

QualIM[®]: a software for training in the reading of digital medical images*

QualIM[®]: software para treinamento na interpretação de imagens médicas digitais

Silvio Ricardo Pires¹, Regina Bitelli Medeiros², Simone Elias³

Abstract **OBJECTIVE:** A software called QualIM[®] – Qualificação de Imagens Médicas was developed for training of practitioners in the interpretation of digital mammograms classified according to BI-RADS[®] categories, utilizing images manipulation tools on state-of-the-art displays. **MATERIALS AND METHODS:** A Delphi 7-based system stores data resulting from mammographic findings interpretation during the training, comparing them with a golden-standard data set. The database includes computed radiography, direct radiography and digitized images. The software converts computed radiography and direct radiography images into TIFF format, preserving their original spatial and contrast resolution. During the training, the images are manipulated with the aid of the software tools (zoom, inversion, digital rulers and others). Depending on the image complexity, up to eight mammographic views, six ultrasonography images and two anatomopathological images can be displayed. **RESULTS:** The training was initiated in 2007 and is currently included in the radiology residency program. Based on data entered by the practitioner, the software automatically generates a BI-RADS compliant text that is compared with a database. **CONCLUSION:** The QualIM software is a digital educational tool aimed at assisting practitioners in the recognition of visual patterns on mammographic images as well as in the interpretation of mammograms based on the BI-RADS classification.

Keywords: Training; Digital mammography; Displays.

Resumo **OBJETIVO:** Foi desenvolvido um *software* denominado QualIM[®] – Qualificação de Imagens Médicas para treinamento de profissionais na interpretação de exames digitais de mamografias utilizando ferramentas de manipulação de imagens, em monitores específicos, classificadas em BI-RADS[®]. **MATERIAIS E MÉTODOS:** O sistema, desenvolvido em Delphi 7, armazena as respostas da interpretação de imagens mamográficas durante o treinamento e compara aos dados inseridos denominados “padrão-ouro”. O sistema contém imagens de *computed radiography*, *direct radiography* e digitalizadas. O *software* converte as imagens do *computed radiography* e *direct radiography* para o formato TIFF, mantendo as resoluções espacial e de contraste originais. Profissionais em treinamento manipulam o realce da imagem utilizando ferramentas de *software* (*zoom*, *inversão*, *régua digital*, *outras*). Dependendo da complexidade, são apresentadas até oito incidências mamográficas, seis imagens de ultra-som e duas de anatomopatológico. **RESULTADOS:** O treinamento iniciou em 2007 e atualmente faz parte do programa de residência em radiologia. O *software* compõe o texto, de forma automática, das informações inseridas pelo profissional, baseado nas categorias BI-RADS, e compara com a base de dados. **CONCLUSÃO:** O *software* QualIM é uma ferramenta digital de ensino que auxilia profissionais no reconhecimento de padrões visuais de uma imagem mamográfica, bem como na interpretação de exames mamográficos, utilizando a classificação BI-RADS.

Unitermos: Treinamento; Mamografia digital; Monitores.

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INTRODUCTION

Digital mammography can already be considered as a reality. However, images interpretation with the aid of software tools presents itself as a paradigm, requiring from practitioners a certain level of knowledge about digital image properties. It is possible that this fact explains the Food and

Drug Administration (FDA) recommendations on the need of a minimum eight-hour training on interpretation of digital images for specialists⁽¹⁾.

A key tool utilized for understanding the digital image properties is the histogram of the image itself, as this tool clarifies the physical properties of enhancement for the identification of simulated structures. The histogram of an image shows the distribution of gray levels on the image. The higher the number of levels in the gray-scale, the

* Study developed at Laboratório de Qualificação de Imagens Médicas (QualIM) – Department of Imaging Diagnosis at Universidade Federal de São Paulo/Escola Paulista de Medicina (Unifesp/EPM), São Paulo, SP, Brazil.

1. PhD, MD, Physicist at Laboratório de Qualificação de Imagens Médicas (QualIM) – Department of Imaging Diagnosis at Universidade Federal de São Paulo/Escola Paulista de Medicina (Unifesp/EPM), São Paulo, SP, Brazil.

2. PhD, Professor, Head for Coordination of Medical Physics at Universidade Federal de São Paulo/Escola Paulista de Medicina (Unifesp/EPM), São Paulo, SP, Brazil.

3. PhD, Post-Doctorate Research Fellow, Fundação de Amparo à Pesquisa do Estado de São Paulo (Fapesp), São Paulo, SP, Brazil.

Mailing address: Dr. Silvio Ricardo Pires. Rua Mirassol, 313, Vila Clementino. São Paulo, SP, Brazil, 04044-010. E-mail: silvio@cfr.epm.br

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greater is the possibility of manipulating the image contrast in a soft way, enhancing the structures of interest with higher accuracy.

By utilizing preprocessing tools one can change the contrast and brightness of an image, and, in such a manner manipulating the information of the image matrix that forms the histogram. The contrast resolution has direct influence on the image quality. Considering that the physical dimensions of a mammographic image are fixed, and that a digital image is formed pixel by pixel, one can therefore say that spatial resolution also has a direct influence on the quality of a mammography. The larger the image matrix, the smallest is the size of the pixel. Consequently, it is possible to identify smaller objects with higher accuracy and without any marked distortion⁽²⁾.

One way to assess practitioners performance in relation to the response of detectability of structures visualized on a digital image is the application of kappa statistics, which allows the determination of the agreement between findings and the actual position of such structures, through simulated images. The kappa values can be determined by equation 1.

$$k = \frac{\sum_{i=1}^g \frac{F_{ii}}{N} - \sum_{i=1}^g \frac{R_i C_i}{N^2}}{1 - \sum_{i=1}^g \frac{R_i C_i}{N^2}}$$

Equation 1 Determination of kappa values.

where: F_{ii} corresponds to the argument numbers by category; R_i and C_i correspond to the sum of the lines and columns of the categories; N corresponds to the sum of all categories.

Individual preferences or subjectivity in the images interpretation seem to affect the specificity and sensitivity for detection of lesions; however the utilization of specific tools for image manipulation may contribute to make these factors less significant in the process of breast cancer diagnosis^(1,3).

Quality assurance in the different phases of imaging diagnosis process constitute a real concern for official agencies and specialists that currently face the challenge of utilizing digital technologies aimed at the interpretation of mammographic images.

Detectability will be reliant to a significant degree on the adoption of appropriate quality assurance programs, i.e., the application of processes and procedures in the area of imaging diagnosis providing training and capacitation for the practitioners involved.

The introduction of digital mammography in the clinical practice requires specific training for mastering such resources, allowing the specialist to make the most from the recognized advantages of digital systems⁽¹⁾. Perhaps the digital systems will minimize the individual preferences and subjectivity in image interpretation and will play a role in the specificity and sensitivity for detection of lesions⁽⁴⁾.

According to FDA recommendations, the interpretation of mammographic images should be performed on a 14 bits/pixel display, with 5.0 megapixels. However, there are lower-cost displays currently in use that do not meet these specifications^(1,5). How can the display parameters affect breast lesions detectability? This is a matter that is yet to be clarified, and has motivated studies proposing comparisons of practitioners performances in the detection of signs on digital images while using different visualization devices⁽⁶⁾.

The practitioner's experience is one of the factors affecting the diagnostic accu-

racy. Clinical training in this type of imaging modality is essential for early detection of malignant tumors and reduction of false-positive results⁽⁷⁾.

The present study is aimed at applying a specific tool for training practitioners (radiologists, mastologists, residents in radiology, among others) in the interpretation of digital mammographic images allowing the recognition of an appropriate standard for diagnosis of images according to BI-RADS[®] categories.

MATERIALS AND METHODS

A Delphi 7-based software called QualIM[®] – Qualificação de Imagens Médicas (Qualification of Medical Images) has been developed to manage a MS-SQL Server 2000 database. The main role of the software is the storage of reports reflecting BI-RADS categories, resulting from training in the interpretation of mammographic images. The software has been designed for the maintenance of information stored in a database only accessible by means of an administrative password. Figure 1 shows the access interface for the training in digital images interpretation.

The software has been developed for training in workstations equipped with displays specific for mammography, with up

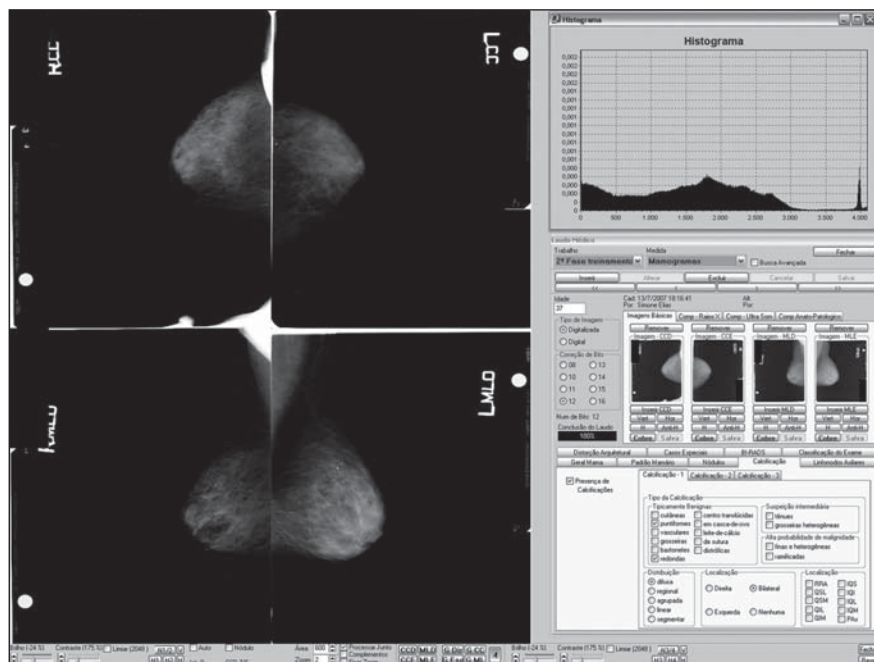


Figure 1. Training interface in the interpretation of mammographic images.

to 5.0-megapixel resolution and 14 bits/pixel in a gray-scale, namely Barco model MFGD5421 and Clinton model DL-3000.

The database system is compatible with computed radiography (CR), direct radiography (DR) or conventional radiography (films) images digitalized with a Lumiscan 75 laser scanner (Lumisys, Inc.; Sunnyvale, USA) in TIFF format with 12 bits/pixel. All the DICOM digital images collected in DVD, without data compression, and with spatial resolution above 5.6 Mp (> 2,560 × 2,048 pixels matrix).

The database currently comprises 436 cases classified into BI-RADS categories, and the distribution is demonstrated on Figure 2.

The software has a tool that converts DICOM CR and DR images into TIFF images, with the possibility of preserving the original spatial and contrast resolutions. The images originate from different units and were submitted to double interpretation by experienced specialists in mammography. Input of copies of these images and respective reports is made by an experienced specialist in digital systems, who performs the third interpretation of the images, generating a database referred to as a “golden standard”.

The access to the radiological images is achieved by means of a specific menu, the QualIM software being adapted for the exhibition of mammographic images with up to eight projections, the main ones being craniocaudal, medial-lateral (left and right) and supplementary images. Depending on the case complexity, up to six sonographic images and two anatomopathological results can be visualized.

The first phase is based on the training in images manipulation employing a software with simulated breast images, where the practitioner learns, by means of the histogram manipulation, the main visual image patterns for enhancement of suspicious structures. In this phase the tools that guide the practitioner in the manipulation of the histogram by means of contrast and brightness controls, are introduced. The software provides numerical data for aiding in the decision making for an effective enhancement of the structure. The training tool includes resources such as image rotation (clockwise and counter clockwise), image

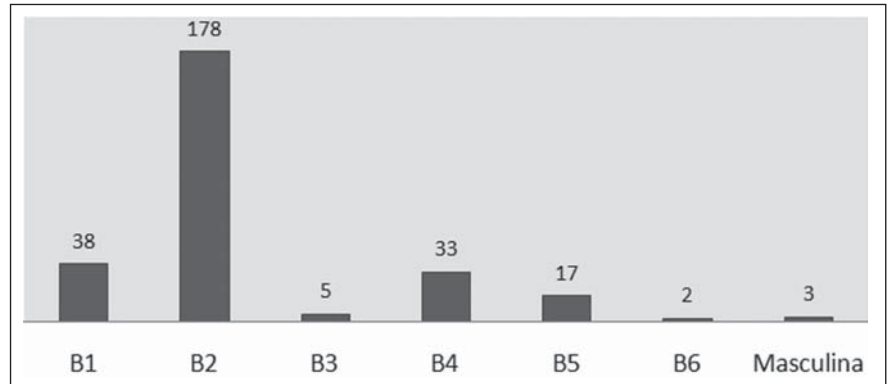


Figure 2. Distribution of cases fed into the database for training.

mirroring, zoom, and a ruler for measuring nodules or other structures of interest.

The next phase consists of the training in images interpretation according to BI-RADS categories. In this phase, a tool that automatically manipulates the histogram enhancement is introduced allowing the user to make fine adjustments based on the previously acquired concepts. The practitioner performs the interpretation of the image utilizing all the concepts included in the fourth edition of BI-RADS published by the American College of Radiology. The practitioner responses agreement, as well as the time spent in the images interpretation are recorded. The reports data are stored in a specific interface, capable of a 99% coverage of all the BI-RADS concepts. A specific resource has been built into the software by which, for every access

of the practitioner to the training system, new cases amongst the BI-RADS categories are presented, exposing the practitioner to a diversity of cases with different degrees of complexity.

Figure 3 shows an example of the training interface. At left, a right medial-lateral view demonstrating an enhanced structure of interest and with the digital ruler over the magnified area. At right, a left medial-lateral view without any enhancement manipulation of the image.

Figure 4 shows the description of a report stored in the database considered as the golden-standard for evaluation of mammographic images. A feature has been implemented to automatically show the report based on the data entered by the practitioner during the images interpretation according to BI-RADS categories.

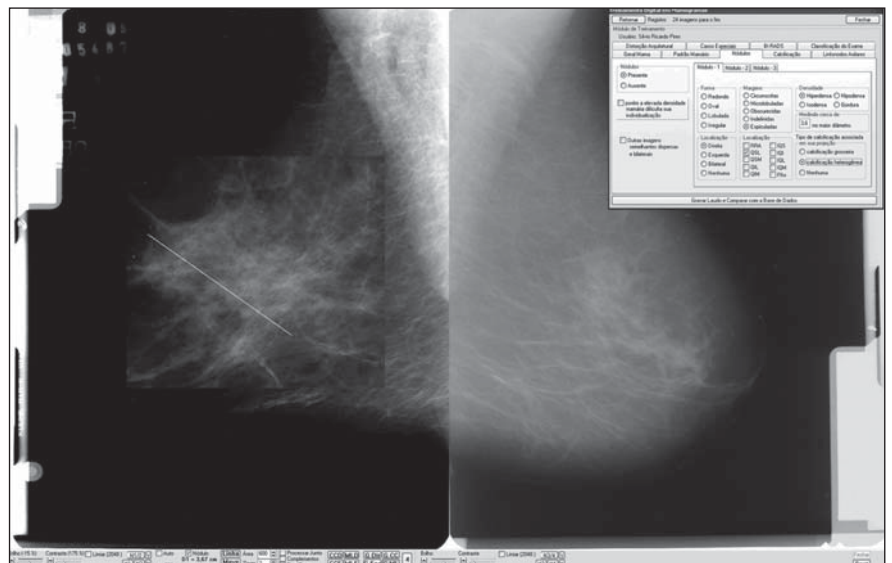


Figure 3. Representation of images analysis during training.

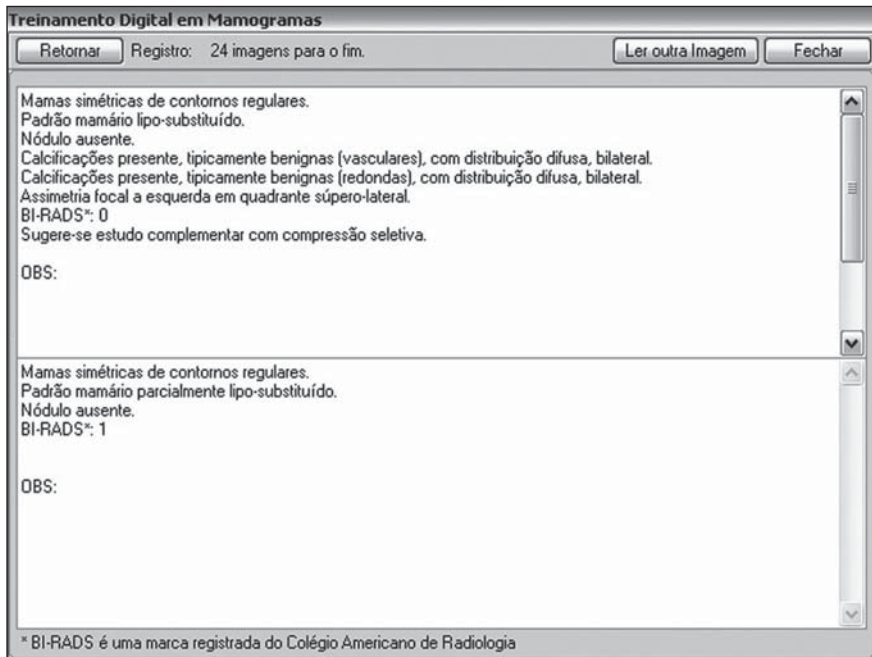


Figure 4. Interface for evaluation of mammographic images.

Once the evaluation is completed, the practitioner can investigate any information of interest.

Six specialists were trained. The training started in 2007 and currently it is a part of the program of residency in radiology.

RESULTS

The overall results from both the simulated mammographic image manipulation and analysis of mammographic images classified according to BI-RADS categories demonstrate that the practitioners im-

proved both in detectability of structures as well as in the time required for detection. Figure 5 presents their performance in the detection of signs on digital systems. The graph demonstrates mean kappa values and mean time spent in the interpretation of simulated breast images. The initial kappa value was 0.64, with mean interpretation time of 4 minutes and 50 seconds, and the final result was 0.72 for kappa, with mean interpretation time of 4 minutes. The vertical axis at left represents the kappa values evolution for kappa, and the vertical axis at right represents the time in minutes.

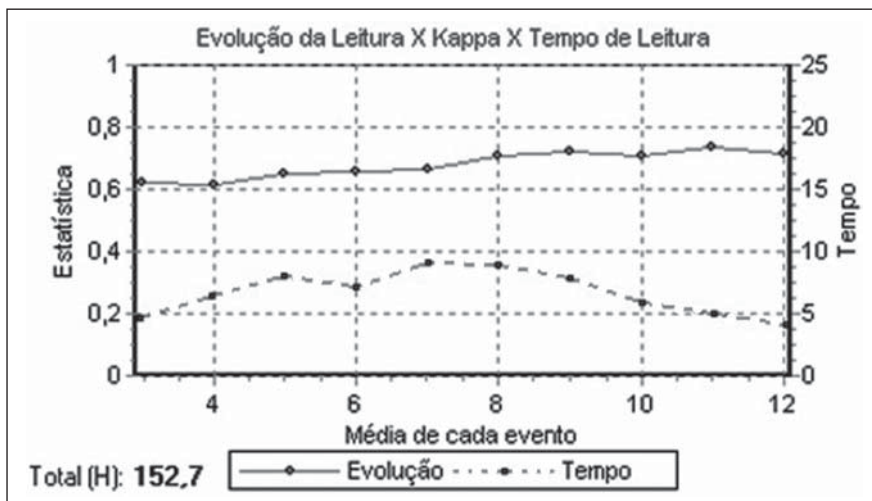


Figure 5. Progress of the specialist in the evaluation of the digital image.

The database developed in the present study comprises clinical cases in all BI-RADS categories, originated from conventional mammography units (with digitalized images) and digital units (CR and DR images) from different centers, which increases the recognition of visual patterns for the training of practitioners.

DISCUSSION

The QualIM database presents the advantage of comprising clinical cases classified into all BI-RADS categories, originated from both conventional and digital mammography units installed in different centers. This allows the practitioner to be trained for the recognition of visual patterns on CR, DR and digitalized images. The dynamics in the data storage exposes the practitioner to a diversity of cases in different levels of complexity, supplemented by other imaging modalities such as ultrasonography and anatomopathological studies. The advantage of the QualIM software is that it allows the importation and conversion of DICOM images generated by the different systems (CR – Agfa, Kodak and Fuji, and DR – Lorad, Siemens, General Electric) into TIFF files, preserving both the images' spatial and contrast resolutions⁽⁸⁾.

The selection of cases according to their complexity allowed by the software adjusts the level of the training to the level of professional experience. Some current training softwares^(1,8,9) that rely exclusively on phantom images, which generates a certain degree of discouragement in the practitioners as the training progresses. The differential in this training model consists in the evaluation of clinical cases classified into BI-RADS categories, enhancing the standardization of the language adopted for the images interpretation⁽¹⁰⁻¹²⁾. Additionally it can be made with or without tutoring, and the progress in training is based on individual performance.

The interpretation of images on workstations displays has been comprehensively studied^(3,13) with the objective of evaluating the practitioner's performances in the interpretation of images as compared with the conventional system (printed films)⁽¹³⁾. Studies have concluded that the interpreta-

tion of images on video monitors is well accepted, the specialist's adaptation is rapid, and no significant difference has been found in the accuracy and speed of interpretation between the conventional method (printed film) and soft-copy display, provided the practitioner is appropriately trained^(14,15).

The training was developed in compliance with the minimum FDA⁽⁵⁾ requirements regarding workstation monitors spatial and contrast resolution, besides luminance and appropriate environment^(1,5).

CONCLUSION

The QualIM software is an effective tool for education in digital systems, as it assists the practitioner in the recognition of the correct visual patterns of mammographic images by means of image histogram manipulation, allowing the training in the interpretation of mammographic images according to the BI-RADS classification with greater efficiency in the detection of findings, in less time.

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REFERENCES

1. Pisano ED, Cole EB, Kistner EO, et al. Interpretation of digital mammograms: comparison of speed and accuracy of soft-copy versus printed-film display. *Radiology*. 2002;223:483–8.
2. Gonzales RC, Woods RE. *Processamento de imagens digitais*. São Paulo: Edgard Blücher; 2000.
3. Pisano ED, Gatsonis C, Hendrick E, et al. Diagnostic performance of digital versus film mammography for breast-cancer screening. *N Engl J Med*. 2005;353:1773–83.
4. Bauab SP. Mamografia digital: um caminho sem volta. *Radiol Bras*. 2005;38(3):iii–iv.
5. U.S. Food and Drug Administration. Center for Devices and Radiological Health. MQSA program. [cited 2007 Oct 10]. Available from: <http://www.fda.gov/cdrh/mammography/digital.html>
6. Pires SR. *Software gerenciado de base de dados e imagens radiológicas para avaliação de monitores* [tese de doutorado]. São Paulo: Universidade Federal de São Paulo; 2007.
7. Kemp C, Baracat FF, Rostagno R. Lesões não palpáveis da mama. *Diagnóstico e tratamento*. Rio de Janeiro: Revinter; 2003.
8. Angelo MF, Schiabel H, Escarpinati MC. Uma ferramenta para visualização e conversão de arquivos DICOM. *Anais XXIV Congresso Brasileiro de Radiologia*. 2005;24. Congresso Brasileiro de Radiologia, Brasília, 2005.
9. Wang J, Peng Q. An interactive method of assessing the characteristics of softcopy display using observer performance tests. *J Digit Imaging*. 2002;15 Suppl 1:216–8.
10. Scaranelo AM, Barros N. Normatização no laudo de mamografia no Brasil: a utilização do modelo americano (BI-RADS™) também na clínica privada. *Radiol Bras*. 2000;33:311–6.
11. BI-RADS – Sistema de laudos e registros de dados de imagem da mama. 4ª ed. São Paulo: Colégio Brasileiro de Radiologia, American College of Radiology; 2004.
12. Davydenko G, Gurvich V, Smekhov M. Application of StatPhantom software for image quality evaluation. *J Digit Imaging*. 2002;15 Suppl 1: 219–20.
13. Krug KB, Stützer H, Girnus R, et al. Image quality of digital direct flat-panel mammography versus an analog screen-film technique using a phantom model. *AJR Am J Roentgenol*. 2007;188: 399–407.
14. Kundel HL, Polansky M. Measurement of observer agreement. *Radiology*. 2003;228:303–8.
15. Hemminger BM. Soft copy display requirements for digital mammography. *J Digit Imaging*. 2003; 16:292–305.