Solvent Use in Private Research Laboratories in Japan: Comparison with the Use in Public Research Laboratories and on Production Floors in Industries

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Abstract: Solvent Use in Private Research Laboratories in Japan: Comparison with the Use in Public Research Laboratories and on Production Floors in Industries: Takaaki Hanada, et al. Kyoto Industrial Health Association—Background and Objectives: Solvents used in production facility-affiliated private laboratories have been seldomly reported. This study was initiated to specify solvent use characteristics in private laboratories in comparison with the use in public research laboratories and on production floors. Elucidation of the applicability of conclusions from a public laboratory survey to private institutions is not only of scientific interest but also of practical importance. Materials: A survey on use of 47 legally stipulated organic solvents was conducted. The results were compiled for April 2011 to March 2013. Through sorting, data were available for 479 unit workplaces in private laboratories. Similar sorting for April 2012 to March 2013 was conducted for public research laboratories (e.g., national universities) and production floors (in private enterprises) to obtain 621 and 937 cases, respectively. Sampling of workroom air followed by capillary gas-chromatographic analyses for solvents was conducted in accordance with regulatory requirements. Results: More than one solvent was usually detected in the air of private laboratories. With regard to solvent types, acetone, methyl alcohol, chloroform and hexane were prevalently used in private laboratories, and this was similar to the case of public laboratories. Prevalent use of ethyl acetate was unique to private laboratories. Toluene use was less common both in private and public laboratories. The prevalence of administrative control class 1 (i.e., an adequately controlled environment) was higher in laboratories (both private and public) than production floors. Conclusions: Solvent use patterns are similar in private and public laboratories, except that the use of mixtures of solvents is substantially more popular in private laboratories than in public laboratories.

(J Occup Health 2014; 56: 393–398)

Key words: Organic solvents, Private research laboratories, Production floor, Public research laboratories

The use of organic solvents (referred to as solvents thereafter) is widespread not only on production floors in enterprises but also in public and private laboratories for testing, development and research. It may be the case that the practice of solvent use varies depending on the objectives of the laboratories. Thus, solvent use in laboratories affiliated with production facilities of enterprises may be more oriented, for example, to the testing of products and different from the use on the production floors1-3). It is further possible that the solvent use may not be similar between laboratories in industrial settings and those in public research facilities such as national or public universities4-6). Nevertheless, essentially no reports are available on solvent use in enterprise-run research facilities, although health effects of solvent use in laboratories have been reported, as to be detailed later. The present survey was initiated to investigate the types and use patterns (i.e., single or mixed) of solvents used in laboratories in private enterprises in comparison with those in public research laboratories and production floors.

Materials and Methods

Survey of solvent use in private laboratories

In the two-fiscal year period of April 2011 to March 2013, about 2000 unit workplaces utilizing solvents were surveyed in Kyoto prefecture and its surrounding areas in Japan, and the results were compiled as a database7,8). When testing and research laboratories were selected (after regulation-defined classification of...
activities, such as “testing and research”), 481 laboratories were identified (defined as unit workplaces according to the definition by regulations and guidelines9−12). Of the 481 laboratories, >90% of laboratories belonged to manufacturing companies, and the remaining belonged to independent enterprises (including medical facilities such as hospitals), respectively. For comparison purposes, the survey database for the period of April 2012 to March 2013 (i.e., one fiscal year) was sorted for cases of production floors (i.e., those other than laboratories) in private enterprises. In practice, 945 cases were available. Sorting of the same database for public research laboratories (e.g., those in national universities) gave 613 cases.

Solvents analyzed in workroom air

In practice, 47 types of solvents (7 solvents in Group 1 and 40 solvents in Group 2) were considered in accordance with regulations. The methods of sampling (with Tedlar bags) and analyses (by capillary gaschromatography) were as previously detailed elsewhere1−3, 6). Group 3 solvents were not taken into account, as they are natural solvent mixtures and do not fit with the gaschromatographic identification11, 13).

Statistical analyses

The \( \chi^2 \)-test was applied as necessary.

Results

Number of solvents in one unit workplace

The distribution histograms are shown in Fig. 1. With regard to the number of solvents detected in one unit workplace, more than one solvent was detected per laboratory room in most of the private laboratories [Fig. 1 (A)], which was in a sharp contrast to the cases of public laboratories [Fig. 1 (B)] where a single solvent was detected in most cases. The mode was 3 for the former, whereas it was 1 for the latter. When statistical evaluation by the \( \chi^2 \)-test was conducted for the difference in prevalence of single-solvent workplaces (in contrast to multiple solvent workplaces), the prevalence was significantly lower \((p<0.01)\) for private laboratories than for public laboratories. The difference between private laboratories and production floors was also significant \((p<0.01)\).

Number of staff or workers in one unit workplace

When the number of staff or workers in a unit workplace in private laboratories was depicted in a histogram [Fig. 2 (A)] in comparison with those in the other two groups [Fig. 2 (B) and (C)], it was interesting to note that the distribution was more or less similar in the three groups in the sense that the mode was 1 in all of three cases followed by gradual decreases as the number of subjects increased. This was rather contrary to expectations based on the different distributions in solvent numbers [Fig. 1 (A), (B) and (C)]. Nevertheless, the prevalence of unit workplaces with one staff member or worker was significantly lower \((p<0.01)\) by the \( \chi^2 \)-test in private laboratories than in public laboratories. There was no significant difference \((p>0.10)\) between private laboratories and production floors.

Fig. 1. Number of solvents in workroom air of laboratories and production floors

(A) Private laboratories. (B) Public laboratories. (C) Production floors. Note that the distribution does not follow a normal distribution. The median was 3 solvents in (A), 1 solvent in (B) and 3 solvents in (C).
Most common solvents

The top 15 most common solvents are shown in Table 1 for private laboratories, in comparison with those for public laboratories and for production floors. The most remarkable difference was the high prevalence of acetone and methyl alcohol, which was commonly found both in private (51 and 42% respectively) and in public laboratories (33 and 26%). Whereas methyl alcohol was also commonly used (34%) on production floors, use of acetone was less prevalent (22%). In a sharp contrast, use of toluene was quite prevalent on production floors (48%), but this multipurpose solvent\(^1\) was less frequently detected in private laboratories (20%) and even less so in public laboratories (10%). The same was also the case for isopropyl alcohol, which showed a low prevalence in private and public laboratories (27 and 12% respectively) in contrast to its high prevalence (42%) on production floors. The prevalence for chloroform was high in both types of research laboratories (18% and 18%) but quite low (out of the top 15 solvents) in production floors. Similarly, use of hexane was prevalent in private (34%) and public laboratories (14%) but less so on production floors (5%). Ethyl acetate was frequently used in private laboratories (39%) and on production floors (33%) but not often in public laboratories (11%).

Comparison of workroom conditions

When compared in terms of administrative control classes (ACCs\(^1\)), the distribution of classes for private laboratories was as follows: 98.3, 1.3, and 0.4% for ACC 1, 2, and 3, respectively. Those for public laboratories and production floors were 99.3, 0.4, 0.3%, and 83.8, 10.2 and 6.0%, respectively. The \(\chi^2\)-test revealed that the prevalence of ACC 1 did not show significant difference between the two types of laboratories (\(p>0.10\)), but there was a significant difference in prevalence between production floors and either of the two types of laboratories (\(p<0.01\) for both). It appeared that workroom conditions were better for both private and public laboratories than for production floors.

Discussion

To the best of the authors’ knowledge, the present study is the first systematic report on the solvent use in private research laboratories. It was made clear that the pattern of solvent use in private laboratories was similar to that in public laboratories in terms of the popular use of acetone and methyl alcohol. Relatively prevalent use of chloroform and hexane was also common to these two groups of laboratories. In contrast, toluene and isopropyl alcohol were less commonly used in private laboratories, whereas these two solvents were most commonly used on production floors (Table 1). More than one solvent was often detected in private laboratories, whereas single-solvent use was unique to public laboratories (Fig. 1), which may suggest that the risk of simultaneous exposure to multiple solvents is higher in private laboratories than...
in public laboratories, although the workroom environments were generally better than those of production floors; the proportion of ACC 1 (i.e., adequately controlled environment) was higher in laboratories than on production floors. It is known that such better work environments were achieved by extensive use of exhaust chambers in public laboratories, and the same situation appeared to have been achieved also in private laboratories.

Increasing attention has been focused on the safety of the laboratory environment. Based on a literature survey, information from 13 selected publications on types of solvents and possible health effects on laboratory staff and personnel has been summarized in Table 2. The health effects reported are various from neuromuscular Raynaud’s phenomenon to reproductive disturbances such as miscarriage and abortion. The description of the laboratories involved are generally brief and insufficient in most cases (with two exceptional cases) to make a clear identification of whether the laboratory studied was a research-oriented one or testing and development sections affiliated with production facilities. Detailed descriptions of solvents involved were provided in earlier reports, but simpler descriptions were provided in later reports. Information related to exposure prevalence by solvent types was available only in limited cases. Nevertheless, the use of chloroform may require attention because this solvent is commonly used in laboratories but only on rare occasions on production floors (Table 1). The descriptions of solvent application in histology laboratories would be expected to be simple because xylene, toluene or the combination of them would be the only solvents used in this field of study. Overall, therefore, it was not possible to examine if the observations as summarized in Table 1 could be confirmed through a literature survey.

There are several limitations in the present study. The study was based on sampling of laboratory air and analyses of solvent vapor concentrations, and no other relevant data were available. For example, the amounts of solvents or solvent mixtures used in the laboratories remained unknown. The use of exhaust chambers was considered to be adequate. This observation was, however, based on expert judgments at the time of visits to the laboratories, and no quantitative data on installation and operation were available. For example, the ventilation was, however, based on expert judgments at the time of visits to the laboratories, and no quantitative data on installation and operation were available.

In conclusion, private laboratories (mostly as testing and development sections affiliated with production facilities) share characteristics in common with public (research-oriented) laboratories in terms of the prevalent use of acetone, methyl alcohol, chloroform and hexane, and limited use of toluene and isopropyl alcohol. In the laboratory air, more than two solvents were often detected in private laboratories.
whereas only one solvent vapor was detected in the majority of public laboratories. Despite such differences in solvent use patterns, the work environments in laboratories (irrespective of private or public) were maintained generally adequately, being better than the conditions on production floors.

**Acknowledgments:** Thanks are due to the administration and our fellow staff at Kyoto Industrial Health Association for their interest in and support to this work.

**Conflicts of interest:** The authors declare that they have no conflicts of interest.

### References


