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Pre-analytical variables evaluation in laboratory tests of patients attended at the Vitória da Conquista Central laboratory, Bahia, Brazil

Avaliação de variáveis pré-analíticas em exames laboratoriais de pacientes atendidos no Laboratório Central de Vitória da Conquista, Bahia, Brasil

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ABSTRACT

Introduction: Laboratory tests are intended to provide information necessary to clarify diagnoses or specific situations that cannot be elucidated by other means. Laboratory analyses are subject to several interferences. Even healthy individuals could suffer variations in laboratory tests due to biological factors, which may lead to misinterpretation of the results. **Objective:** Assess the pre-analytical variables in patients' laboratory tests at the Vitória da Conquista Central Laboratory, Bahia, Brazil. **Material and method:** This is a cross-sectional study with a descriptive approach and the use of a questionnaire as a research instrument. Data were collected through individual interviews, carried out at the laboratory. **Results:** The sample consisted of 425 patients, with female predominance (76.5%). Regarding patient instructions for laboratory tests, 94.6% had not been given any previous guidance, and 68.5% used some kind of medication, which could produce alterations in the exams. The use of the antihypertensive agents captopril, enalapril, hydrochlorothiazide or propranolol was associated with increased serum urea [odds ratio (OR) = 7.2, confidence interval (CI) = 95%, 1.87-27.58; $p = 0.002$], and smoking was associated with increased red blood cells count (OR = 3.7, CI = 95%, 0.86-15.75; $p = 0.02$). **Conclusion:** The findings indicate that pre-analytical variables remain an important focus for attention to the clinical laboratory. The correct data collection of patients' conditions is critical to support the post-analytical phase with useful information for the production of reliable exams and serve as a useful interpretation to diagnosis.

Key words: pre-analytical variables; interference; laboratory examination.

RESUMO

Introdução: *Os exames laboratoriais têm como objetivo fornecer informações necessárias para o esclarecimento de diagnósticos ou situações específicas não passíveis de serem elucidadas por outros meios. As análises laboratoriais estão sujeitas a diversos interferentes. Mesmo indivíduos saudáveis podem apresentar variações nos exames decorrentes de fatores que podem gerar equívocos na interpretação dos resultados.* ***Objetivo:*** *Avaliar a influência de variáveis pré-analíticas em exames laboratoriais de pacientes atendidos no Laboratório Central do município de Vitória da Conquista, Bahia, Brasil.* ***Material e método:*** *Trata-se de um corte transversal com abordagem descritiva e utilização de questionário como instrumento de pesquisa. Os dados foram coletados por meio de entrevistas individuais, realizadas na instituição pesquisada.* ***Resultados:*** *A amostra foi composta por 425 pacientes, com predomínio de indivíduos do sexo feminino (76,5%). No que se refere a instruções para realização dos exames laboratoriais, 94,6% dos pacientes não receberam nenhum tipo de orientação prévia e 68,5% utilizavam algum tipo de medicamento que pode produzir alterações em exames. O uso dos anti-hipertensivos captopril, enalapril, hidroclorotiazida ou propranolol esteve associado ao aumento da ureia sérica [*odds ratio *(OR) = 7,2; intervalo de confiança (*IC*) = 95%, 1,87-27,58;* p *= 0,002]. O tabagismo associou-se ao aumento de eritrócitos (OR = 3,7; IC = 95%, 0,86-15,75;* p *= 0,02).* ***Conclusão:*** *Os achados indicam*

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que variáveis pré-analíticas são importante fonte de atenção para o laboratório clínico. A correta coleta de dados acerca das condições dos pacientes é fundamental para instrumentar a fase pós-analítica com informações relevantes para a produção de exames fidedignos e que sejam úteis ao processo do diagnóstico.

Unitermos: *variáveis pré-analíticas; interferência; exame laboratorial.*

RESUMEN

Introducción: *Las pruebas de laboratorio tienen como objetivo proporcionar información necesaria a la aclaración de diagnósticos o situaciones específicas que no se pueden esclarecer por otros modos. Los análisis de laboratorio están sujetos a diversos interferentes. Incluso individuos sanos pueden presentar variaciones en las pruebas derivadas de factores que pueden crear equivocaciones en la interpretación de los resultados.* ***Objetivo:*** *Evaluar la influencia de variables preanalíticas en pruebas de laboratorio de pacientes atendidos en el Laboratório Central de Vitória da Conquista, Bahía, Brasil.* ***Material y método:*** *Estudio transversal con enfoque descriptivo y empleo de cuestionario como herramienta de investigación. Los datos fueron recogidos mediante entrevistas individuales, realizadas en el establecimiento investigado.* ***Resultados:*** *La muestra se compuso por 425 pacientes, con predominio de mujeres (76,5%). En cuanto a instrucciones para realización de las pruebas, el 94,6% de los pacientes no recibieron ningún tipo de orientación previa y el 68,5% utilizaban algún tipo de medicamento que puede producir alteraciones en pruebas. El uso de los antihipertensivos captopril, enalapril, hidroclorotiazida o propranolol estuvo asociado con el aumento de la urea sérica [oportunidad relativa (OR) = 7,2; intervalo de confianza (IC) = 95%, 1,87-27,58;* p = *0,002]. El tabaquismo se ha asociado al aumento de eritrocitos (OR = 3,7; IC = 95%, 0,86-15,75;* p = *0,02).* ***Conclusión:*** *Los hallazgos clínicos indican que variables preanalíticas son importante causa de atención para el laboratorio clínico. La correcta recogida de datos acerca de las condiciones de los pacientes es esencial para instrumentar la fase postanalítica con información relevante para la realización de pruebas fiables y que sean útiles para el proceso del diagnóstico.*

Palabras clave: *variables preanalíticas; interferencia; prueba de laboratorio.*

INTRODUCTION

Laboratory tests have as their main objective to provide necessary information to confirm diagnoses or specific situations not likely to be clarified by other means. Data obtained by anamnesis must be always taken into account so that the yielded results are accurate[1].

The pre-analytical phase, object of this study, encompasses the step between ordering and conducting tests at a laboratory. According to Lippi *et al*. (2013)[2], the pre-analytical phase is responsible for more than two-thirds of laboratory errors. Hollensead *et al*. (2004)[3] reported that errors in the pre-analytical phase can account for 84.5% of total errors at a clinical laboratory.

The influence of pre-analytical variables can become insignificant, as one considers knowledge and observation of relevant information regarding patients, such as chronobiologic variation, gender, age, physical activity, fasting, use of medications, smoking, alcohol consumption and diseases such as diabetes and hypertension (HT), which can influence and affect the value of results for diagnosis. Because of that, such information must be considered in the pre-analytical step of the process and also in the post-analytical one, for validation of the obtained results[4-6].

Another source of variation in laboratory tests is pregnancy. That condition is associated with physiological and anatomical adjustments in women, which lead to marked changes in the mother's body in the composition of the humoral and formed elements of circulating blood. The knowledge of such changes is important to distinguish what is abnormal from reference ranges adjusted for pregnant women[7].

Among the requirements assessed in the pre-analytical phase, adequate fasting time stands out for blood collection. It is an important factor to consider, because it can influence reliability and interpretation of test results[8]. Nowadays there are no standardized protocols to prepare patients for laboratory tests. Besides, fasting definitions are largely heterogeneous among health professionals and also in the literature[9].

The Brazilian Society of Clinical Pathology/Laboratory Medicine (Sociedade Brasileira de Patologia Clínica/Medicina Laboratorial) published a report on the necessity of fasting for clinical tests. A meal can temporarily alter blood composition. Without this prerequisite, each test must be analyzed in the light of what the subject has ingested. The reference values used for those analytes and the risk assessments for cardiovascular diseases were obtained by means of studies carried out in fasting conditions, although recent recommendations bring the possibility of evaluating serum lipids without the adoption of this procedure[10].

The pharmaceuticals interference of in analytical determinations is also a frequent challenge in laboratory clinical practice[11]. Medicines administered in therapeutic doses, as well as their metabolites, can potentially, along with reagents or analytes, interfere in and alter laboratory tests results[12]. Many pharmaceuticals exert effects *in vivo* by a physiological mechanism (when the drug causes alterations at the body level) and *in vitro* (when a physical or chemical property of the drug interferes in the test reaction)[13]. Due to the easy acquisition of medicines and the of self-medication practice, the risk of interactions among several drugs and the probability of interference with the analytical methods used in the different laboratory tests can increase[14].

HT and diabetes *mellitus* (DM) are considered relevant public health problems. In elderly people, a prevalence of HT between 52% and 63% is estimated; DM affects around 8% of the population, although 50% of the diabetic populationis unaware of their diagnosis. The high prevalence of these conditions causes great cardiovascular risk, and pharmacotherapy has been widely used for treatment with multiple drugs, thus with stronger chances of interference in the tests. Therefore, it is necessary to screen situations in which medicines can interfere in both results of laboratory analyses and the diagnostic process[15-17].

OBJECTIVE

The objective of this article was to assess pre-analytical variables interference in laboratory test results and contribute to the development of strategies for prevention and reduction of laboratory tests errors.

MATERIAL AND METHOD

This is a cross-sectional study, of quantitative nature, with a descriptive approach and use of a semi-structured questionnaire of the National Research in Health (PNS)[18] – an adapted version for this study – that had been applied on individual interviews at the collection site in the participating institution. The study was carried out with patients attended in the Laboratório Central Municipal (LACEM) of Vitória da Conquista, Bahia, Brazil, from March to April 2017. That laboratory meets the demand of more than 80% of municipality tests from the Unified Health System (SUS).

The population estimated for planning this sample was obtained based on data produced by the laboratory, which cares for around 90 thousand patients a year, what corresponds to more than 500 thousand tests. For that population, a sample of 384 individuals was estimated (considering an increase of 10% for possible sample losses), amounting an n of 422 patients. In this calculation, the following were considered: a) hypothetical frequency of 50% due to the heterogeneous outcomes to be analyzed; b) unawareness of the frequency of the main outcome. Confidence limit of 5% and drawing effect of 1.

The following inclusion criteria defined eligibility for participation in the study: being an adult patient admitted to LACEM, from 7 a.m. to 12 noon; having gone through laboratory tests; accepting to participate in the research; signing the informed consent form. Patients that have only gone through urine and/or stool test or that in any moment did not agree to participate in the study were excluded.

The study was approved by the Research Ethics Committee of the Multidisciplinary Institute of Health of Universidade Federal da Bahia, under no. 1,938,158, from February 22, 2017. All the steps of this study followed the guidance of the resolution by Conselho Nacional de Saúde (CNS) 466/2012 and respected the ethical principles of beneficence and non-maleficence.

In the analyses of patients' laboratory results, the reference values employed in the laboratory studied were used. The used cut-off points can vary in comparison with other sources due to the different reference values that are adopted for diverse populations according to their characteristics (**Table 1**).

Patients' information was digitized at a spreadsheet in Microsoft Office Excel®, and the analyses were conducted in the statistical package Epi Info® version 7.2.0.1. The continuous variables were analyzed by means, median, mode and standard deviation (SD); the categorical variables, by simple frequency and proportion. A confidence interval (CI) of 95% was considered for assessing parameters of interest; and $p < 0.05$, for statistical significance. For univariate analysis of the association between categorical variables and outcome, the chi-square test was considered; for comparison of two groups in relation to continuous variables, Student's t test.

TABLE 1 – Laboratory tests used in the analyses and the reference values adopted at the LACEM of Vitória da Conquista, Bahia

Laboratory tests	Reference values
Erythrocytes (women)	4-5.2 (10^{12} l)
Erythrocytes (men)	4.5-5.9 (10^{12} l)
Hemoglobin (women)	12-16 g/dl
Hemoglobin (men)	13.5-17.5 g/dl
Leukocytes	4,000-10,000 mm^3
Glucose	60-99 mg/dl
Urea	17-43 mg/dl
Creatinine	6-1.3 mg/dl
GGT	9-64 U/l
Total cholesterol	Desirable: < 200 mg/dl
Triglycerides	Desirable: < 150 mg/dl

LACEM: Laboratório Central Municipal; GGT: gamma-glutamyltransferase.

RESULTS

During the studied period, 425 patients were interviewed. In this sample, there was predominance of females (76.5%), with mean ages of 46 years (SD = 16.3). Most of them had low educational attainment. Illiterates or those who did not finish primary school encompassed 32% of the sample, while 22.6% of the subjects had complete primary education.

The main self-reported diseases in the analyzed population were HT (40%), dyslipidemia (27.3%) and DM (12.9%). When assessing glycemia results, 30.9% of diabetic patients had poor glycemic control (data not demonstrated). We should mention that 50.1% of the patients reported having some type of chronic disease. When questioned about ethnicity, 78.3% declared not to be white (**Table 2**).

It must be observed that 17.8% of the interviewed women were pregnant. During pregnancy, it is common for changes to occur in analyte concentrations; that is why reference intervals must be specific for those patients. The number of leukocytes, for instance, increases considerably during pregnancy. The blood count of 44.7% of those pregnant patients presented increase of leukocytes, this being a statistically significant association ($p < 0.01$).

In **Table 3** some pre-analytical variables are listed that can be associated with interference in laboratory tests. In relation to smoking, 84.2% of the smoking patients declared to have smoked on the same collection day or on the previous day, and 16% presented increased number of erythrocytes, with this association being statistically significant [odds ratio (OR) 3.7; CI = 95%; 0.86-15.75; $p = 0.02$].

The average travel time of patients who walked to the laboratory (16.2%) was 18.32 minutes (SD = 16.8). Physical

TABLE 2 – Sociodemographic characteristics of patients from the LACEM of Vitória da Conquista, Bahia, in 2017

Variable		*n**	%
Age			
	< 60 years	342	80.5
	≥ 60 years	83	19.5
Sex			
	Female	325	76.5
	Male	100	23.5
Schooling level			
	Never studied/Incomplete elementary school	136	32
	Complete elementary school/Incomplete middle school	96	22.6
	Complete middle school/Incomplete high school	59	13.9
	Complete high school/Higher education	133	31.5
Ethnicity			
	Non-white	333	78.4
	White	92	21.6
Chronic disease			
	Yes	213	50.2
	No	212	49.8
Pregnant			
	Yes	58	17.8
	No	267	82.2

*LACEM: Laboratório Central Municipal; *n can vary between categories due to sample losses.*

TABLE 3 – Pre-analytical variables related to interference in laboratory tests of patients from the LACEM of Vitória da Conquista, Bahia, in 2017

Variable		*n**	%
Alcohol consumption			
	Yes	65	15.3
	No	360	84.7
Alcohol consumption on the previous day			
	Yes	8	12.3
	No	57	87.7
Smoker			
	Yes	38	8.9
	No	387	91.1
Tobacco use on collection day or on the previous day			
	Yes	32	84.2
	No	6	15.2
Physical activity			
	Yes	52	12.2
	No	373	87.8
Walking to the laboratory			
	Yes	69	16.2
	No	356	83.7
Adequate fasting time**			
	Yes	351	83.6
	No	74	17.4
Menopause			
	Yes	116	35.7
	No	209	64.3
Use of medications			
	Yes	291	68.5
	No	134	31.5

*LACEM: Laboratório Central Municipal; *n can vary between categories due to sample losses; **fasting time up to 14 hours.*

activity causes variations in the energetic needs of metabolism and can lead to a transient increase in glycemia, besides producing a physiological change that physical activity itself conditions. Patients with increased glycemia values demonstrated association with walking to the laboratory (OR = 2.03; CI = 95%; 1.14-3.64; $p = 0.01$) (**Table 4**).

TABLE 4 – Univariate analysis of interferents in laboratory tests of patients from the LACEM of Vitória da Conquista, Bahia, in 2017

Variable	Abnormal test (*n*)*	Normal test (*n*)*	OR (CI 95%)	*p* value**
Pregnancy				
Yes	21	26	0.2 (0.1-0.4)	0.000001
No	37	242	1	
Tobacco use				
Yes	36	2	3.7 (0.8-15.7)	0.02
No	321	66	1	
Means of going to the laboratory				
Walking	21	48	2 (1.1-3.6)	0.01
Public transport or car	63	293	1	
Menopause				
Yes	31	39	1.9 (1.1-3.5)	0.01
No	41	100	1	
Antihypertensive medication use				
Yes	8	112	7.2 (1.9-27.6)	0.002
No	3	302	1	

LACEM: Laboratório Central Municipal; OR: odds ratio*; *n can vary between categories due to sample losses; **statistical significance* – p < *0.05 in the chi-square test.*

Among the patients who participated in the study, 17.4% had inadequate fasting time, the minimum being one hour and 45 minutes; and the maximum, 20 hours and 10 minutes. Among the interviewed patients, 56.9% stated they did not receive any type of recommendation about the fasting time necessary for the test. Regarding the instructions for the conduction of laboratory tests, data pointed that 94.6% of the patients were not given any kind of previous guidance.

Menopausal women (38.7%) presented creatinine below reference values; however, no significant association was found. Despite this result, menopause is a condition associated with decreased creatinine levels. Besides, 43% of menopausal women presented high total cholesterol levels (OR = 1.9; CI = 95%; 1.1-3.5; $p = 0.01$). The result points to a close association between menopause and increase in cholesterol levels.

It was found that 68.5% of the patients used some type of medicine [antihypertensive agents stood out (captopril, enalapril, hydrochlorothiazide and propranolol)]. The use of those medicines was associated with the increase in urea levels (OR = 7.2; CI = 95%; 1.87-27.58; $p = 0.002$).

DISCUSSION

The pre-analytical variables have great impact upon the quality of laboratory results and can raise erroneous interpretations. When establishing the clinicolaboratorial correlation of results, one must bear in mind the possible alterations related to physiological variables, such as sex, age, ethnicity, and pregnancy[19].

HT is primarily treated with medications. In this study, patients who used some of these medications presented more chance to have increased urea levels (OR = 7.2; CI = 95%; $p < 0.05$). The effect brought about by the drug present in the sample to be analyzed produces analytical interference, that is, alteration of the correct result. Similar data were observed in the literature[13, 15]. This finding demonstrates the need to have knowledge on the use of patients' medications and, above all, prize the post-analytical phase with the verification of results by a trained analyst qualified to release the reports.

In the present study, smoking patients showed greater possibility to have a high erythrocyte count (OR = 3.7; CI = 95%; 0.8-15.7; $p = 0.02$). This increase can be explained by the high affinity of carbon monoxide with hemoglobin. As a result, the body increases erythrocyte production as a compensation, to increase availability of binding sites with oxygen. The extent of those effects is related to the number of cigarettes smoked and the amount of smoke inhaled[20, 21]. However, the number of cigarettes and the frequency of consumption were not the object of questioning of this research.

Another analyzed biological parameter was the hemoglobin mean of pregnant women (12.9 g/dl) and no-pregnant women (14.4 g/dl), a significant difference (statistical F = 30.4; $p < 0.001$) in the hemoglobin values mean between both groups. The results obtained by Lurie *et al*. (2000)[22] and Petraglia *et al*. (1994)[23] also showed a tendency for hemoglobin decrease in pregnant women. Normal gestation is associated with physiological adjustments; there is hemodilution by the increased plasma volume not accompanied by the expansion of erythrocyte mass. This change is necessary to supply the demand of the hypertrophied vascular system, as well as the enlarged uterus and the protection from the deleterious effects of fall in cardiac output. Because of that, reference values must be specific for this population and defined by gestational trimester[7, 24].

The number of leukocytes, especially because of neutrophils, increases considerably during a normal gestation, from 5,000/mm^3-7,000/m^3 to averages between 8,000/mm^3 and 16,000/mm^3. This increase in neutrophils ensures a safe development of the fetus, protecting it during the whole gestational period[7, 25].

Our results confirm these findings, because they present a positive association ($p < 0.05$) between gestational status and increased leukocyte count. Gebauer *et al*. (2005)[25] and Hangai *et al*. (2003)[26] also reported similar results.

This study demonstrated that 96.4% of the patients allegedly were not provided with any type of guidance prior to tests. The lack of previous guidance increases the chances of inadequate conditions for test conduction and, consequently, higher chances of interference. Still about this issue, 17.4% of the subjects had a prolonged fasting time (over 14 hours), and 68.5% used medicines; 8.9% declared themselves smokers and, among these, 84.2% smoked on the collection day or on the previous day.

Those pieces of information must be registered so that the interferences that appear from the altered test results do not lead to errors in result interpretation or unnecessary repetitions, resulting in a new collection.

It took patients who walked to the laboratory around 18.32 minutes to get there. This walking can be considered a light physical activity. The effect of physical activity on some blood components is generally transient and depends on the mobilization of water and other substances among the different body compartments. The arteriovenous difference in the concentration of glucose increases due to a greater tissue demand for glucose[19]. Those patients also demonstrated significant association with altered glycemic values (OR = 2.03; CI = 95%; 1.14-3.64; $p = 0.01$). However, the analysis became limited because of the influence of other factors, as being diabetic or using medicines that can influence glycemia. A percentage of patients known to be diabetic (30.95%) had poor glycemic control; besides, part of those patients with altered glycemia can be of undiagnosed diabetic people, as approximately 50% of the population with diabetes do not know they are sick and many times remain undiagnosed until signs of complications appear[16]. It is worth highlighting that 28.2% of the patients associated hydrochlorothiazide and first generation beta-blockers, such as atenolol and propranolol. The use of such drugs in association can contribute to the onset of diabetes, causing intolerance to glucose[15]. This contingent can also contribute to patients with poor glycemic control.

The sociodemographic profile of the studied patients was similar to those published in the Brazilian literature. There was a women predominance, who, as a rule, use health services more frequently[27, 28].

The study presented limitations regarding fasting analyses and interferences in laboratory tests, because just 1.8% of the interviewed patients did not meet the minimum of eight hours of fast. Most of the interviewed patients reported that, even without having been offered guidance, had knowledge that it was necessary to be in fasting to go through the test.

So that laboratory test result becomes a reliable and useful information for a diagnosis, monitoring and staging or prognosis of a disease, it needs to be analyzed carefully and be sufficiently assessed in different populations within statistical methods or methods of reliable references, to provide an interpretation of results that are possible and useful for clinical practice[29].

It is important to highlight that food ingestion triggers several physiological responses that can affect blood biochemical markers. Lima *et al.* (2012)[30] and Lippi *et al*. (2010)[31] demonstrated variability higher than the acceptable for many tests, such as blood count, albumin, bilirubin, phosphorus, calcium, magnesium, and potassium, in healthy volunteers who had their blood collected after a light breakfast.

Patients' definition of color or presumption of ethnicity is not something easy, especially in Brazil, due to the high degree of miscegenation, thus poor precision exists in the identification of black, brown, white, yellow, or indigenous people[32]. The total protein serum concentration, for example, is known for being higher in blacks than in whites, as well as the activity of creatine kinase (CK) and lactate dehydrogenase (LDH), an effect related with the amount of skeletal muscle, which tends to be larger in blacks[32, 33]. We chose not to conduct analyses in that perspective, because ethnicity was self-reported, with predominance of non-whites; besides, the conduction of CK tests in the studied groups was minimal. We stress the fact that information being self-reported brings limitations to the presented results.

Phillips *et al.* (2000)[34] studied the mobilization of neutrophils of the marginated granulocyte pool in healthy volunteers of different ethnic origins to investigate the cause of ethnic neutropenia. Black patients mobilized significantly less neutrophils in response to exercise. These variations could not be assessed in this study, because it is difficult to differentiate if the effects in laboratory tests come from race or social economic conditions, as well as it is difficult to determine patients' ethnicity.

The consequences of laboratory errors or inadequacies in the process can, many times, be serious, especially when the laboratory test is used in the establishment of a diagnosis. Interferences can produce errors that create false positive results, false negative ones or even inadequate interpretations due to pre-analytical alterations not taken into account in the analysis or clinical decisions. Both circumstances jeopardize patients' health and produce unnecessary costs for the health system[35].

CONCLUSION

The findings indicate that pre-analytical variables continue being an important source of attention for the clinical laboratory. The present study demonstrated elevated frequency of patients who had not been given any type of previous guidance for the conduction of the laboratory test, and there are several circumstances that bring alterations in the tests.

The correct collection of data on patients' conditions is fundamental to supply the post-analytical phase with useful information for the production of reliable tests and their coherent interpretation, contributing to the establishment of a correct diagnosis and the monitoring of diseases. The professionals involved in receiving and collecting blood must be duly trained for collection of information on pre-analytical conditions (exercises, fasting, diet, alcohol consumption, smoking habit, medical indication, medicines in use), besides the situation of each patient, as gestation and menopause, which can be associated with alterations in some laboratory tests due to biological factors, pre-analytical and/or methodological, as demonstrated in this work and in the specialized literature.

A team well-trained for the collection of information on conditions previous to laboratory tests and their application at the moment of interpreting alterations associated in laboratory tests contributes decisively to the ensured quality in clinical laboratories.

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CONFLICT OF INTERESTS

The authors declare there are no conflicts of interests.

REFERENCES

1. Maksoud JG. O uso inadequado dos exames complementares. Rev Pediatria. 1995; 17(1): 3-4.

2. Lippi G, Becan MK, Behúlová D, et al. Pre analytical quality improvement: in quality we trust. Clin Chem Lab Med. 2013; 51(1): 229-41.

3. Hollensead SC, Lockwood WB, Elin RJ. Errors in pathology and laboratory medicine: consequences and prevention. J Surg Oncol. 2004; 88(1): 162.

4. Lippi G, Guidi GC, Mattiuzzi C, Plebani M. Pre analytical variability: the dark side of the moon in laboratory testing. Clin Chem Lab Med. 2006; 44(4): 358-65.

5. Brasil. Ministério da Saúde. Resolução RDC 302, de 13 de outubro de 2005a. Diário Oficial da União de 14 de outubro de 2005. Available at: http://www.mte.gov.br/legislacao/Portarias/2005/p_20051111_485. pdf.

6. Dalpino FB. Caracterização e ritmos biológicos de parâmetros bioquímicos séricos em uma população brasileira. [thesis]. Universidade Estadual de Campinas, Faculdade de Ciências Médicas; 2005.

7. Souza AI, Filho MB, Ferreira LOC. Alterações hematológicas e gravidez. Rev Bras Hematol Hemoter. 2002; 24(1): 26-36.

8. Oliveira CF, Fernandes TRL. Analysis of the pre-analytical phase in a private pathology laboratory of Maringá city-PR, Brazil. J Bras Patol Med Lab. 2016; 52(2): 95-100.

9. Simundic AM, Cornes M, Grankvist K, Lippi G, Nybo M. Normalização dos requisitos de recolha de amostras em jejum: para o grupo de trabalho sobre pré-analíticas Fase (WG-PA) da Federação Europeia de Química Clínica e Medicina Laboratorial (EFLM). Clin Chim Acta. 2014; 432(1): 33-7.

10. Recomendações da Sociedade Brasileira de Patologia Clínica/ Medicina Laboratorial (SBPC/ML): necessidade de jejum para coleta de sangue para a realização de exames laboratoriais. 2016; 1. Available at: http://www.sbpc.org.br/?C=2777.

11. Kroll MH, Ellin RJ. Interference with clinical laboratory analyses. Clin Chem. 1994; 41(5): 1996-2005.

12. Catrou LLC. Uso racional de medicamentos: conceitos, estratégias e perspectivas no Brasil. Rev Racine. 2000; 18(102): 64-74.

13. Ferreira BC, Santos KL, Rudolph SC, Alcanfor JDX, Cunha LC. Estudo dos medicamentos utilizados pelos pacientes atendidos em laboratório de análises clínicas e suas interferências em testes laboratoriais: uma revisão da literatura. Rev Eletrônica Farmácia. 2009; 6(1): 33-43.

14. Martinello F, Silva EL. Interferência do ácido ascórbico nas determinações de parâmetros bioquímicos séricos: estudos in vivo e in vitro. J Bras Patol Med Lab. 2003; 39(4): 323-34.

15. Souza AS, Santiago EC, Almeida LC. Interferências nos exames laboratoriais causados pelos anti-hipertensivos usados no Brasil. Rev Eletron Atualiza Saúde. 2016; 3(3): 101-13.

16. Brasil. Ministério da Saúde. Secretaria de Políticas de Saúde. Departamento de Ações Programáticas Estratégicas. Caderno de Atenção Básica Série A. Normas e manuais técnicos nº 16: diabetes mellitus. Departamento de Atenção Básica. Brasil: Ministério da Saúde; 2006. p. 29-44.

17. Dias JCR, Campos JADB. Diabetes mellitus: reasons for prevalence in different geographic regions of Brazil, 2002-2007. Ciênc Saude Colet. 2012; 17(1): 239-44.

18. Pesquisa Nacional de Saúde (PNS). 2013. Available at: http://www.pns.icict.fiocruz.br/index.php?pag=proposicao.

19. Sumita NM, Barbosa I, Andriolo A, et al. Recomendações da Sociedade Brasileira de Patologia Clínica/Medicina Laboratorial para coleta de sangue venoso. 1 ed. Comitê de Coleta de Sangue da SBPC/ML e BD Diagnostics – Pre analytical Systems; 2005.

20. Nunes E. Consumo de tabaco: efeitos na saúde. Rev Portuguesa de Clínica Geral. 2006; 22(1): 225-44.

21. Camargo TM, Rocha-Junior DS, Ferreira SR, et al. Influência do tabagismo sobre as análises laboratoriais de rotina: um estudo piloto em adultos jovens. Ciênc Farm Básica. 2006; 27(3): 247-51.

22. Lurie S, Mamet Y. Red blood cell survival and kinetics during pregnancy. Eur J obstet Gynecol Reprod Biol. 2000; 93(2): 185-92.

23. Petraglia B, Pessoa LGS, Rezende JF, Chaves HN, Montenegro CAB. Avaliação dos valores eritrocitários no ciclo grávido-puerperal. J Bras Ginecol. 1994; 104(5): 139-44.

24. Dani C, Rossetto S, Castro SM, Wagner SC. Prevalência da anemia e deficiências nutricionais, através de diferentes parâmetros, em mulheres grávidas atendidas em dois serviços de saúde pública no Rio Grande do Sul. RBAC. 2008; 40(3): 171-5.

25. Gebauer DLP, Bertholo LC. Alterações hematológicas e dos níveis de ferro sérico em gestantes do Centro Municipal de Saúde de Ijuí (RS). Infarma. 2005; 17(7/9): 64-9.

26. Hangai MM. Estudos dos parâmetros laboratoriais do hemograma de gestantes, através da comparação com o hemograma de pacientes não gestantes, no município de São José, na Grande Florianópolis. Laes Haes. 2003; 143(1): 116-38.

27. Pinheiro RS, Viacava F, Travassos C, Brito AS. Gênero, morbidade, acesso e utilização de serviços de saúde no Brasil. Ciênc Saúde Coletiva. 2002; 7(4): 687-707.

28. Gomes R, Nascimento EF, Araújo FC. Por que os homens buscam menos os serviços de saúde do que as mulheres? As explicações de homens com baixa escolaridade e homens com ensino superior. Cad Saúde Pública. 2007; 23(3): 565-74.

29. Ferreira C, Andriolo A. Intervalos de referência no laboratório clínico. J Bras Patol Med Lab. 2008; 44(1): 11-6.

30. Lima GO, Salvagno GL, Lippi G. Influence of a regular, standardized meal on clinical chemistry analytes. Ann Lab Med. 2012; 32(4): 250-6.

31. Lippi G, Lima OG, Salvagno GL, et al. Influence of a light meal on routine haematological tests. Blood Transfus. 2010; 8(2): 94-9.

32. Gonzalez LR, Camata CNM, Azevedo VAZ, Kitamura S. Neutropenia étnica na prática da medicina do trabalho. Rev Bras Med Trab. 2010; 8(1): 47-52.

33. Burtis CA, Ashwood ER. Tietz: fundamentos de química clínica. 6 ed. Rio de Janeiro: Guanabara Koogan; 2008.

34. Phillips D, Rezvani K, Bain BJ. Exercise induced mobilization of the marginated granulocyte pool in the investigation of ethnic neutropenia. J Clin Pathol. 2000; 53(6): 481-3.

35. Lippi G. Governance of pre-analytical variability: traveling the right path to the bright side of the moon? Clin Chim Acta. 2009; 404(1): 32-6.

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