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Field Study

Occupational Hazards of Hospital Personnel: Assessment of a Safe Alternative to Formaldehyde

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Abstract: Occupational Hazards of Hospital Personnel: Assessment of a Safe Alternative to Formaldehyde: Fabio BERTON, *et al*. Department of Public Policies and Public Choice, University of Eastern Piedmont, Italy—Objectives: Formaldehyde — a chemical widely used to preserve organic tissues in hospitals — is known to be carcinogenic in the long term and to cause breathing-related symptoms in the short term. We have taken advantage of an experiment to quantify this second effect among hospital workers in terms of probability of showing respiratory symptoms with respect to a benchmark in which tissues are preserved using a procedure with arguably no impact, i.e., under-vacuum sealing. **Methods:** This paper exploits an experimental situation with controls for potential confounding effects to estimate a logistic regression of the probability that formalin (a solution of formaldehyde and water) causes respiratory symptoms. **Results:** The probability for formalin users was found to be eight to ten times higher than for personnel testing under-vacuum sealing. **Conclusions:** The substitution of formaldehyde with under-vacuum sealing would markedly improve the health of personnel.
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Key words: Experimental design, Formaldehyde, Impact evaluation, Indoor pollution

Workers are today exposed to numerous occupational hazards. Among chemicals, formaldehyde represents a health threat in several workplaces. Formaldehyde is used in construction materials, manufacturing and consumer products and in pathology and anatomy laboratories as a tissue preservative. Despite its advantages, formaldehyde has some drawbacks that demand caution: it is allergenic to the skin and produces irritating vapors that may cause runny noses and itchy eyes as well as chronic respiratory problems[6, 8]. Millions of workers are regularly exposed to various concentrations of the chemical[5] through inhalation of the gaseous form and dermal exposure to liquid formaldehyde. In a recent analysis by the IARC[4] formaldehyde was classified as a human carcinogen (group 1) on the basis of experimental observations in rodents and epidemiological studies of exposed groups in manufacturing settings and in the funeral industry[3].

Massive indoor exposure is found in hospitals: anatomists and technicians in histology and embalming laboratories are indeed exposed to formalin, a solution of formaldehyde in water. Several attempts have been made to find a substitute, but so far, all of the proposed alternatives have failed[7].

To overcome these problems, pathologists at the San Giovanni Battista University Hospital of Turin (Italy) proposed a new procedure: under-vacuum sealing (UVS). The process lasts a few seconds: specimens are sealed into plastic bags immediately after removal from human bodies; the bags are labeled with identification data and then kept in a refrigerator at 4°C inside the premises of the surgical theater until they are transferred to pathology. Once the sealed bags arrive at the pathology labs, the tissue is removed and routinely processed.

Advantages linked to this procedure have already been reported elsewhere[1, 2]. This processing was tested for more than two years in a single surgical theater and is now being used in the whole hospital. This paper takes advantage of the data collected during these tests to quantify the impact of formaldehyde on hospital workers' respiratory symptoms.

Data and Method

The vacuum sealer was introduced at the S. Giovanni Battista hospital in November 2008; at that time, a random sample of the personnel of the surgi-

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cal theaters and of the technical staff of the pathology laboratories was drawn to use the new procedure. In order to collect data, the relevant staff were interviewed one month after having either used formalin or UVS during the period of December 2008 to April 2009. The questions concerned respiratory symptoms (the outcome variable), the procedure actually used (formalin or UVS), gender, age, actual experience, ward, occupation, education and whether the interviewee lives in the metropolitan area of Turin, suffers from existing breathing-related diseases or finds it difficult to handle organic tissues (as proxies for possible confounding effects). Overall, 171 individuals were interviewed; after correcting for the missing values in the relevant variables, the sample includes 156 observations.

Table 1 shows some descriptive analyses by procedure. The differential in terms of respiratory symptoms is neat: only 4.3% of the respondents using UVS reported that they suffered from respiratory symptoms such as cough, chest pain, shortness of breath and wheezing; this figure was about 30 percentage points more for formalin users. No relevant difference in terms of gender, exposure to air pollution (measured by the residence area), preexistence of respiratory symptoms, age, potential experience and occupation was found: this confirmed the randomness of the group drawn to test UVS. However, some differences in terms of difficulties in handling the procedure and of education exist. These make multivariate analysis necessary.

From this perspective, the probability of suffering from respiratory symptoms is modeled as a logistic function of the procedure (formalin or UVS) with controls for seasonal effects, exposure to air pollution, preexistence of comparable symptoms, gender, occupation, ability in handling the procedure and human capital; the logit command of the STATA statistical software, version 10.0 (2009; Stata Corp., College Station, TX, USA) was used for estimation. Since actual experience was observed for 115 individuals only, in the following section we first compared the results for different specifications of human capital in the subsample of workers for which actual experience was observed. Once we proved that the odds ratios of using formalin were only marginally affected by the way we control for human capital, we took advantage of the specification that allows for the largest sample size to propose further robustness checks, including estimation of the Mantel-Haenszel odds ratio for all the subsamples taken into account; the cc command of STATA was used in this case.

Results

Table 2 reports our main results. The four specifications differ in the manner in which individual human capital was controlled for: namely, through actual experience, age, potential experience or education. In order for the sample size not to affect the comparison of results, all specifications were estimated in the subsample for which all the variables were observed (115 observations). The results are neat: the odds ratio of showing respiratory symptoms after using formalin was nine to ten times higher than for workers using UVS and having difficulties in using formalin further increases this effect.

The fact that the odds ratios of using formalin were only marginally affected by the manner in which human capital was controlled, allows us to trade the specification for a larger sample size and to further check the robustness of our results in subsamples of the population under study. Results are shown in Table 3. By using specification that included potential experience, 41 more observations were available and

Table 1. Descriptive statistics

	Using UVS (70 observations)	Using formalin (86 observations)
Experiencing respiratory symptoms	4.3%	34.9%
Women	72.9%	75.6%
Living in metropolitan area	78.6%	80.2%
With existing respiratory symptoms	30.0%	29.1%
Mean age (yr)	40.3	40.0
Mean potential experience (yr)	18.4	18.7
Having difficulties in handling the procedure	10.0%	23.3%
With a tertiary degree or more	54.3%	47.7%
Physicians	27.1%	25.6%
Lab technicians	38.6%	37.2%

Source: our computations for the collected data.

Table 2. Estimation results

	Specification 1 (115 observations, ps-R^2: 0.3155)				Specification 2 (115 observations, ps-R^2: 0.3037)			
	OR	*p* value	95% Confidence interval		OR	*p* value	95% Confidence interval	
Using formalin	**10.2*** **	0.005	2.040	51.392	**9.1*** **	0.006	1.859	44.876
Spring	5.9	0.12	0.640	54.324	5.8	0.12	0.631	53.335
Metropolitan area	0.6	0.50	0.151	2.490	0.7	0.63	0.168	2.917
Existing symptoms	0.8	0.73	0.223	2.846	0.9	0.84	0.240	3.187
Women	0.7	0.52	0.197	2.262	0.8	0.67	0.211	2.729
Medical personnel	1.6	0.43	0.480	5.523	1.3	0.67	0.375	4.551
Difficulties with formalin	8.2***	0.004	1.962	34.490	7.5***	0.006	1.805	31.081
Actual experience	1.0	0.21	0.891	1.025				
Age					1.0	0.87	0.600	1.538
Age squared					1.0	0.83	0.995	1.006
Potential experience								
University degree								
	Specification 3 (115 observations, ps-R^2: 0.3046)				Specification 4 (115 observations, ps-R^2: 0.3021)			
	OR	*p* value	95% Confidence interval		OR	*p* value	95% Confidence interval	
Using formalin	**9.0*** **	0.007	1.841	43.511	**8.7*** **	0.007	1.794	42.587
Spring	6.4	0.11	0.668	60.468	5.7	0.14	0.582	56.474
Metropolitan area	0.7	0.61	0.169	2.832	0.7	0.56	0.162	2.680
Existing symptoms	0.9	0.87	0.254	3.194	0.9	0.84	0.249	3.087
Women	0.7	0.60	0.214	2.449	0.7	0.56	0.197	2.394
Medical personnel	1.4	0.57	0.432	4.637	1.5	0.59	0.368	5.800
Difficulties with formalin	7.5***	0.005	1.810	30.980	7.7***	0.005	1.871	31.694
Actual experience								
Age								
Age squared								
Potential experience	1.0	0.57	0.965	1.067				
University degree					0.9	0.90	0.221	3.789

***significant at 99%; **significant at 95%; *significant at 90%. Benchmark: male non-medical staff living outside the metropolitan area of Turin with no previous breathing-related diseases. Source: our computations for the collected data.

sample size grew to 156; the odds ratios of showing respiratory symptoms when using formalin remained high in this case — about eight times as much as for personnel testing UVS — and significant. Robustness was checked on subsamples of women only (116 observations), the oldest and youngest 80% of the population (128 and 125 observations respectively), individuals with the highest school attainment (i.e., uppersecondary school or more: 139 observations) and individuals who did not report any other respiratory symptoms before the experiment (110). Odds ratios of showing symptoms when using formalin (with respect to UVS) were always significant and ranged from 7.64 to 9.96, with a spike to 20.02 for young workers. An additional impact was found for individuals who had difficulties in using formalin and, in some cases, during spring.

The relatively small number of observations with respect to the number of covariates may nonetheless still be a problem. For this reason, we also estimated crude (i.e., without controls) odds ratios for all the subsamples considered so far and tested their homogeneity; we then estimated an overall Mantel-Haenszel odds ratio and tested the hypothesis that it significantly affects our outcome variable. The results are reported in Table 4, where the four estimations proposed in Table 2 of course boil down to only one. The crude odds ratios were in general larger than those reported in Tables 2 and 3, thus confirming that our set of controls captured some confounding effects. Nonetheless, the homogeneity test accepted the hypothesis that the odds ratios of having respiratory symptoms when using formalin were constant across subsamples. The overall Mantel-Haenszel odds ratio was around 12, and its association test further confirmed that formalin had a significantly positive impact on the probability of having respiratory symptoms.

Table 3. Robustness checks

	Full sample (156 observations, ps-R^2: 0.3155)				Women only (116 observations, ps-R^2: 0.3713)			
	OR	*p* value	95% Confidence interval		OR	*p* +value	95% Confidence interval	
Using formalin	**8.0*** **	0.002	2.092	30.194	**9.6*** **	0.009	1.748	52.923
Spring	5.5**	0.045	1.038	29.206	4.1	0.12	0.701	23.530
Metropolitan area	0.7	0.51	0.210	2.159	0.7	0.63	0.181	2.808
Existing symptoms	1.8	0.29	0.611	5.134	3.9*	0.052	0.990	15.237
Women	1.2	0.75	0.381	3.809				
Medical personnel	1.2	0.71	0.407	3.787	1.8	0.45	0.415	7.373
Difficulties with formalin	6.9***	0.003	1.929	24.648	17.6***	0.002	2.807	110.777
Potential experience	1.0	0.26	0.981	1.072	1.0	0.18	0.981	1.109
	Oldest 80% (128 observations, ps-R^2: 0.2784)				Youngest 80% (125 observations, ps-R^2: 0.3624)			
	OR	*p* value	95% Confidence interval		OR	*p* value	95% Confidence interval	
Using formalin	**7.6*** **	0.004	1.921	30.422	**20.0*** **	0.006	2.413	166.186
Spring	6.8**	0.026	1.263	36.558	6.1	0.11	0.648	56.653
Metropolitan area	0.8	0.72	0.203	2.982	0.6	0.50	0.153	2.487
Existing symptoms	2.0	0.25	0.618	6.371	1.8	0.39	0.478	6.553
Women	1.0	0.96	0.294	3.206	1.1	0.93	0.263	4.307
Medical personnel	1.0	0.98	0.266	3.604	2.9	0.14	0.712	11.853
Difficulties with formalin	3.8*	0.071	0.891	16.314	7.4***	0.007	1.734	31.801
Potential experience	1.0	0.57	0.960	1.076	1.0	0.6	0.950	1.093
	High education (139 observations, ps-R^2: 0.3293)				No existing symptoms (110 observations, ps-R^2: 0.2464)			
	OR	*p* value	95% Confidence interval		OR	*p* value	95% Confidence interval	
Using formalin	**10.0*** **	0.004	2.078	47.716	**7.8** **	0.012	1.581	38.613
Spring	5.0	0.16	0.539	45.647	5.2	0.16	0.524	50.928
Metropolitan area	0.5	0.26	0.146	1.687	0.9	0.90	0.196	4.159
Existing symptoms	1.4	0.58	0.433	4.497				
Women	1.0	0.95	0.288	3.219	0.5	0.38	0.137	2.116
Medical personnel	1.5	0.48	0.477	4.888	1.0	0.96	0.287	3.733
Difficulties with formalin	7.2***	0.003	1.967	26.607	4.3*	0.054	0.975	19.025
Potential experience	1.00	0.99	0.952	1.051	1.0	0.89	0.943	1.052

***significant at 99%; **significant at 95%; *significant at 90%. Benchmark: male non-medical staff living outside the metropolitan area of Turin with no previous breathing-related diseases. Source: our computations for the collected data.

Discussion

The impact of formalin on the short-term probability of displaying respiratory symptoms is thus robust and significantly positive. However, one may still argue that interviewed individuals have an interest in cheating about their health status, for instance, in order to avoid further exposure to the chemical or to get some compensation for the risk they run into. In this last section, we argue that this is probably not the case, for four reasons. First of all, both the selection of workers that tested UVS and the interviews were under the complete control of the researchers; the hospital personnel had thus no possibility to affect the results by, for instance, deciding to enter the test group or to fill in more questionnaires. Second, interviewees were aware that data were collected for statistical purposes only by the authors of this study, who would have no possibility of affecting any decision about the procedures used within the hospital. Third, using (or not using) chemicals like formaldehyde does not affect hospital workers' wages according to Italian collective and local bargaining rules. Fourth, we are confident that most of the medical personnel are perfectly aware of the importance of giving unbiased responses to a statistical test. We are thus confident that our results represent a reliable quantitative estimate of the impact of formalin on hospital workers' short-term respiratory symptoms.

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Table 4. Crude odds ratios and Mantel-Haenszel estimations

Subsample	Observations	«Crude» odds ratio	*p* value	95% Confidence interval	
With actual experidence	115	12.1***	0.001	2.712	54.285
With potential experidence	156	12.0***	<0.001	3.467	41.288
Women only	116	11.7***	0.001	2.593	52.737
Oldest 80%	128	9.2***	0.001	2.601	32.478
Youngest 80%	125	28.2***	0.001	3.669	216.372
High education	139	16.8***	<0.001	3.808	74.177
With no symptoms	110	9.8***	0.003	2.155	44.899
Test of homogeneity (M-H): chi-square(6) = 1.11; Pr > chi-square = 0.9809					
M-H combined odds ratio: 12.79; 95% confidence interval: [7.389 – 22.131]					
Association test (M-H OR = 1): chi-square(1) = 119.32; Pr > chi-square = 0.000					

***significant at 99%; **significant at 95%; *significant at 90%; degrees of freedom for chi-square distributions are shown in parentheses. Source: our computations for the collected data.

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