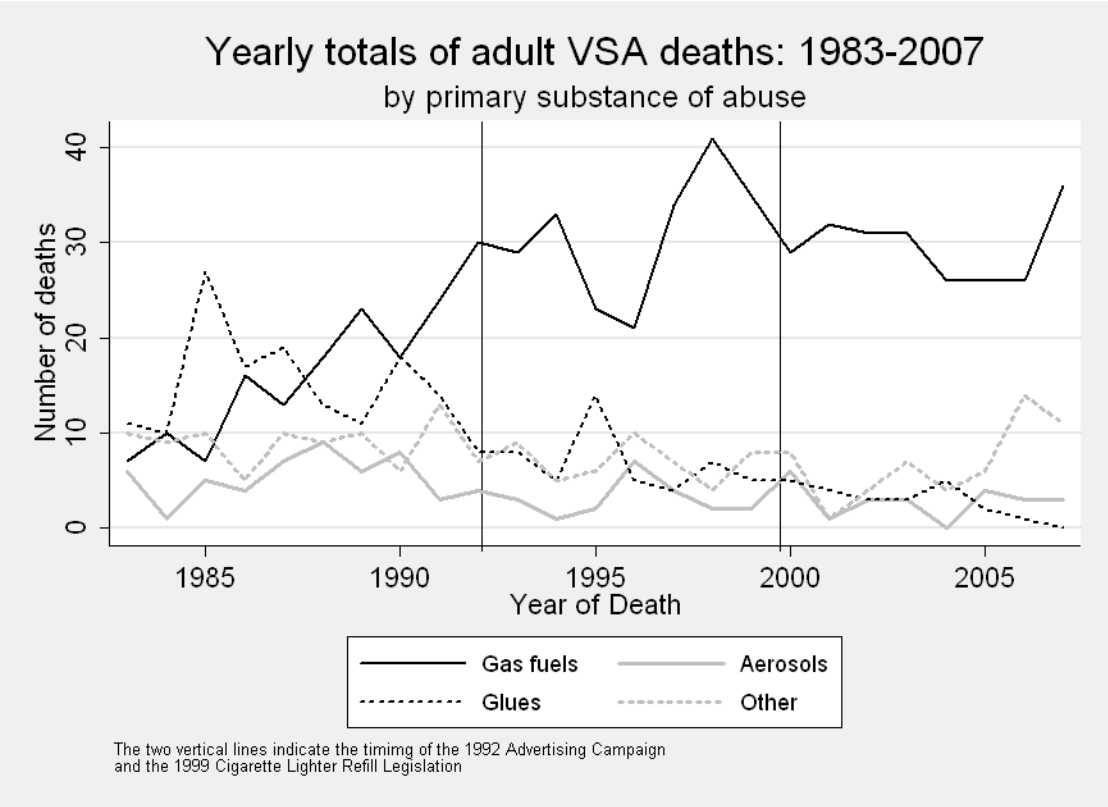
Table 10: Primary substance of abuse and its association with age group, sex and year of death (grouped).

Primary Substance		Gas fuel RRR (95% CI)	Aerosol RRR (95% CI)	Glue RRR (95% CI)	Other RRR (95% CI)
Children	Boys	1.00	1.00	1.00	1.00
	Girls	1.00	2.74 (1.89 to 3.97)	0.11 (0.01 to 0.79)	0.94 (0.57 to 1.55)
Adults	Men	1.00	1.00	1.00	1.00
	Women	1.00	1.12 (0.60 to 2.09)	0.43 (0.22 to 0.83)	0.38 (0.20 to 0.72)
Children	1983-1987	1.00	1.00	1.00	1.00
	1988-1992	1.00	0.98 (0.66 to 1.44)	0.19 (0.09 to 0.41)	0.69 (0.46 to 1.03)
	1993-1997	1.00	0.28 (0.16 to 0.48)	0.18 (0.07 to 0.45)	0.21 (0.12 to 0.39)
	1998-2002	1.00	0.77 (0.46 to 1.26)	0.05 (0.01 to 0.34)	0.14 (0.06 to 0.32)
	2003-2007	1.00	0.81 (0.40 to 1.65)	0.13 (0.02 to 1.01)	0.22 (0.07 to 0.65)
Adults	1983-1987	1.00	1.00	1.00	1.00
	1988-1992	1.00	0.61 (0.32 to 1.15)	0.37 (0.23 to 0.59)	0.50 (0.29 to 0.84)
	1993-1997	1.00	0.28 (0.14 to 0.56)	0.18 (0.11 to 0.29)	0.35 (0.20 to 0.60)
	1998-2002	1.00	0.19 (0.09 to 0.40)	0.10 (0.06 to 0.17)	0.19 (0.11 to 0.35)
	2003-2007	1.00	0.20 (0.09 to 0.43)	0.05 (0.03 to 0.11)	0.40 (0.23 to 0.68)

Fig 7


Yearly totals of child VSA deaths: 1983 to 2007
by primary substance of abuse
Number of deaths
0
10
20
30
40
1985
1990
1995
2000
2005
Year of Death
Gas fuels
Aerosols
Glues
Other
The two vertical lines indicate the timimg of the 1992 Advertising Campaign
and the 1999 Cigarette Lighter Refill Legislation

Fig 8


Yearly totals of adult VSA deaths: 1983-2007
by primary substance of abuse
Number of deaths
0
10
20
30
40
1985
1990
1995
2000
2005
Year of Death
Gas fuels
Aerosols
Glues
Other
The two vertical lines indicate the timimg of the 1992 Advertising Campaign
and the 1999 Cigarette Lighter Refill Legislation

As seen in part from table 7, Fig 7 and Fig 8 but based on the best fitting multinomial model (Table 10), the primary substance of abuse was significantly associated with sex ($p<0.001$), age group ($p<0.001$) and year group ($p<0.001$). There was also evidence that the association with sex differed between adults and children ($p=0.004$).

From Table 10, it would appear that the ratio of aerosol to gas fuel deaths (i.e. the relative risk) was higher among girls than boys (RRR=2.74 (1.89 to 3.97)) but differed little between women and men, while the ratio of glue to gas fuel deaths was lower in females than males both in adults (RRR=0.43 (0.22 to 0.83)) and particularly in children (RRR=0.11 (0.01 to 0.79)).

The association between primary substance and year group also differed significantly between adults and children ($p=0.002$). From table 10 it would appear that the ratio of aerosol to gas fuel deaths and glue to gas fuel deaths decreased by an estimated 80% (RRR=0.20 (0.09 to 0.43) and 95% (RRR=0.05 (0.03 to 0.011)) respectively among adults between year groups 1983-1987 and 2003-2007. Among children a similar pattern was observed for the ratio of glue to gas fuel deaths (RRR=0.13 (0.02 to 1.01)) but not for aerosol to gas fuel deaths (RRR=0.81 (0.40 to 1.65)).

Based on Figures 7 and 8 it would appear that these findings were primarily due to a decline in the number of glue deaths (occurring in children during the 1980s and in adults through the latter part of the 1980s and into the 1990s)

and a graded increase in the number of gas fuel deaths in adults, a trend which has started to plateau in more recent years.

2.531 Primary product abused

The distributions of primary product abused by age and sex for gas fuel deaths and aerosol deaths separately are presented in Figures 9 and 10 respectively. Overall lighter fuel was the predominant primary product of abuse in gas fuel deaths associated with 91% of gas fuel deaths in children and 75% of gas fuel deaths in adults (Fig 9). For aerosol deaths, deodorants were the main primary product abused, particularly in children, accounting for 66% of aerosol deaths in girls and 50% of aerosol deaths in boys. Deodorants were less commonly associated with aerosol deaths in adults. Indeed among the small number of aerosol deaths in women nearly half (6 out of 14) were associated with hairspray, while for men 40% of aerosol deaths were associated with “Other aerosols” a category which included cleaning fluids, insect sprays, paint sprays and aerosol glue.

Fig 9

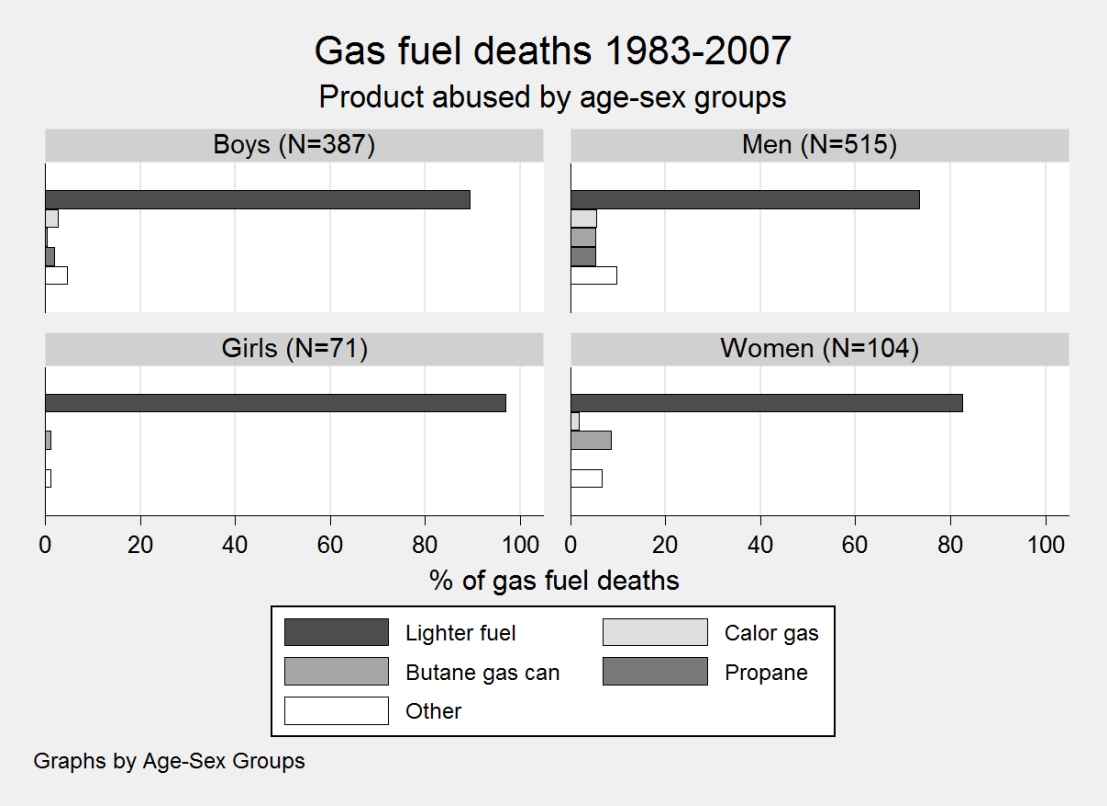
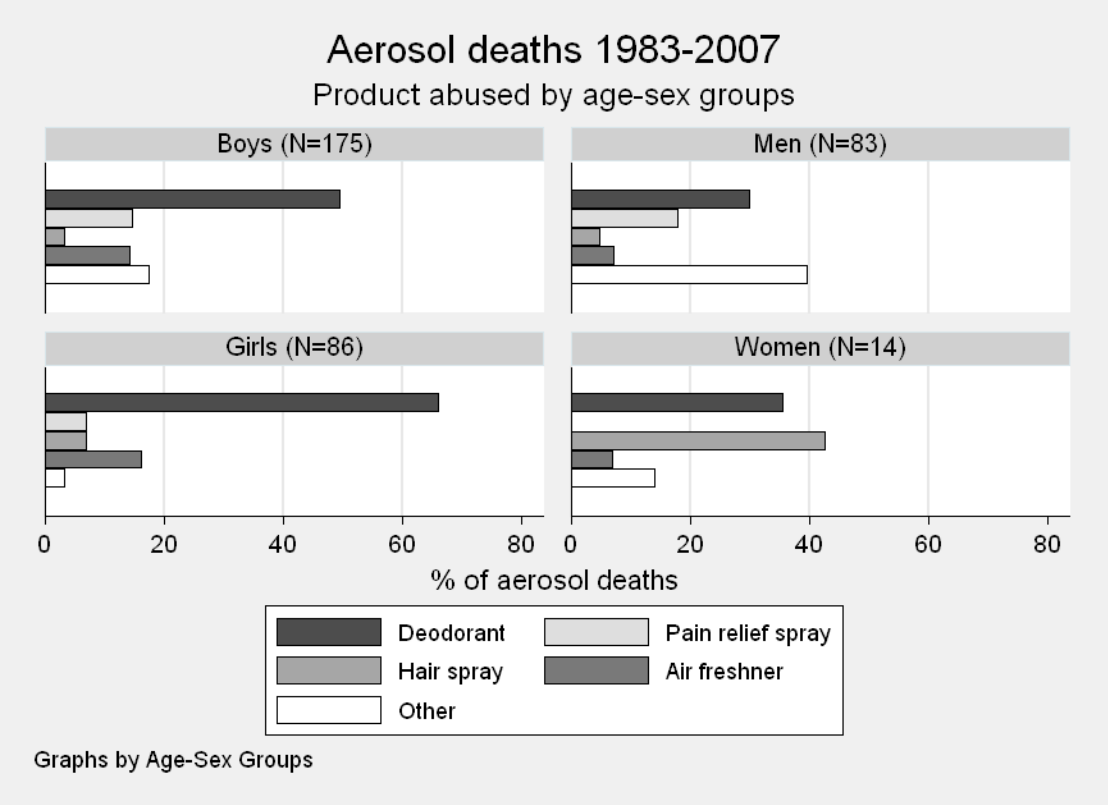

Gas fuel deaths 1983-2007
Product abused by age-sex groups
Boys (N=387)
Men (N=515)
Girls (N=71)
Women (N=104)
0
20
40
60
80
100
% of gas fuel deaths
Lighter fuel
Calor gas
Butane gas can
Propane
Other
Graphs by Age-Sex Groups

Fig 10


Aerosol deaths 1983-2007
Product abused by age-sex groups
Boys (N=175)
Men (N=83)
Girls (N=86)
Women (N=14)
0
20
40
60
80
% of aerosol deaths
Deodorant
Pain relief spray
Hair spray
Air freshner
Other
Graphs by Age-Sex Groups

2.54 Season of VSA Death

Table 11: Season of death and its association with age group.

Season	Winter	Spring	Summer	Autumn
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Children	1.00	1.00	1.00	1.00
Adults	1.00	0.88 (0.68 to 1.14)	0.69 (0.53 to 0.89)	0.79 (0.61 to 1.02)

From Table 7 it would appear that on average over the 25 years of study fewer deaths occurred in the winter months than in any other season (19.3% in the winter months, 26.7% in the spring, 27.8% in the summer months and 26.2% in the autumn) and this appeared to be the case in all four age-sex groups, particularly in boys. Using multinomial regression, season of death was significantly associated with age group ($p=0.028$) but there was no evidence of an association with sex or year group. From Table 11, it would appear that the ratio of summer to winter deaths was lower among adults than children (RRR=0.69 (0.53 to 0.89)).

2.55 Time of VSA Death

Time of death (Table 12 and Fig 11) was by contrast associated with age group ($p<0.001$) and year group ($p=0.0051$). The ratios of night deaths to evening deaths and of morning deaths to evening deaths were both higher in adults than children (RRR=2.52 (1.71 to 3.72) and RRR=2.17 (1.51 to 3.12) respectively) whereas the ratio of afternoon deaths to evening deaths was higher in 1983 to 1987 than in subsequent year groups.

Table 12: Time of death and its association with age group and year of death (grouped).

Time		Evening 7pm-1am	Morning 7am-1pm	Afternoon 1pm-7pm	Night 1am-7am
		RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Age Group	Child	1.00	1.00	1.00	1.00
	Adult	1.00	2.17 (1.51 to 3.12)	1.22 (0.95 to 1.57)	2.52 (1.71 to 3.72)
Year Group	1983-1987	1.00	1.00	1.00	1.00
	1988-1992	1.00	1.08 (0.66 to 1.77)	0.53 (0.38 to 0.73)	0.64 (0.37 to 1.08)
	1993-1997	1.00	0.78 (0.43 to 1.41)	0.64 (0.44 to 0.92)	0.54 (0.29 to 1.01)
	1998-2002	1.00	1.16 (0.67 to 2.01)	0.62 (0.42 to 0.89)	1.03 (0.60 to 1.77)
	2003-2007	1.00	0.72 (0.36 to 1.42)	0.65 (0.42 to 1.00)	0.96 (0.52 to 1.78)

Fig 11

However time of death can be days after collapse and/or some time after actual death if the subject died alone. In an attempt to address the latter issue we therefore re-ran our final model including only those 843 subjects where the death was witnessed. As a result, the association with year group lost statistical significance (p=0.357) but the association with age group persisted (p=0.002). The ratios of night to evening deaths and of morning to evening deaths remained higher in adults than children (RRR=2.31 (1.29 to 4.11) and RRR=2.15 (1.27 to 3.64) respectively).

2.56 Day of VSA Death

Table 13: Death Rates per 100 days (VSA Deaths 1983-2007).

	No. of deaths	No. of days	Death rate per 100 days	Rate ratio	95% CI
England & Wales					
Weekday	1234	6320	19.53	1.00	Baseline
Weekend	461	2610	17.66	0.90	0.81 to 1.01
Public Holiday	27	201	13.43	0.69	0.47 to 1.01
Scotland					
Weekday	187	6319	2.96	1.00	Baseline
Weekend	76	2610	2.91	0.98	0.75 to 1.28
Public Holiday	6	202	2.97	1.00	0.45 to 2.26
Northern Ireland					
Weekday	57	6270	0.91	1.00	Baseline
Weekend	30	2610	1.15	1.26	0.81 to 1.97
Public Holiday	2	251	0.80	0.88	0.21 to 3.59
Combined analysis adjusted for differences between countries (P=0.069)					
Weekday				1.00	Baseline
Weekend				0.93	0.84 to 1.02
Public Holiday				0.74	0.53 to 1.03

In order to investigate whether VSA deaths were more common on weekends and public holidays, lists of public holidays covering the 25 years of the study period were compiled. There were a total of 201 public holidays in England and Wales, 202 in Scotland and 251 in Northern Ireland.

The observed patterns (Table 13) were not completely consistent across all 3 areas. For England and Wales death rate per day was highest on weekdays but for Northern Ireland it was highest at weekends. When we combined information having adjusted for area, death rates per day, contrary to what one might hypothesise, appeared to be highest on weekdays, although the difference in rates between weekdays, weekends and public holidays just fell short of statistical significance at the 5% level (p=0.069).

When data on day of death were simply pooled across all areas and compared between age groups (Table 7), the percentage of VSA deaths on weekends and public holidays differed little between children and adults (30.9% versus 27.3%, p=0.083, chi-sq with Yates correction). No VSA deaths coded as suicides occurred on a public holiday.

One of the problems with the above analysis is that subjects dying at a weekend or public holiday may not be found and certified dead until the next working day. We therefore repeated the above analysis including only those subjects where the death was witnessed (n=930). There was no evidence of any difference in death rate per day between public holidays, weekends and

weekdays (p=0.849). The odds ratio for public holidays versus weekdays was 1.03 (0.89 to 1.19) and for weekends versus weekdays 0.92 (0.58 to 1.45).

2.6 Other Substances

In addition to volatile substances associated with VSA deaths a record is routinely kept of up to five other non-volatile substances present at death. Typically such information is obtained from post-mortem and coroner's reports. In the following analyses, because of the way in which information is coded we have to assume that no information means no other substances were present at death. However this means that our prevalence figures will be conservative and, as we suspect that the completeness of information may have improved over time, Fig 12 presents information for 1983 to 2007 whereas Figure 13 presents the same information but restricted to 2003-2007.

Fig 12

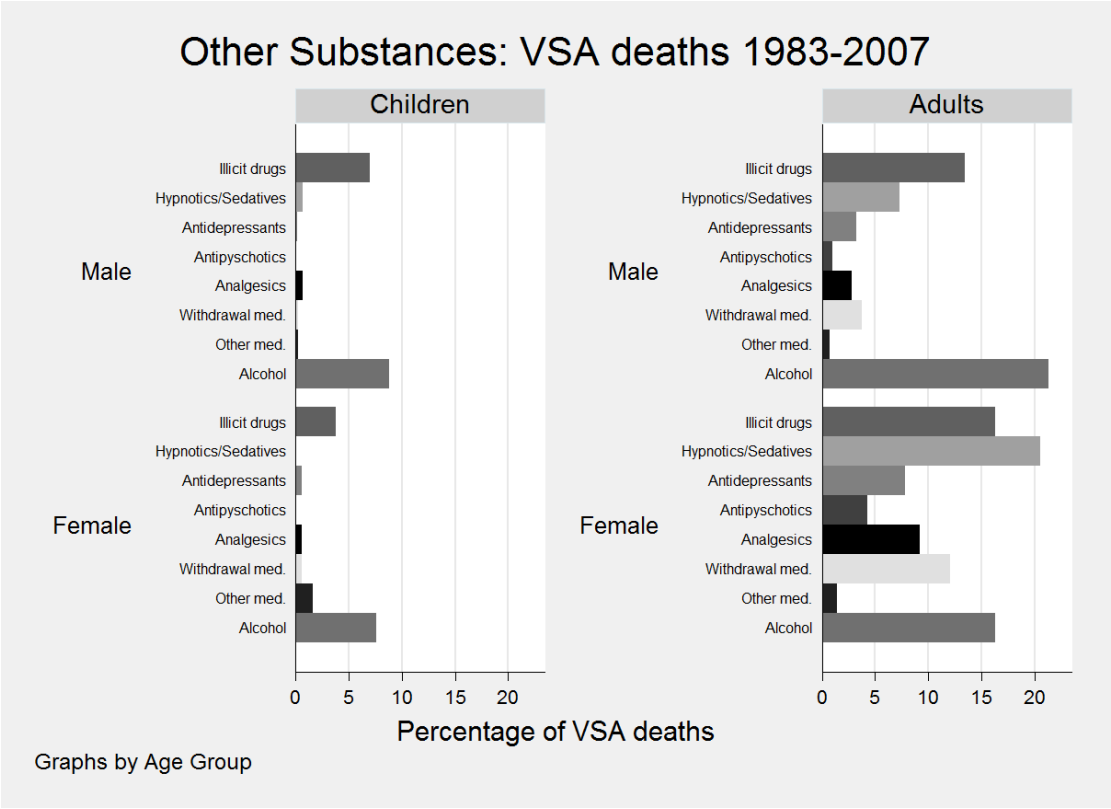
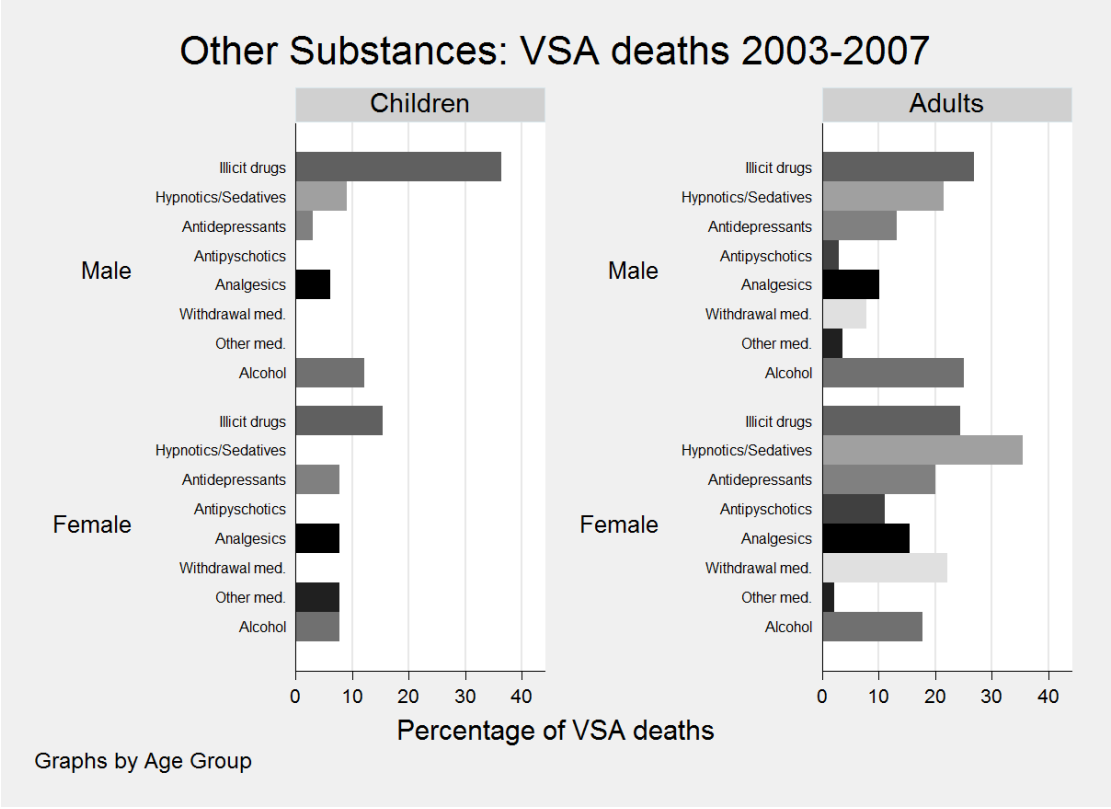


Fig 13



Based on the full data set only 16% of deaths in boys and 15% of deaths in girls had a mention of any other substance and the most common substances mentioned tended to be illicit drugs (7% of deaths in boys and 4% of deaths in girls) and alcohol (9% and 8%). In the last 5 years (i.e. 2003-2007), the percentage of deaths in boys and girls with mention of illicit drugs was 36% and 15% and for alcohol 12% and 8%. Cannabis was present in 30% (10/33) of VSA deaths in boys and heroin in 6% (2/33).

With respect to adults and based on the full data set, 39% of deaths in men and 50% of deaths in women had a mention of ‘other substances’. For men, as in the child data, the most commonly mentioned ‘other substances’ were alcohol and illicit drugs whether we looked at the whole data set (21% and

13%) or in the last 5 years (25% and 27%). For women the most common other substances were hypnotics/sedatives (21% based on 1983-2007 and 36% based on 2003-2007). In the last 5 years, heroin was present in 8% of VSA deaths in men (13/167) and cannabis in 18% (30/167), and benzodiazepines were present in 33% (15/45) of VSA deaths in women.

Differences in the magnitude of prevalence estimates between Figures 12 and 13 are difficult to interpret as, in addition to differences in precision, they may reflect differences in the completeness of information or changes over time or indeed a combination of both.

3. Discussion

From this analysis it would appear that the sustained and marked fall in deaths, previously reported among the under 18s following the Department of Health's advertising Campaign of February 1992, occurred and to a similar degree among both boys and girls. In addition based on Figures 2 and 3, it would appear that beyond 1992, the number of VSA deaths among children continued to fall, which was not unexpected given prevalence data for 16 year olds from the UK arm of the European School Survey Project. This found that reported ever use of inhalants (glues, etc) to get a high fell between 1995 and 2007 from 21% to 10% among girls and 20% to 8% among boys.[9] In keeping with these findings we highlighted increases in the mean age at death over time in both males and females as well as a steady rise in the number of women dying of VSA, a trend which may have peaked in recent years.

The overall effect of these changes has been a marked shift in the distribution of deaths between the 4 major age-sex groups changing dramatically from 48% boys, 11% girls, 40% men and 1% women in 1983 -1987 to 13% boys, 5% girls, 65% men and 17% women in 2003-2007. Therefore although VSA as a percentage of all cause mortality remains higher in children than adults our findings serve as a reminder that in terms of public health policy and education the adult population, which in 2003-2007 contributed 82% of all VSA deaths, should not be neglected.

The implications of the apparent increase in the number of VSA deaths in women are unclear as this trend does not appear to have continued into 2008.

According to the most recent VSA mortality report, which was compiled by the International Centre for Drug Policy at St George's, there were a total of 36 VSA deaths in 2008, down from 59 in the previous year, and although the proportion of VSA deaths occurring in adults remained high (86%) there were no deaths among females aged 18 years and above. However this is just one year's data and could prove to be an anomaly in the long run.[10]

One possible explanation for the change in the age distribution is that children who started abusing volatile substances in the 1980's have continued the habit into adult life and that to some extent we are observing a cohort effect. However the extent to which adult cases today have recently started to abuse volatile substances as opposed to having a history of abuse reaching back into childhood is unclear.

In terms of the characteristics and circumstances of VSA deaths we have found many differences between the four main age-sex groups which may help to appropriately target any future prevention strategies. Most adults who die from VSA are single/divorced/separated or widowed, although the proportion married and or cohabiting is higher among women than men (27% versus 16%). In a far higher proportion of adult deaths than child deaths the fatal abuse was not witnessed (82% versus 49%) and took place indoors (81% versus 56%). Differences in employment status between groups are difficult to interpret as they may simply reflect secular trends. However of note is the higher proportion of girls than boys who were students or still at school at time of death (87% versus 64%). A comparison of VSA male deaths in the

over 16s (2000-2007) with the UK male employed population in the second quarter of 2004 provides some indication that VSA deaths at least in men occur predominantly in the lower socioeconomic groups. Although this finding might be changed if we could standardise for age, it is nevertheless in line with previous work on our data set by Esmail et al,[11] who using data for 1985 to 1991 and the Townsend deprivation index reported a positive association between deprivation and VSA mortality at the level of the county/region. Also of note is the 12% of child VSA deaths with a history of being 'in care', which seems slightly high when compared to the figure of 4.8% for ever in public care before age 17 years based on the 5, 10 and 16 year follow ups of the 1970 British Birth Cohort.[12]

In terms of the primary substance of fatal abuse, a higher proportion of VSA deaths in girls than boys were from abuse of aerosols (47% versus 23%) whereas higher proportions of VSA deaths in boys than girls were from abuse of gas fuels (50% versus 39%) and glues (7% versus 1%). Among adults fatal abuse of aerosols was almost as common in male as in female deaths (8% versus 10%), although a higher proportion of VSA deaths in men than women were from abuse of glues (21% versus 8%) and a higher proportion of VSA deaths in women than men from abuse of gas fuels (74% versus 52%). In terms of trends over time, the proportion of VSA deaths from glues fell in children during the 1980s (Fig 7) and in adults through the latter part of the 1980s and into the 1990s (Fig 8). In the case of children, this links back to previous work on our database by Esmail et al, [13] who reported a sustained fall between 1981 and 1989 in yearly solvent deaths (i.e. deaths associated

with volatile substances that are liquid at room temperature e.g. type writer correction fluid, toluene in glue) in the under 18's consistent with the introduction in England and Wales in 1985 of the Intoxicating Substances (Supply) Act. However, whether the fall in solvent and therefore glue deaths was simply a continuation of an underlying trend or whether it was set in train by the legislation remains unclear given the inconsistencies in data collection methods prior to 1983.

Other time trends included an increase in the proportion fatally abusing indoors and an increase in the proportion of adult VSA deaths from abuse of gas fuels, a trend which may have reached a plateau in more recent years.

Despite evidence from the European School Survey project that the prevalence of volatile substance abuse in children differs little between the sexes,[9] the number of VSA deaths continues to be markedly higher in boys than girls and in men than women. One possibility is that physical and/or emotional activity prior to abuse, which was more common among VSA deaths in males than females, contributes to this difference by increasing the risk of death.

Based on our data for 2003-2007, it would appear that in roughly a third of VSA deaths in boys (36%), an illicit drug was present at the time of death. In most the illicit drug was cannabis (30%) but in some it was heroin (6%). Whether this suggests that the presence of other drugs increases the risk of death from volatile substances and/or that combined abuse is relatively

common in males compared to females in this age group is unclear. A recent MORI report [14] for the Department of Health suggested that among younger and newer abusers such combined use was uncommon but that where it did take place, the volatile solvent was generally combined with cannabis.[14]

Time of day, day of the week and season of death were also investigated but contrary to our prior hypothesis, there was no evidence that the number of VSA deaths per day was higher on public holidays and or weekends. However, with many deaths not witnessed it is possible that some subjects who died on public holidays/weekends were not found until later and death certified on a week day, although when we restricted our analysis to the subset of witnessed deaths our findings were unchanged. A higher proportion of VSA deaths occurred in the summer months compared to the winter months but this was more marked in children than adults, a possible consequence of the long school summer holiday. The ratio of afternoon to evening VSA deaths fell sharply between 1983-1987 and 1988-1992 but overall (i.e. based on the full 25 years) a higher proportion of VSA deaths in adults than children occurred at night or in the morning (28% versus 15%) with a slightly higher proportion of deaths in children than adults occurring in the evening (51% versus 41%). However, one possible explanation of these findings is that among subjects who die of VSA abuse in the evening, adults are more likely than children to remain undiscovered until the following morning. This is certainly plausible given the higher proportion of deaths in adults than children where the fatal abuse was not witnessed and the high level of missing information among un-witnessed deaths. However, when we

re-ran the analysis including only those deaths that were witnessed, associations with age group persisted relatively unchanged, although the overall association with year group fell short of statistical significance.

Study Limitations

One of the strengths of the St George's database is that the methods used for data collection have been stable and systematic since 1983. Nevertheless, over the 25 years to 2007 there have been changes both in staff and in the types and completeness of information available. Using sensitivity analyses we have tried to address the issue of potential bias due to changing levels of missing information. However, other changes over time such as in the interpretation of the coding frame may be far more subtle and less easy to detect and although less likely to affect variables used on a regular basis (i.e. in yearly reports) are an unavoidable consequence of such a long term surveillance database. In terms of data accuracy we are reliant on 'as is' information and this is an issue particularly in relation to time and day of death, both of which may be recorded some time after the subject actually died. Again we have tried to address this issue by re-running some analyses based only on deaths that were witnessed where we feel that information on day and time of death may be more accurate.

4. Acknowledgements

The authors would like to thank all those who have contributed over the years to the development and maintenance of the St George's Volatile Substance Abuse (VSA) database (1983-2007) on which this report is based. In particular we would like to thank: HM Coroners and the Office for National Statistics (England and Wales), The Crown Office (Scotland), The General Register Offices for Scotland and Northern Ireland, The State Pathologist's Department and Coroners Service (Northern Ireland), the Deputy Viscount in Jersey, HM Greffier in Guernsey, and The High Bailiff and Coroner of Inquests (Isle of Man), who provided the original information on deaths; the British Aerosol Manufacturers' Association, the Health and Safety Executive and Peter Streete (Medical Toxicology Laboratory, Guy's and St Thomas' NHS Foundation Trust) for providing access to their information; the Health and Safety Executive and the Railways Inspectorate for liaison over workplace deaths where necessary; St George's staff past and present who coded the data and ran checks on the database; Jennifer Taylor who managed the data collection throughout the 1990's; Prof. Martin Bland whose previous investigations of the data helped to inform our current analysis; and the Department of Health whose funding supported the St George's VSA Programme over a large part of its history.

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6. Appendix

A1: Summary Protocol

Background

St George's Volatile Substance Abuse (VSA) Programme has been monitoring volatile substance abuse deaths in the UK since 1971 and has been funded by the Department of Health since the 1980s. The programme is ongoing. Our information comes mainly from coroners but also from press cuttings and from death data supplied by ONS. Our methods of data collection have been stable and systematic since 1983 and a statistical summary of our data is published annually (available at www.vsareport.org).

The St George's VSA programme is a monitoring programme designed to provide information on current trends in VSA mortality. It therefore facilitates timely public health action such as the Department of Health's advertising Campaign of February 1992 aimed at parents and the Legislation which banned the sale of butane cigarette lighter refills to under-18 year olds which came into effect in October 1999, and allows us to evaluate the impact of such action. [1]

One of the charities working in the field (Re-Solv) has recently been awarded a grant from the Big Lottery Fund to undertake research on Volatile Substance Abuse. As a small part of their 'research' programme they wish to fund us to carry out further statistical analyses of our existing data on VSA deaths; looking only at deaths occurring during the period 1/1/1983 to 31/12/2007. The aim of the analysis is to address gaps in knowledge about VSA deaths, including circumstances of death and gender and age profiles in order to improve Re-Solv's response to VSA, and support its education and prevention work. The Big Lottery Fund organisation requires a statement regarding our ethical approval status.

Subjects
All study subjects are dead. The analysis funded through Re-Solv will be restricted to deaths occurring between 1/1/1983 and 31/12/2007.

The Data
The data are held in various forms:

1) The main study database, anonymised by the use of case numbers. This currently includes information on 2,094 VSA deaths occurring between 1/1/1983 and 31/12/2007.
2) An electronic administrative database containing names and case numbers.
3) Paper files containing names and case numbers.

Data security
All electronic files are held on the University computer in the password-protected accounts of Programme staff. Paper files are stored in locked filing cabinets.

Summary of work to be undertaken for Re-Solv
Secondary analysis of the main study database: The analysis will be restricted to deaths occurring between 1/1/1983 and 31/12/2007 and focus on the following five broad questions:

- What are the characteristics of those dying VSA-related deaths?
- What are the circumstances of deaths (e.g. indoors or outside, seasonal variations, alone/in company, etc.)?
- What are the changing patterns in VSA deaths 1983-2007 (e.g. primary substance abused in different age-gender groups)
- Do changes in the number of VSA deaths 1983-2007 within age-gender groups reflect well defined events (e.g. The Cigarette Lighter Refill (Safety) Regulations 1999)?
- Is the average age of death rising in males and females?

Dates of death are held on the main study database as day of the week, month and year. If full dates of death are required (i.e. including day of death), information will need to be obtained from the administrative database and extracted from paper records.

Ethics

The St George's VSA programme is a mortality monitoring programme, and only holds information on subjects who are dead. Its intent is to provide information to the public, interest groups and policy makers regarding current trends in VSA mortality and to evaluate the impact of any resulting legislation or government instigated campaign. For these reasons we have never regarded the programme as requiring ethical approval. We do not feel that the proposed work to be undertaken for Re-Solv changes this situation but would value your opinion.

[1] Esmail A, Anderson HR, Ramsey JD, Taylor J, Pottier A. Controlling deaths from volatile substance abuse in under 18s: the effects of legislation. *BMJ* 1992;**305**:692.

A2. Data Editing

1. Data cleaning:
    - Amyl Acetate V28 and V30 recoded from 94 to 46: Amyl Acetate now coded as a: 'paint thinner' (only one instance).
    - The 'In Care' variable (X14 on the database) included 5 categories:
        1) In care including on weekend leave and absconded
        2) Yes previously
        3) On remand inc. in custody and on bail, (on probation), or subject of a Care Order.
        4) In prison
        5) No

      For those under 18 years of age we wanted 'in care' to exclude those living independently, those on remand/on bail/on probation/in prison, and those living at home under a care order/supervision order/supervision of social worker. However it was not clear how we should treat those children with a code of X14=3, as prior to being placed say 'on remand' they might have been 'in care' i.e. lived in a children's home, a children's home with education provided on the premises, or been living with officially appointed foster parents. There were only 12 subjects with X14=3 and for these subjects we went back to the paper records. Coding changes were made for only two subjects (one from 3 to 2 and another from 3 to 5). An additional subject was re-coded from 6 (a non-existent code) to 3.

      Old documentation suggested that children who were or had been in foster care were not always coded as X14=1 or X14=2. For those under the age of 18 we therefore decided to look at variable X15=6 (currently fostered) and recode X14 accordingly. However, where the fostering was within a family (e.g. grandparents) and there was no documented local authority involvement or other indication of the child being or having been 'in care', X14 was coded as 5 (i.e. not in care).

2. Date of death on the VSA database was coded as day of the week, month, and year. On the administration database it was coded day, month and year. In order to determine whether death occurred on a public holiday we required dates in the administration database format. We therefore merged in dates from the administration database and checked them against the VSA database dates for discrepancies. Discrepancies were checked against paper records. Sometimes discrepancies arose because one date referred to the date on the death certificate and the other to the date last seen. These were resolved in favour of the date on the death certificate. During this process we also identified a duplicate record on the VSA database, three records that should not have been included on the VSA database due to insufficient evidence of solvent abuse and one record that should have been included on the VSA database but was somehow missed. Appropriate edits have now been made.

It should be noted that our checks may not have picked up all those for whom date of death was coded as date last seen rather than date on the death certificate.

3. When we looked at the Social class coding for 2000-2007 it became apparent that the number coded as having worked in an elementary occupation (code=9) was suspiciously high. All deaths 2000-2007 with a code of 9 for Soc 2000 were listed and their occupational history checked against paper records. There was one case where 9 had been used instead of 0 (unknown), the majority with 9 were coded correctly according to occupation (either as stated in the death certificate or found in the notes). In some cases however 9 was used for long term unemployed/never worked/homeless etc and it was decided to recode these to 0 (unknown) in order for the VSA data to be compared accurately with national data.

4. Sexual activity (X10) /Exercise(X13)

   Based on a review of early coding notes and from a cross tabulation of X10 (sexual activity) and X13 (exercise) we strongly suspect that the exercise variable (X13) was only expanded to include emotional activity (i.e. sexual activity and/or emotional upset) as well as physical activity in 1990 and that deaths prior to 1990 were not subsequently re-coded to take account of the change.

   For the purposes of this report, X13 was therefore automatically re-coded throughout the data set as follows:

   Recode X13=1 (definite) if X10=1 (definite)
   Recode X13=2 (possible) if X10=2 (possible)
   Recode X13=9 (missing) if X13=3 (no) and X10=9 (missing)

A3. Previous journal/conference publications based on the St George's VSA database

Anderson HR, Dick B, MacNair RS, Palmer JC, Ramsey JD. An investigation of 140 deaths associated with volatile substance abuse in the United Kingdom (1971-81). *Hum Toxicol* 1982;**1**:207-221.

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Ramsey J, Anderson HR, Bloor K, Flanagan RJ. An introduction to the practice, prevalence and chemical toxicology of volatile substance abuse. *Hum Toxicol* 1989;**8**:261-269.

Anderson HR. Increase in deaths from deliberate inhalation of fuel gases and pressurised aerosols. *Br Med J* 1990;**301**:41.

Ramsey JD, Anderson HR, Taylor J, Flanagan RJ. Volatile substance abuse (solvent abuse). *Proceedings of the International Symposium on Forensic Toxicology, June 15-19, 1992. US Department of Justice, Federal Bureau of Investigation.*

Bland JM, Taylor J: Deaths due to volatile substance misuse are greatly underestimated (letter). *Br Med J* 1998;**316**:146.

Taylor JC, Bland JM, Anderson HR: Authors overestimated number of teenagers dying from misusing volatile substances (letter). *Br Med J* 1998;**316**:312.

Ramsey JD, Anderson HR, Field-Smith ME, Butland BK: Deaths from misuse of anaesthetics (letter). *The Pharmaceutical Journal* 2005;**275**: 251.

A4. Supporting Figures

Fig 1A

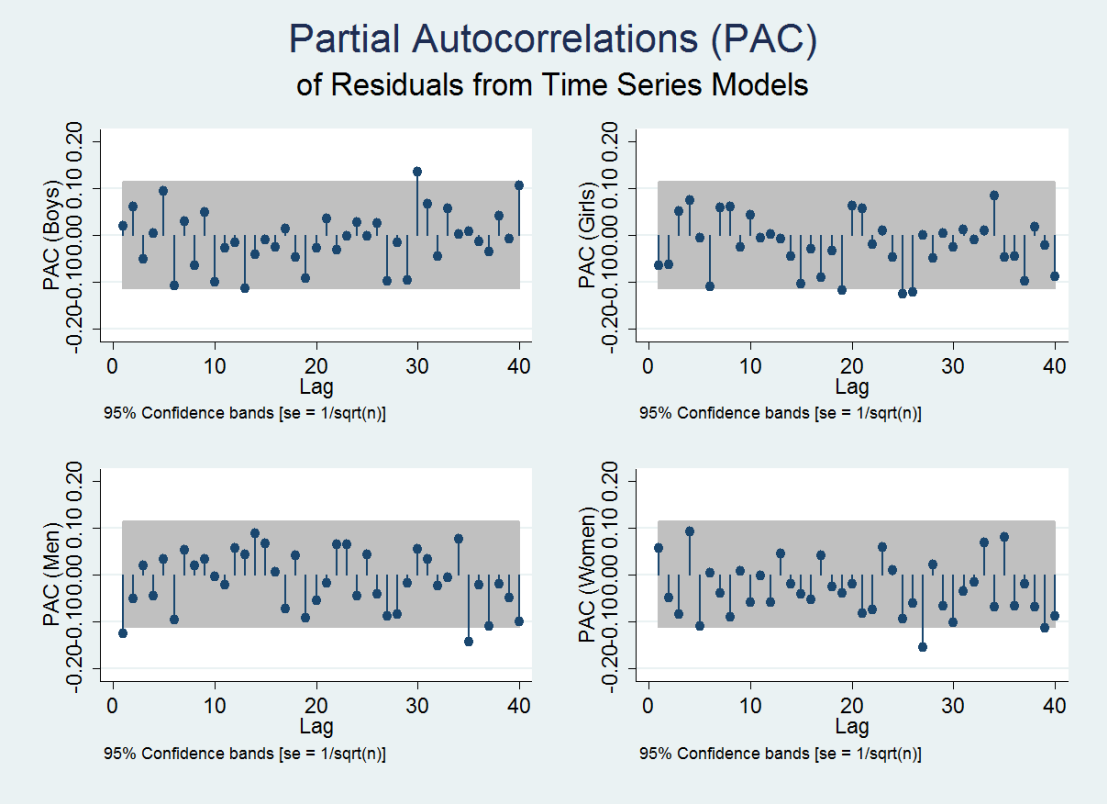


Fig 1B

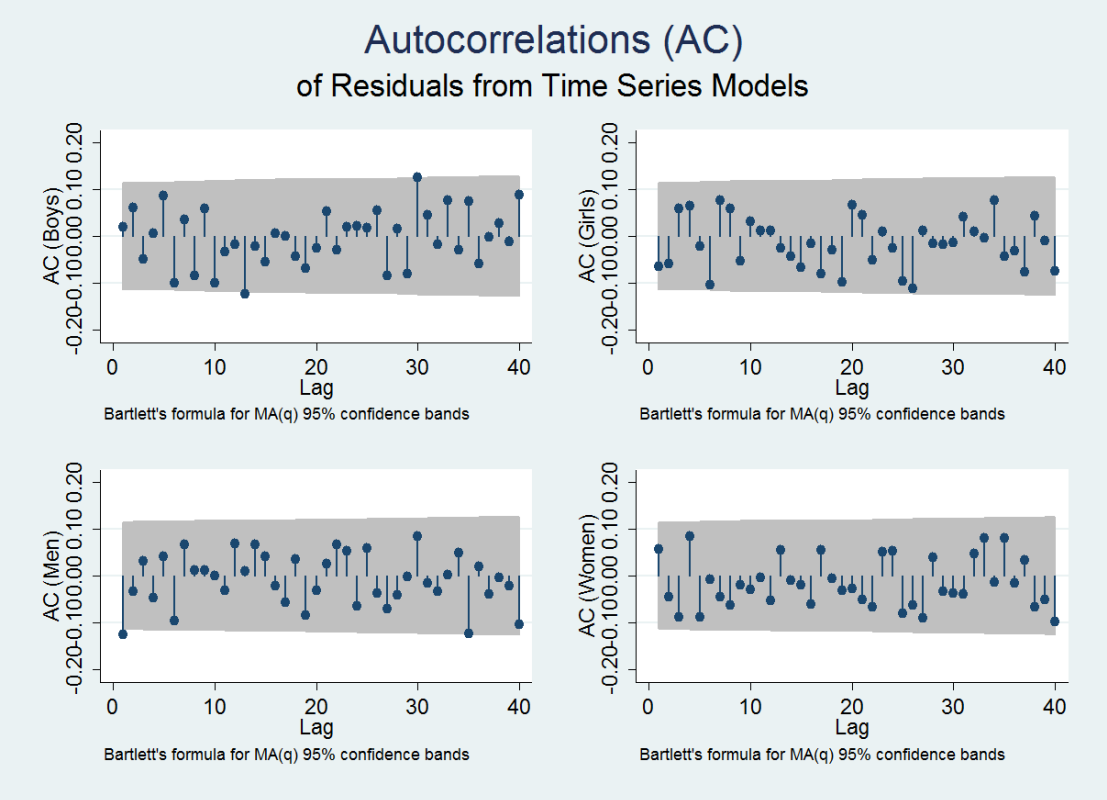
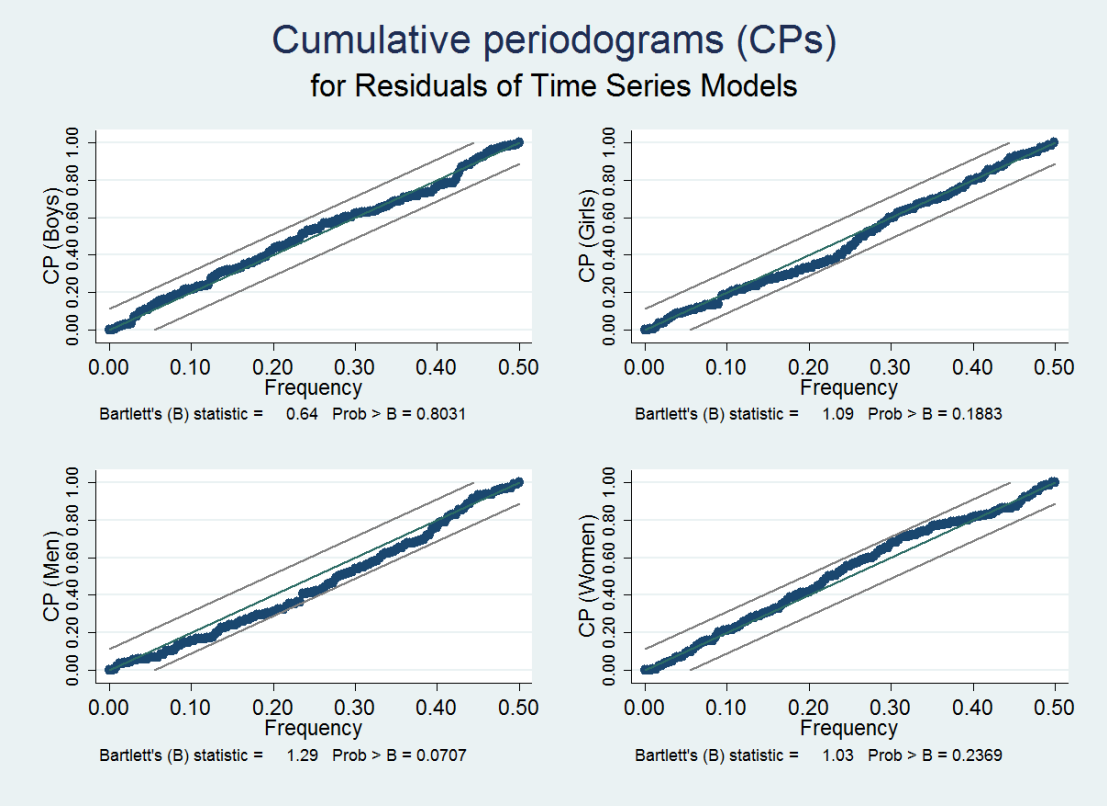


Fig 1C


Cumulative periodograms (CPs)
for Residuals of Time Series Models
CP (Boys)
0.00 0.20 0.40 0.60 0.80 1.00
0.00 0.10 0.20 0.30 0.40 0.50
Frequency
Bartlett's (B) statistic = 0.64 Prob > B = 0.8031
CP (Girls)
0.00 0.20 0.40 0.60 0.80 1.00
0.00 0.10 0.20 0.30 0.40 0.50
Frequency
Bartlett's (B) statistic = 1.09 Prob > B = 0.1883
CP (Men)
0.00 0.20 0.40 0.60 0.80 1.00
0.00 0.10 0.20 0.30 0.40 0.50
Frequency
Bartlett's (B) statistic = 1.29 Prob > B = 0.0707
CP (Women)
0.00 0.20 0.40 0.60 0.80 1.00
0.00 0.10 0.20 0.30 0.40 0.50
Frequency
Bartlett's (B) statistic = 1.03 Prob > B = 0.2369

A5. Supporting Tables

Table A1: Choosing the base time series model for males aged<18 years.

Model		Log likelihood	Over-dispersion parameter	F test for improvement in model fit (df)	P value
Constant		-693.098503	2.2768	-	-
Trend component	t	-567.6670399	1.4110	177.79 (1,298)	<0.001
	$t+t^2$	-549.144355	1.3109	28.26 (1,297)	<0.001
	$t+t^2+t^3$	-544.318079	1.2639	7.64 (1,296)	0.006
	$t+t^2+t^3+t^4$	-542.7390093	1.2645	2.50 (1,295)	0.115
Seasonal Component 1	$t+t^2+t^3$ + $\sin(2\pi t/12)$+ $\cos(2\pi t/12)$	-522.7126699	1.1455	18.86 (2,294)	<0.001
Seasonal Component 2	$t+t^2+t^3$ + $\sin(2\pi t/12)$+ $\cos(2\pi t/12)$ + $\sin(2\pi t/6)$ + $\cos(2\pi t/6)$	-517.1358526	1.1122	5.01 (2,292)	0.007
Removing residual autocorrelation	$t+t^2+t^3$ +$\sin(2\pi t/12)$+ $\cos(2\pi t/12)$ + $\sin(2\pi t/6)$ + $\cos(2\pi t/6)$+ Y_{t-2}	NA	1.0702	NA	0.002@

@ Wald chi-sq

Table A2: Choosing the base time series model for females aged<18 years.

Model		Log likelihood	Over-dispersion parameter	F test for improvement in model fit (df)	P value
Constant		-318.7419659	1.1679	-	-
Trend component	t	-301.1654928	1.0101	34.80 (1,298)	<0.001
	$t+t^2$	-298.0308122	1.0110	6.20 (1,297)	0.013
	$t+t^2+t^3$	-295.4356872	1.0065	5.16 (1,296)	0.024
	$t+t^2+t^3+t^4$	-287.9779104	0.95247	15.66 (1,295)	<0.001
	$t+t^2+t^3+t^4+t^5$	-287.9756448	0.95439	0.0047 (1,294)	NS
Seasonal Component 1	$t+t^2+t^3+t^4$ + $\sin(2\pi t/6)+ \cos(2\pi t/6)$	-284.9281399	0.94639	3.22 (2, 293)	0.041
Seasonal Component 2	$t+t^2+t^3+t^4$ + $\sin(2\pi t/6)+ \cos(2\pi t/6)$ + $\sin(2\pi t/4) + \cos(2\pi t/4)$	-282.0800631	0.98137	2.90 (2, 291)	NS
Removing residual autocorrelation	$t+t^2+t^3+t^4$ +$\sin(2\pi t/6)+ \cos(2\pi t/6)$ + Y_{t-1}	NA	0.95493	NA	0.025@

@ Wald chi-sq

Table A3: Choosing the base time series model for females aged≥18 years.

Model		Log likelihood	Over-dispersion parameter	F test for improvement in model fit (df)	P value
Constant		-277.3424422	1.2043	-	-
Trend component	t	-259.9028103	1.0951	31.85 (1,298)	<0.001
	$t+t^2$	-256.8079791	1.0927	5.66 (1,297)	0.018
	$t+t^2+t^3$	-256.4113104	1.1090	0.72 (1,296)	NS
	$t+t^2+t^3+t^4$	-256.4112003	1.1125	-	-
	$t+t^2+t^3+t^4+t^5$	-256.320794	1.1146	-	-
Seasonal Component 1	$t+t^2$ + $\sin(2\pi t/6)$+ $\cos(2\pi t/6)$	-253.8605022	1.0685	2.76 (2,295)	NS
Seasonal Component 2	$t+t^2$ + $\sin(2\pi t/6)$+ $\cos(2\pi t/6)$ + $\sin(2\pi t/2)$ + $\cos(2\pi t/2)$	-251.8353596	1.0894	-	-
Removing residual autocorrelation	No additional terms required				

Table A4: Choosing the base time series model for males aged≥18 years.

Model		Log likelihood	Over-dispersion parameter	F test for improvement in model fit (df)	P value
Constant		-597.3676	1.0292	-	-
Trend component	t	-594.6918308	1.0126	5.29 (1,298)	0.022
	$t+t^2$	-592.1645521	1.0056	5.03 (1,297)	0.026
	$t+t^2+t^3$	-588.8693228	0.9782	6.74 (1,296)	0.010
	$t+t^2+t^3+t^4$	-588.8210222	0.9810	0.10 (1,295)	NS
	$t+t^2+t^3+t^4+t^5$	-588.105731	0.9768	1.46 (1,294)	NS
Seasonal Component 1	$t+t^2+t^3$ + $\sin(2\pi t/12)$+ $\cos(2\pi t/12)$	-586.0230698	0.9710	2.93 (2,294)	NS
Seasonal Component 2	$t+t^2+t^3$ + $\sin(2\pi t/3)$+ $\cos(2\pi t/3)$ + $\sin(2\pi t/12)$ + $\cos(2\pi t/12)$	-583.6237076	0.9620	-	-
Removing residual autocorrelation	No additional terms required				

Table A5: Choosing the multinomial model for primary substance abused.

Model	Log likelihood	Chi-sq for improvement in model fit (df)	P value
Null model	-2536.263	-	-
age group	-2436.988	198.55 (3)	<0.001
age group + year group	-2315.702	242.572 (12)	<0.001
age group + year group + sex	-2290.204	50.996 (3)	<0.001
(age group ∗ year group) + sex	-2274.09	32.228 (12)	0.001
(age group ∗ year group) + (sex ∗ age group)	-2267.447	13.286 (3)	0.004
(age group ∗ year group) + (sex ∗ age group) + (year group ∗ sex)	-2260.735	13.424 (12)	NS

Note (A ∗ Y) = A + Y + interaction of A and Y

Table A6: Choosing the multinomial model for season of death.

Model	Log likelihood	Chi-sq for improvement in model fit (df)	P value
Null model	-2881.823	-	-
age group	-2877.269	9.108 (3)	0.028
age group + sex	-2875.52	3.498 (3)	NS
age group + year group	-2873.292	7.954 (12)	NS

Note (A ∗ Y) = A + Y + interaction of A and Y

Table A7: Choosing the multinomial model for time of death.

Model	Log likelihood	Chi-sq for improvement in model fit (df)	P value
Null model	-1750.908	-	-
age group	-1731.501	38.814 (3)	<0.001
age group + year group	-1717.37	28.262 (12)	0.005
age group + year group + sex	-1715.802	3.136 (3)	NS
age group ∗ year group	-1706.931	20.872 (12)	NS

Note (A ∗ Y) = A + Y + interaction of A and Y

Table A8: Choosing the logistic model for fatal abuse indoors.

Model	Log likelihood	Chi-sq for improvement in model fit (df)	P value
Null model	-786.2065	-	-
age group	-737.9213	96.5704 (1)	<0.001
age group + year group	-723.7885	28.2656 (3)	<0.001
age group + year group + sex	-719.3235	8.93 (1)	0.0028
(age group ∗ sex) + year group	-717.4163	3.8144 (1)	0.051 (NS)
(year group ∗ sex) + age	-715.8104	7.0262 (3)	NS
(year group ∗ age group) + sex	-717.2813	4.0844 (3)	NS

Note (A ∗ Y) = A + Y + interaction of A and Y

Table A9: Choosing the logistic model for fatal abuse alone.

Model	Log likelihood	Chi-sq for improvement in model fit (df)	P value
Null model	-1257.861	-	-
age group	-1136.824	242.074 (1)	<0.001
age group + year group	-1134.98	3.688 (4)	NS
age group + sex	-1135.503	2.642 (1)	NS

Note (A ∗ Y) = A + Y + interaction of A and Y

Table A10: Choosing the logistic model for 'exercise' (definite or possible) preceding death.

Model	Log likelihood	Chi-sq for improvement in model fit (df)	P value
Null model	-1013.287	-	-
year group	-965.1068	96.3604 (4)	<0.001
sex + year group	-949.63	30.9536 (1)	<0.001
age group + year group +sex	-947.6315	3.997 (1)	0.046
age group + (year group ∗ sex)	-945.4381	4.3868 (4)	NS
sex + (age group ∗ year group)	-944.6463	5.9704 (4)	NS
year group +(sex ∗ age group)	-947.2942	0.6746 (1)	NS

Note (A ∗ Y) = A + Y + interaction of A and Y