CORRESPONDENCE

Increase in neuropsychiatric symptoms after occupational exposure to low levels of styrene

Editor,—Recently, Edling *et al* (1993; 50:843-50) presented a paper on neuropsychiatric effects of low level exposure to styrene. Bearing in mind previous reports and our own experience with styrene exposed workers in the glass reinforced plastics industry we consider that some extra points need to be made.

Firstly, although the results of the questionnaire (Q16) seem at first glance to show differences between exposed workers and controls, they do not differ to a statistically significant degree, as the authors themselves stated. Furthermore there is no unequivocal trend in the answers given. Whereas questions No 1, 3, and 15 are rated with Yes more often by exposed workers than by controls and there is a decrease after an exposure free period, questions No 4, 6, and 8 ratings show an increase after that time. As the questions of the Q16 are specific for effects presumed as neurotoxic, there seems to be some inconsistency in the results reported. For comparison, in table 1 we show the results of Q16 when presented to styrene exposed boat builders and non-exposed carpenters and furnishers of the same plant. Here, no trends towards an over-representation of single symptoms according to exposure and no difference in the average number of symptoms are to be seen. A major reason for that would be that the workers were presented with the questionnaire along with other questions on personal history. We specifically avoided them being led to believe that the symptoms asked for could be related to their daily work. We are aware, however, that our controls were matched neither in number nor in age to the exposed group.

Secondly, we do not agree with the authors' opinion that the acute symptom scores "correlated positively" with exposure parameters. It is obvious that the correlations in figs 3 and 4 are biased by two excessive values. It is easy to see that if these values are eliminated, there is no dose-response relation shown in fig 3 and even a reverse trend shown in fig 4. This

outcome is then in accordance with previously reported results and with our own findings.¹ Using a questionnaire to quantify acute irritative symptoms according to Molhave *et al*² we found no positive correlation between individual styrene exposure, measured in ambient air and blood, and occurrence of symptoms. In our experience, there is no evidence of a dose-response relation at exposures below 100 ppm. Nevertheless exposed workers from the same plant reported significantly more irritative symptoms than non-exposed ones. Most published reports seem to confirm these results.³⁻⁶

Thirdly we must point out that no link has yet been established between symptoms on the one hand and diseases on the other. On the contrary, the lack of a dose-response relation between symptoms and exposure parameters suggests that the occurrence of symptoms is not a sign of neurotoxic effects but merely indicates the personal susceptibility towards chemical odours or a certain sensitivity of the mucous membranes.

The decisive question seems to be again, whether each observable effect should be considered to be "handwriting on the wall" and should therefore be referred to as "toxic". Toxic effects are synonymous with adverse effects.⁷ This term should, in our opinion, not be applied to each health complaint which is reported.⁸ One should regard an effect as such as a neutral concept, and one should distinguish between effects as such and adverse effects (= unacceptable effects).⁹

As a consequence, future research activity should focus on possible links between early subjective symptoms and the development of objective health impairment, in order to identify risk indicators if possible, and distinguish them from simple, acute irritations that are completely reversible after the end of exposure.

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Authors' reply

We appreciate Nasterlack's and Triebig's careful reading of our paper and their comments. We believe that their interpretation of our data is partly due to a misunderstanding of the Q16 and perhaps also to a different approach to occupational medicine.

In our study we used the Q16, which has been established as a sensitive screening instrument for solvent exposed workers.¹ The Q16 was originally developed so that the total sum of positive answers determined whether or not the worker was affected by solvent exposure. Nasterlack and Triebig make the mistake of analysing single questions or a combination of questions. Further, they compared our results with their own questionnaire results, but did not use matched controls in their study. This is unfortunate, as you have to control for age when using the Q16. There was a thorough discussion on the use of controls in our paper (p 849).

Nasterlack and Triebig want to omit the values that suggest effects (figs 3 and 4 in our paper). We prefer to present the results in full to provide the reader with the opportunity to analyse and interpret them. The reader might then, as did Nasterlack and Triebig, reach a different conclusion. We agree that the correlations are weak and stated specifically in our paper (p 850): "these correlations must be interpreted with caution". Other findings,²⁻⁴ more recent than those cited by Nasterlack and Triebig, support our conclusion of an effect of low level exposure to styrene.

Concerning approaches to occupational medicine we believe that one aim of our discipline is to identify, at an early stage, exposures to toxic substances that increase the likelihood of adverse effects in a population. We believe that the worker himself is a very sensitive indicator in this context and that symptoms can and should be used to identify and measure possible effects. If the workers report effects it must be our task to find, through research, the possible causes. Even exposures causing less serious or reversible effects, such as irritation should

Comparison of the results of Q16 questionnaire as reported by Edling *et al* (1993) and Nasterlack *et al* (unpublished results)

Symptom No	Edling <i>et al</i> (1993)		Nasterlack <i>et al</i> (unpublished)	
	Exposed (n = 20)	Controls (n = 20)	Exposed (n = 45)	Controls (n = 11)
1	10 (50)	0 (0)	5 (15)	2 (18)
2	1 (5)	1 (5)	2 (6)	0 (0)
3	6 (30)	2 (10)	1 (3)	1 (9)
4	1 (5)	1 (5)	1 (3)	0 (0)
5	1 (5)	0 (0)	0 (0)	0 (0)
6	2 (10)	1 (5)	1 (3)	1 (9)
7	8 (40)	6 (30)	1 (3)	3 (27)
8	3 (15)	1 (5)	5 (15)	0 (0)
10	1 (5)	2 (10)	2 (6)	0 (0)
11	8 (40)	7 (5)	0 (0)	2 (18)
12	2 (10)	2 (10)	5 (14)	2 (18)
13	4 (20)	2 (10)	2 (6)	2 (18)
15	9 (45)	3 (15)	10 (29)	3 (27)
16	0 (0)	0 (0)	1 (3)	1 (9)
Mean (SD)	3.1 (2.9)	1.5 (1.8)	1.0 (1.2)	1.5 (2.1)

Symptoms 9 and 14 were asked about in different ways and are therefore not included. Values in parentheses for numbers with symptoms are %.

be avoided if our aim is to create a good work environment. The exact meaning of words such as "adverse", "toxic", "disease", or "illness" is important but the process of defining them must not obstruct the improvement of the work environment.

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Coal mining, emphysema, and compensation revisited

Editor,—Journalists should always check their facts. The same principle presumably applies to higher forms of life. Morgan (1993;50:1051-2) criticises the Industrial Injuries Advisory Council (IIAC) for its decision to recommend the prescription of chronic bronchitis and emphysema for coal miners. He notes, presumably sardonically, that it was "perhaps coincidental" that the IIAC report was sent to the Secretary of State in November 1992, shortly after the announcement of large scale impending pit closures.

In fact it is plain from the face of the IIAC report¹ that it was sent to the Secretary of State in August 1992—that is, two months before the Government's announcement of pit closures. The report was not officially published until November. Delays of several months between submission and publication are quite usual and so a conspiracy theory (or at least one that implicates IIAC) seems entirely unwarranted. The present writer is not without criticisms of the role of the IIAC² but it does help to get one's facts right.

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The correction of urinary mercury concentrations in untimed, random urine samples.

Editor,—We note with interest the continuing number of reports defining dose-effect relations for occupational exposure to mercury (Hg) that have used urinary Hg concentrations from untimed, random samples (spot urines) either as a cumulative exposure dose¹ or a simple dose index.²

These studies often use spot urinary Hg concentrations readily available from routine biological monitoring strategies in the chloralkali and other Hg utilising industries. Diurnal variation in the metal's excretion has been noted,^{3,4} but the higher concentrations found in morning samples compared with afternoon and evening samples have been suggested as being of no practical relevance in a biological monitoring scheme.⁴ Urinary Hg concentrations are said to reflect integrated exposure over the preceding weeks or months in workers with long term exposure. There has been debate about whether creatinine or other forms of correction for urinary concentration are better in reducing intra individual variation of urinary Hg and thus making a single spot measurement more closely reflect true Hg excretion.⁵ We present some data on the effect of suggested methods for the correction of spot urinary Hg samples in reducing within day and between day intraindividual variation.

Within day variation was studied in 17 workers with long term exposure to Hg vapour at a single factory. All spot urine samples were taken during a single day at the approximate times of before work, 1000, 1300, 1600, 1900, and 2200 hours. Mercury was measured by an automated method⁶; creatinine, specific gravity (SG), and osmolality were also measured. The total analytical imprecision (CV_A) for urinary Hg corrected for either creatinine, SG or osmolality was between 5% and 6%. All Hg measurements were either uncorrected (nmol/l) or corrected per mM creatinine, to SG 1.016, and to 500 mosmol. The between day variation was studied in 10 workers with relatively constant, long term exposure to Hg vapour at a single factory. Spot urine samples were taken from each worker at the same time of day on each day of the working week (five days). The samples from this study were uncorrected or corrected for creatinine concentration or for an SG of 1.016.

The mean (range) urinary Hg concentrations in the workers from the within day and between day studies were 58 (4-268) and 32 (6-50) nmol/mmol creatinine respectively. The table shows the calculated mean and standard deviation (SD) of the intraindividual coefficients of variation (CV_T) for urinary Hg results in the two studies and, the comparison by ANOVA, of the mean CVs of corrected urinary Hg results with uncorrected results. The data from the within day study confirmed the previously reported diurnal variation.^{3,4}

A low mean and SD of intraindividual CVs derived from multiple spot urinary Hg values would imply that a single urine sample closely reflects the true Hg excretion in that individual subject. Creatinine correction of Hg concentration significantly reduced mean intraindividual variation, both between and within day, to about 50%

of the variation in uncorrected urine values.⁷ Although the mean intraindividual CV_T, both within and between day, was less with creatinine correction than with SG correction, the difference did not reach significance (ANOVA, Boniferroni multiple comparison test). There was some evidence from F tests, however, that creatinine correction may be more reproducible between subjects than SG correction. It should be noted that, even with creatinine correction, the mean CV_T of around 15% with the imprecision of our method implies that two consecutive daily spot urine samples, taken at a time to reduce the influence of diurnal variation, could statistically be around 45%-50% apart ($t \cdot \sqrt{2 \cdot CV_T}$). It has been widely accepted in clinical pathology that acceptable analytical imprecision should be less or equal to half the average intraindividual biological variation (CV_B).⁸ This value for urinary Hg corrected for creatinine can be derived from the formula $CV_T^2 = CV_A^2 + CV_B^2$. Thus we suggest that the combined analytical precision of any urinary Hg and creatinine method should be less than 7.3%.

Correction for creatinine and, perhaps slightly less satisfactorily, correction for SG reduce the uncertainty of a spot urinary Hg concentration in reflecting accurately the true Hg excretion in an individual subject. Corrected spot urinary Hg results have proved their use both in routine biological monitoring and in studies describing dose-effect relations that may aid in setting standards. It is important, however, that the limitations and errors associated with their use as dose measures are understood.

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Comparison of mean CVs of corrected urinary Hg results with uncorrected results

	CV _T Creatinine corrected mean (SD)	CV _T SG(1.016) corrected mean (SD)	CV _T Osmolality corrected mean (SD)	CV _T Uncorrected// mean (SD)
Within day (17 subjects)	22.4 (7.9)% p < 0.001	32.2 (12.3)% p < 0.05	36.5 (15.1)% p > 0.05	47.3 (22.2)%
Between day (10 subjects)	15.6 (7.2)% p < 0.05	22.0 (14.0)% p > 0.05	—	37.3 (23.6)%