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The Spanish external quality assessment scheme for mercury in urine

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Summary. - In 1986 the Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT), established the "Programa interlaboratorios de control de calidad de mercurio en orina (PICC-HgU)". The operation of this scheme is explained, criteria for evaluation of laboratory performance are defined and some results obtained are reviewed. Since the scheme started, an improvement in the overall performance of laboratories has been observed. The differences in the analytical methods used by laboratories do not seem to have a clear influence on the results.

Key words: mercury, urine, quality assessment, Spain.

Riassunto *(Il programma spagnolo di valutazione esterna di qualità per la determinazione del mercurio nelle urine)*. - Nel 1986 l'Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT) ha promosso il "Programa interlaboratorios de control de calidad de mercurio en orina (PICC-HgU)". Vengono descritte le procedure operative dello schema, i criteri per la valutazione delle prestazioni dei laboratori e i risultati ottenuti. Da quando lo schema è iniziato è stato osservato un miglioramento nella perfomance globale dei laboratori. I differenti metodi analitici utilizzati dai laboratori non sembrano avere una chiara influenza sui risultati.

Parole chiave: mercurio, urine, valutazione esterna di qualità, Spagna.

Introduction

The Programa interlaboratorios de control de calidad (PICC) is an external quality assessment scheme (EQAS) organized by the Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT) in the field of occupational hygiene and medicine. The programme includes a series of single schemes for different elements and matrices: PICC-PbS (lead in blood), PICC-HgU (mercury in urine), PICC-VO (organic vapours), PICC-FA (asbestos fibres) and PICC-MET (metals in filters) [1]. The PICC-HgU was the second of these single schemes established by INSHT in Spain to test the proficiency of laboratories undertaking analyses in that field.

In 1980, mercury was chosen as a priority substance for risk assessment by the WHO working group on occupational exposure limits for heavy metals. This decision was based on the distribution, occurrence and frequency of exposure, ability of mercury to cause serious functional disorders, and the availability of sound scientific data derived from experimental and epidemiologic studies [2].

Due to its physico-chemical properties, mercury is not only a toxicological problem but also an analytical challenge. For these reasons, the INSHT made the decision to run an EQAS for the analysis of mercury in urine [3].

Status and aims

The PICC-HgU was designed as a proficiency testing scheme to provide laboratories with the means to plan their quality assurance, detect trends, and assess the performance of their analytical procedures.

After an experimental phase of 4 years the scheme started in 1986 with the participation of 20 laboratories. At the end of 1994 there were 52 participants, of whom half were Spanish, while the others were from Latin-American countries. The PICC-HgU is a voluntary scheme, open to any laboratory from any country. The financial support for the scheme is from the resources of INSHT and participation is free of charge.

At the moment, all the participants determine mercury by means of cold vapour-atomic absorption spectroscopy. Stannous chloride is used as the reducing agent by 57%

and 43% use $NaBH_4$. The field of activity of 34% of participants is occupational health and the remaining 66% includes hospital laboratories, universities and other work activities related with health, toxicology and environmental protection [4].

Operation of the PICC-HgU scheme

Preparation of samples

In order to have control samples as similar as possible to actual samples [5], a pool of human urine from subjects not-exposed to mercury is used to prepare the control samples. For each round three new batches are prepared.

The preparation of samples includes several steps. First of all, potassium persulphate is added to give an approximate concentration of 1 g/l in order to avoid degradation of urine. The pool of urine is kept overnight at 4°C, then filtered through an 8 µm membrane filter and spiked with mercury nitrate. The amount of mercury added currently ranges from zero to 300 µg/l, thus the final concentrations in the samples cover the range of values that cause most concern in occupational exposure to mercury [3, 4].

Afterwards, 20 ml aliquots are dispensed into 50 ml glass vials (free from contamination by mercury). The samples are frozen and lyophilized. At the end of the process, samples are vacuum sealed and then packed for distribution to the participating laboratories.

Lyophilization has been utilized for the preparation of the control samples since 1986. Lyophilised samples are stable for long periods without addition of other substances. These samples should be reconstituted with 20 ml of distilled water to give a clear sample ready for analysis.

Each batch of samples is previously analyzed for homogeneity. The coefficients of variation obtained were always below 4%. Therefore it is assumed that the variations in analyte loadings are small as compared to analytical errors.

Circulation of samples

Every two months each participant receives by mail three samples at different concentrations of mercury. Results are requested within thirty days, sent by mail, fax or by phone. Since at present the scheme is not used for laboratory accreditation and the participation is voluntary, the names of the participants are kept anonymous. Communication is maintained using a reference number for each participant and their analytical method.

Evaluation of results and performance indices

The first step in the evaluation of results is the calculation of the mean and the standard deviation (SD) of all the results submitted by laboratories for each sample. Results falling within ± 2 SD from the overall mean are considered as "accepted results".

In the second step, a target value is estimated for each sample. This is calculated as the mean of the results obtained by a group of laboratories that have achieved a good performance. In each round, the laboratories included in this group (reference group) are those who have obtained a mean variance index ≤ 90 (see below). The variability of the results for this reference group is clearly less than the variability for all results and even for the accepted results.

To provide a measure of the performance of individual laboratories two performance indices are used taking as a model the UK-external quality assessment scheme of the Queen Elizabeth Hospital [6]:

- the variance index (IV), calculated as the absolute percent deviation (E) of the result (X) returned by a participant from the target value (D), expressed as a percentage of a chosen coefficient of variation (CCV = 15%), i.e.:

$$IV = (E \times 100)/CCV$$

where

$$E = (|X - D| \times 100)/D$$

- the mean variance index (IVM) that is the mean of the last 10 IVs. The IVM is updated every time a result is returned.

In practice an IV =100 represents a deviation of 15% from the target value. At the same time, if the performance of a laboratory is improving, then the current IV will normally be less than the current IVM. Therefore the lower the IVM of the results of a laboratory the better its performance.

The calculation of performance indices naturally leads to the categorisation of the laboratories. In the PICC-HgU, laboratories who have IV and IVM over 90 show poor performance. Those laboratories who maintain their IVM between 90 and 50 can be considered as having an acceptable performance and those with IVM lower than 50 have a high level of performance.

Reports for the participants

Each participating laboratory is subsequently provided with a report which includes its performance indices and for each sample:

- the target value;
- the results submitted by the laboratories (in anonymous form);
- histogram of the results;
- the overall mean and the coefficient of variation of all results;

- the means and the coefficients of variation of all accepted results and of results categorised by analytical methods.

Results of the scheme

In each round returns are made by over 80% of the laboratories receiving samples. Only laboratories not yielding results regularly are excluded.

Since the scheme started, a tendency to the improvement in the overall performance of laboratories has been observed. A mean value of all IVMs < 100 has been recently reached. At the end of 1986 the mean of all IVMs was 125 whilst at the end of 1994 it was 97. This shows that a greater number of laboratories are now able to approach the target value in a single round.

The mean of the IVMs is used to evaluate the global performance of the scheme, although this parameter should not be the only information taken into account. Performance of an individual participant might have a not negligible influence on the global performance of the scheme, as evaluated by the mean of the IVMs. Reasons for such influences could be the different tendencies in the temporal trends of individual IVMs, and variations in the number of participants in the scheme.

Regarding the individual trends the following points can be noticed. A number of laboratories show a clear tendency to improve their IVM which is especially noticeable in the earlier period of their participation. Others, regardless of their IVM, maintain their value over a long time with more or less no variations. On the other hand, the number of laboratories who joined the scheme has slowly but continuously increased through the time.

The increase in the percentage of laboratories with an acceptable performance is an interesting observation to evaluate the performance of the scheme. In the PICC-HgU there has been a strong increase in the percentage of laboratories who are capable of maintaining not only an acceptable performance but a good performance, continuously, over one year. Thus during 1991 more than 40% of the laboratories have maintained their IVM below 90 as opposed to 14% in 1988. This means that more than 40% of laboratories achieve mean coefficients of variation ≤ 13.5% taking into account that the chosen coefficient of variation is 15% (see performance indices).

Nevertheless there are still laboratories who do not reach the standard required even though they are concerned with improving their results. This unfortunately leads us to think that the achievement of an acceptable performance could be a more serious problem for laboratories that do not participate in any scheme.

The differences in the analytical methods used by laboratories, reduction agent or sample treatment, do not seem to have a clear influence on the results.

In a near future chromium is to be included in this scheme by addition of a chromium compound to the same urine samples.

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Appendix. - Summary of the scheme

Country	Spain.
Name of scheme	Programa interlaboratorios de control de calidad - mercurio en orina (PICC-HgU).
Status of scheme	International, voluntary. Run by Instituto Nacional de Seguridad e Higiene en el Trabajo - (INSHT). *Aims:* to provide laboratories with the means to: plan their quality assurance; detect trends; assess the performance of their measuring procedures. *Participants* (1994): 52 laboratories (50% Spanish and the others from Latin American countries). Field of activity of 34% of participants is occupational health. The remaining includes hospital laboratories, universities and others with work activities related with health, toxicology and environmental protection.
Scheme description	*Control materials:* human matrix (urine); each batch of samples is prepared from a pool of urine from subjects not-exposed to mercury, to which mercury as nitrate is added; mono-elemental samples, in a short time chromium will be incorporated in the scheme, lyophilised in glass vials; a target value is estimated for each sample, this is calculated taking the mean of the results from a group of laboratories that have achieved a good performance for the last 10 samples, that is IVM ≤ 90. *Internal quality control samples*: not provided. *Organization of EQA exercises:* frequency of exercises: bimonthly, each participant receives 3 samples, the mercury content of which ranges from 20 to 300 µg Hg/l; distribution: by mail; time schedule for returning results: 30 days; methods of transmission of results: names of the participants are kept anonymous. Communication by mail or fax is maintained using a reference number for each participant and their analytical method. Elaboration of results: each participant receives his results and overall picture of all results, histogram, along with the "consensus mean", the "target value" and his performance indices. *Performance indices:* the variance index (IV), calculated as the absolute percent deviation (E) of the result (X) returned by a participant from the target value (D), expressed as a percentage of a chosen coefficient of variation (CCV = 15%), i.e.: IV = (E x 100)/CCV; E = ((X - D) x 100)/D; the mean variance index (IVM) that is the mean of the last 10 IVs. The IVM is updated every time a result is returned. Laboratories are considered to show: poor performance, if their IV and IVM are over 90; acceptable performance, when their IVM is between 50 and 90; high level of performance, when their IVM is lower than 50. *Measures taken against poor performance:* none. *Provision of advice and training*: none. *Financial support:* INSHT own resources. Participation is free of charges.
Organization	Olav Mazarrasa Gabinete Técnico Provincial de Seguridad e Higiene en el Trabajo - INSHT Avda. del Faro, 15 ES-39012 Santander, Spain
Analytes and matrices covered	Mercury in urine.