# Design and Evaluation of an Electronic Educational Multimedia Package for Patients with Pyelonephritis

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## Abstract

**Aim:** Pyelonephritis is a subset of urinary tract infections that occurs by the ascent of bacteria from the lower urinary tract to the upper tract, such as kidneys. The purpose of this study is to create an introductory multimedia educational package for pyelonephritis.

**Method:** The required information was retrieved from Medline (through PubMed), Web of sciences, Scopus, and Google Scholar databases by searching "Educational package" or "Training package" and "Pyelonephritis" keywords. In the next step, AutoPlay Media Studio software was selected to build an electronic educational multimedia package, considering the features of different Autoruns. In the usability evaluation stage, the isometric questionnaire 9241 part 10 was used. Four kidney and urinary tract specialists and eight experts in health information technology gave their views to us by completing the stated questionnaire. The results collected from the questionnaires were entered into SPSS-23 software for analysis using descriptive statistics.

**Results:** The content of the educational multimedia package, i.e., the definition of pyelonephritis, types of pyelonephritis, the causes of pyelonephritis, the underlying factors, clinical signs and symptoms, and methods of diagnosis and treatment are presented on different pages of the electronic package, respectively. The results of this usability evaluation showed that the items; "after not using the system for a long time, it is easy for the user to re-learn how to use the system" and "the user can use the system properly without asking his/her colleagues for help" had the lowest mean value (4.2) and the item; "explanations provided help the user to use the system more skillfully" had the highest mean value (4.9).

**Conclusion:** The use of educational multimedia packages by patients can improve awareness and affect public health. Our educational multimedia package is superior to traditional training due to easy access and not being limited to a specific time and place, increasing the quality of learning and awareness.

**Keywords:** Public health; Pyelonephritis; Multimedia; Urinary tract infection

Urinary Tract Infection (UTI) occurs when bacteria enter the bladder through the urethra, causing cystitis (inflammation of the bladder) and bacteriuria (accumulation of bacteria in the urinary tract) (1). The ascent of bacteria through the urethra causes a kidney infection called pyelonephritis, which is mostly caused by an infection with gram-negative bacteria (usually E. coli), and its pathology includes the formation of abscesses in the kidney parenchyma and edema (2).

Pyelonephritis is usually seen in acute, chronic, and emphysematous forms (3). Chronic pyelonephritis is a radiological diagnosis defined by histological changes in the kidney tissue caused by infection (2, 4). Acute pyelonephritis (upper urinary tract infection) is a severe form of urinary tract infection (UTI) that can lead to kidney infection (1). Emphysematous pyelonephritis is a neurotic and destructive infection of the kidney that causes gas to form inside or around the kidney (5).

The annual estimate of pyelonephritis worldwide is between 10.5 and 25.9 million cases. Women are more likely than men to get a urinary tract infection leading to pyelonephritis. It is estimated that 10% of sepsis (blood infection) is caused by pyelonephritis. Nearly 4,000 deaths from pyelonephritis may occur annually (1, 6, 7). Pyelonephritis is the cause of many threatening diseases such as kidney failure, septic shock (infectious shock), and death (8).

There are approximately 250,000 cases of acute pyelonephritis each year, resulting in more than 100,000 hospitalizations (9). Acute pyelonephritis occurs in women in 80% of cases, and it is estimated that half of the women develop urinary tract infections, including pyelonephritis, at least once in their lifetime (10). In Iran, the overall prevalence of pyelonephritis was 0.13 (95% CI: 0.09, 0.17); the prevalence of pyelonephritis in Iran's northern and southern regions was 0.13 and 0.11, respectively (5).

Due to the high prevalence and severe complications of pyelonephritis worldwide, rapid diagnosis and treatment of this disease are necessary, especially in women (11). In most developed countries, antimicrobial resistance of common infectious disease-producing organisms is determined continuously, and these studies are important to identify resistant pathogenic strains and select appropriate antibiotics to treat them. But this is not important in developing, and underdeveloped countries and antibiotic resistance is observed, and rapid treatment of patients with pyelonephritis becomes more difficult (11).

Consequently, due to the increasing prevalence of pyelonephritis in various communities, increasing patient awareness is needed. Improving the level of patients' awareness has a direct role in the process of public health. However, increasing public knowledge is one of the most important factors in promoting public health (12-14). Today, information and communication technology has created new horizons in easy and cost-effective access to health services and up-to-date knowledge.

E-learning with features such as; increasing the quality of learning, easy and convenient access to a large amount of information, and reducing educational costs have replaced traditional methods (15, 16). E-learning also removes time and space barriers and enables one to use training programs in any environment. Digital technology can be used to teach, assist, and even perform the learning process. E-learning is defined as; "the use of information technology tools in the training and education of human resources." Designing and presenting an educational multimedia package can raise people's awareness and knowledge about pyelonephritis and help prevent the complications of this disease (17).

Based on our knowledge, no research has been conducted to design an educational multimedia package to increase the awareness of patients with pyelonephritis. It is noteworthy that, based on the results of prior investigations, the lack of sufficient knowledge inpatient with pyelonephritis in developing societies has led us to design an educational package for patients with pyelonephritis in process-based research (18, 19). Therefore, the purpose of this study was to create an introductory multimedia educational package for pyelonephritis to increase people's awareness about this disease. Knowing this disease and recognizing the factors that cause this disease can prevent many complications.

## Method

This study is descriptive and applied research conducted at Tehran University of Medical Sciences, Iran, in 2020. The required information was collected from library sources and related articles found in reputable scientific databases in the first stage. To retrieve investigations, four scientific databases, namely Medline (through PubMed), Web of Sciences, Scopus, and Google Scholar, were searched up to December 2020, with the keywords "Educational package" or "Training package" or "Learning package" and "Pyelonephritis." Studies were included if they met the following criteria: 1) were original researches or book; chapters; 2) The main focus of our study is to extract useful information about pyelonephritis to educate patients; 3) Studies published in the English language, and 4) all related studies without time limitation.

The exclusion criteria were the following items: 1) Articles which were reviewed, letters, reports, and technical reports; and 2) Non-English published ones were excluded. After reviewing the relevant studies, the information content was determined based on the researcher's opinion; all the information extracted from the related articles was classified and arranged in an Excel sheet to use this information in the design steps. In the third stage, AutoPlay Media Studio software was selected to build an electronic educational package, considering the features of different Autoruns.

This educational package was prepared in multimedia and introduced the disease, types of pyelonephritis, causes, ways of diagnosis, clinical symptoms, and treatment. In the usability evaluation stage, the isometric questionnaire 9241 part 10 was used. The validity and reliability of this questionnaire have already been confirmed in many studies (20-23). This questionnaire includes several domains, but in this research, only the "suitable for education" domain" suitable for education" domain was applied because other domains were irrelevant to the research topic. This domain has eight different items.

In this phase, four kidney and urinary tract specialists and eight experts in health information technology provided their opinions to us by completing the mentioned questionnaire. The results collected from the questionnaires were entered into SPSS-23 software for analysis using descriptive statistics. The steps taken in the design of the multimedia e-educational package are outlined below in Figure 1:
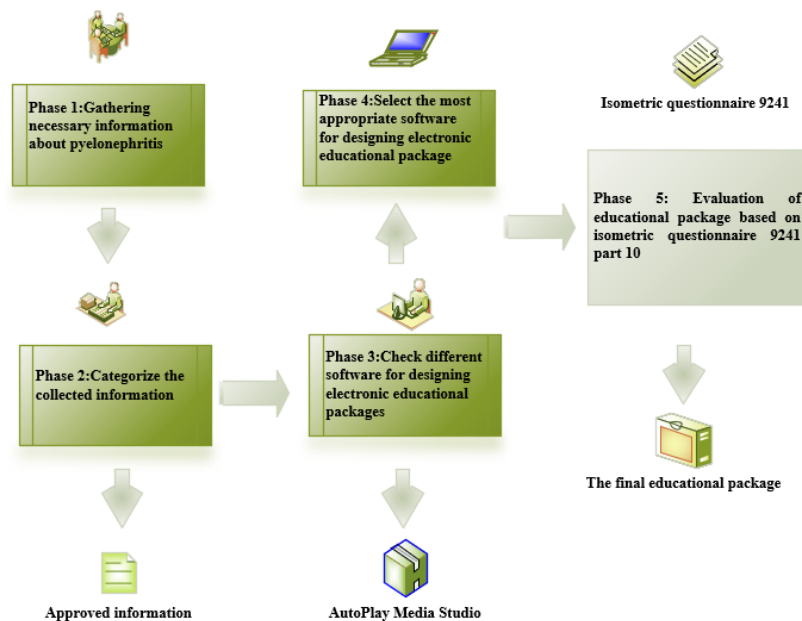


**Figure 1:** Overview of steps taken for the design of the educational multimedia electronic package

## Results

### *Design of the educational multimedia package*

The following is how to design an educational package using the package pages' selected software and images. AutoPlay Media Studio is one of the complete software made by Autorun, and it is also a very rich tool with attractive features and a user interface that helps users create compact discs in multimedia. AutoPlay Media Studio has pre-made designs so that users can create beautiful and, at the same time, professional autoruns by modeling and even using these designs. After collecting the required information and selecting the appropriate software in this study, the educational multimedia package was designed and evaluated electronically. The following figure is the first page of the educational multimedia package (Figure 2):



**Figure 2:** The first page of the educational package

The information content extracted from the studies is as follows: A) definition of pyelonephritis, B) types of pyelonephritis, C) cause of the disease, D) clinical signs and symptoms, E) ways of diagnosis, and F) treatment. The extracted information, included in 21 pages of the educational package, is presented in order.

### *A)    Definition of pyelonephritis*

Urinary tract infection (UTI) is a general term used to describe any urinary tract infection. Urinary tract infections are classified as upper and lower urinary tract infections. These infections include asymptomatic bacteriuria, cystitis, and pyelonephritis. Cystitis and pyelonephritis are symptomatic urinary tract infections that involve the bladder and kidneys and are classified as uncomplicated and complex based on risk factors. Urinary tract infections are the most common urological disease (24). Bacteria are the leading cause of urinary tract infections. The main source is feces that go into the urethra and block the urethra and bladder reflux that carries bacteria from the urethra to the bladder. Most infections are uncomplicated and involve only the bladder, but when the infection migrates to the upper urinary tract, it causes inflammation of the kidneys and renal parenchyma. Most kidney infections occur during a bacterial ascent of the urethra and bladder. Upper urinary tract infections are called pyelonephritis (9).

Information about pyelonephritis is provided in the educational multimedia package as follows in Figure 3:

**Figure 3:** Information about urinary tract infection in the educational multimedia package

### B)    *Types of pyelonephritis*

#### - <u>Acute pyelonephritis</u>

Acute kidney infection is a type of bacterial infection that causes inflammation of the kidneys and pelvis. The most common cause of acute pyelonephritis is Escherichia coli. The infectious agent usually climbs up from the lower parts of the urinary tract, causing kidney involvement. Acute pyelonephritis (AP) is a severe form of urinary tract infection (25). Acute pyelonephritis is common among inflammatory kidney infections and is divided into uncomplicated (non-obstructive) and complex (obstructive) and is clinically known as a bacterial syndrome and is one of the most common bacterial infections. In addition to systemic inflammation, it may cause gastrointestinal symptoms such as abdominal pain, unilateral or bilateral pain in the side, nausea, vomiting, and diarrhea (4). One of the findings in acute infection is enlarged kidneys (26).

The spectrum of acute pyelonephritis is wide, from a mild illness to sepsis syndrome. The presence of vesicoureteral reflux (return of urine to the kidneys) increases the risk of acute pyelonephritis. It can cause a wide range of complications and may cause urinary sepsis, septic shock, and death. The clinical significance of acute pyelonephritis is due to its progression to chronic kidney disease (25).

#### - <u>Chronic pyelonephritis</u>

Chronic pyelonephritis is a controversial disease in terms of its pathogenicity. There is much debate as to whether this disease is a chronic active infection, is caused by recurrent infections, or reflects sustained changes from a single remote infection, or whether its radiological appearance is the same (27). Chronic pyelonephritis is a radiological diagnosis defined by histological changes in the kidney tissue caused by infection.

These changes include kidney ulcers, fibrosis, and tissue damage. Chronic pyelonephritis is characterized by scarring and atrophy (shrinkage) of the kidney that leads to kidney failure. Furthermore, if there is no acute infection, the patient will be asymptomatic. Moreover, after kidney failure, the symptoms associated with it and high blood pressure will appear. Underlying disorders (in structure or

function) of the urinary tract and recurrent infections are responsible for chronic pyelonephritis, and factors such as diabetes, kidney stones, and drug-induced kidney damage are sometimes involved (28).

### - Emphysematous pyelonephritis

Emphysematous pyelonephritis is a necrotic and destructive infection of the kidney that causes gas to form inside or around the kidneys. The disease progresses rapidly and causes a complete infection. Mortality from this disease is high. The prevalence of this disease in diabetic patients has not been controlled, and a percentage of them develop this infection following obstruction of the urinary system (29). Emphysematous pyelonephritis is considered a rare kidney infection. The mechanism of gas formation in this disease is unknown, but various factors involved in the pathogen of this disease include high glucose levels in tissues, the presence of gas-forming microorganisms, impaired blood flow, decreased host immunity, and obstruction in the urinary tract (30). For example, the description of acute pyelonephritis (as an example) is given in the figure below (Figures 4).
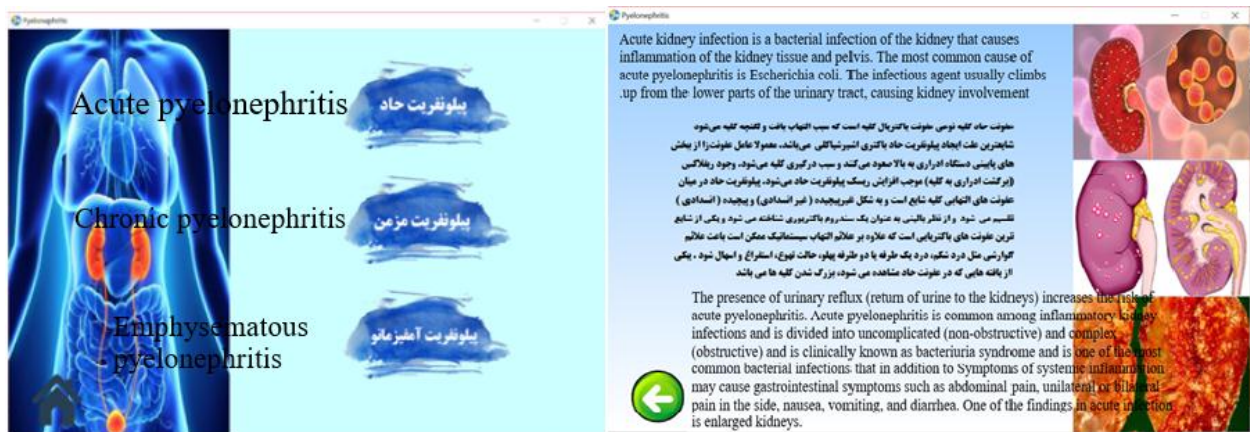


**Figure 4:** Information on acute pyelonephritis

### C)    Cause of the disease

Infectious germs travel from the lower parts of the urinary tract to the kidneys and cause infections. This condition is more common in the presence of urinary tract obstruction (due to stones and structural disorders) or urinary tract dysfunction and reflux (urinary return).

### - Blood-borne transmission

It plays an important role in infants and rarely in adults. In this case, a kidney abscess usually occurs. Direct spread of infection from adjacent organs: For example, in an intra-abdominal abscess or pelvic inflammatory disease, the infection may be transmitted to the kidney (31, 32).

### - Pathogens

Pyelonephritis is mostly caused by gram-negative bacteria (usually E. coli). Among healthy young women, E. coli clones cause pyelonephritis in 90% of cases. E. coli species are less common in older men and women, and Candida bacteria are more prevalent (4). Other pathogens include aerobic gram-negative bacteria, Staphylococcus, Saprophyte, and Enterococci (33).

In this section, explanations about the cause of the disease are provided on different pages of the educational package. Figure 5 shows the cause of the disease.

**Figure 5:** Information on the cause of the disease

### D)    Clinical signs and symptoms

Clinical manifestations and severity of the disease vary. It varies from mild flank pain with low or no fever to septic shock (34). Pyelonephritis is usually manifested by signs and symptoms of systemic inflammation (fever, chills, weakness, and restlessness) and bladder inflammation (frequent urination, urgency to urinate, and burning urination) (29). Nausea, vomiting, weakness, and flank pain are also symptoms of pyelonephritis (4).

Information about the underlying factors, signs, and symptoms of the disease in the educational multimedia package is as follows in Figures 6:
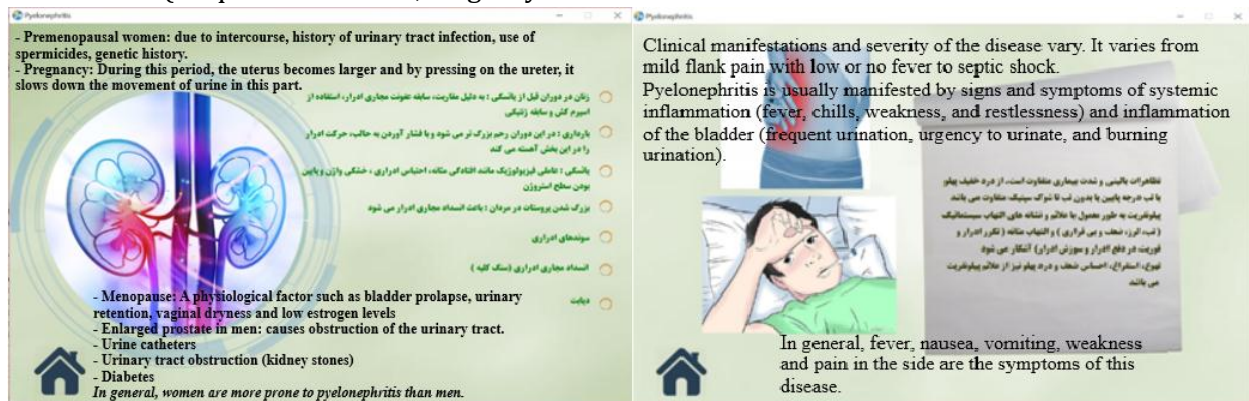


**Figure 6:** Underlying factors of the disease and different signs/symptoms

### E)    Ways of diagnosis

The presence of bacteria in tests can indicate pyelonephritis. The number of bacteria in the tests varies depending on the host factors. The number of bacteria is higher among patients with a history of underlying disease, people with defective immune systems, people with urinary tract obstruction, and the elderly (35). Urine tests can be used to diagnose acute pyelonephritis. However, sometimes due to inconsistencies in the signs and symptoms of pyelonephritis, some diagnostic and research methods such as urine and blood cultures and diagnostic imaging may be needed to enhance the accuracy of the diagnosis (36).

- <u>Urine test</u>

If a urine test shows an infection in the urine, or in other words, white blood cells or bacteria

in the urine, the chances of infecting the kidneys or urinary tract are very high, and the initial diagnosis is confirmed.

### - Urine culture

If the number of bacteria grown in the environment is more than a certain amount (usually more than 10,000 colonies of each type of bacteria), the test is positive, and the person has a urinary tract infection. Urine culture confirms the diagnosis of acute pyelonephritis (37).

### - Blood culture

Blood culture is recommended for hospitalized patients. Blood cultures are performed if the diagnosis is uncertain and are also more common in people with defective immune systems because the infection may enter the bloodstream (38).

### - Diagnostic imaging (computed tomography, CT scan, ultrasound)

Diagnostic imaging tools are used to detect anatomical abnormalities, urinary tract obstruction, and side infections such as appendicitis, cholecystitis, abscess, and emphysematous pyelonephritis. Diagnostic imaging is unnecessary for uncomplicated acute pyelonephritis but should be performed in complicated pyelonephritis to diagnose obstruction and in emphysematous pyelonephritis. Imaging may also be considered for patients who do not respond to appropriate antibiotics within 72 hours of starting treatment (39).

### F)    Treatment

Antibiotics are the main treatment for a kidney infection (40). If the patient is in good general condition and does not have nausea and vomiting, oral antibiotics are prescribed and treated on an outpatient basis. Outpatient treatment with oral antibiotics is successful in most patients with mild complications without pyelonephritis. However, if the symptoms of a kidney infection are severe and are accompanied by uncontrollable nausea and vomiting that makes it impossible to take the drug, the patient should be admitted for intravenous antibiotics (41).

With proper care, clinical manifestations usually subside gradually and may last up to 5 days, but worsening or not reducing clinical manifestations within 24 to 48 hours raises concerns about possible complications such as obstruction, renal abscess, and emphysematous pyelonephritis (42).

Prompt antibiotic treatment of acute pyelonephritis is critical to the prevention of chronic pyelonephritis. Improper treatment or delay in acute pyelonephritis causes chronic pyelonephritis kidney ulcers (24).

The standard course of antibiotic treatment is 7 to 14 days, and urine culture should be repeated 1 to 2 weeks after completion of antibiotic treatment. Treatment failure may be due to resistant organisms, underlying anatomical and functional disorders, or immunodeficiency states. If there is no response, blood and urine cultures should be repeated immediately and possibly diagnostic imaging. Antibiotic changes or surgical intervention may be necessary (43).

Percutaneous catheter drainage (PCD) with antibiotics is suitable for the treatment of emphysematous pyelonephritis. PCD is used to relieve pressure inside the kidneys and drain the infection. If PCD fails to treat emphysematous pyelonephritis, surgery to remove the kidney (nephrectomy) should be performed (44).

These sections provide information about the diagnosis and treatment of pyelonephritis. The following figures are examples of treatment and diagnosis methods (Figures 7):
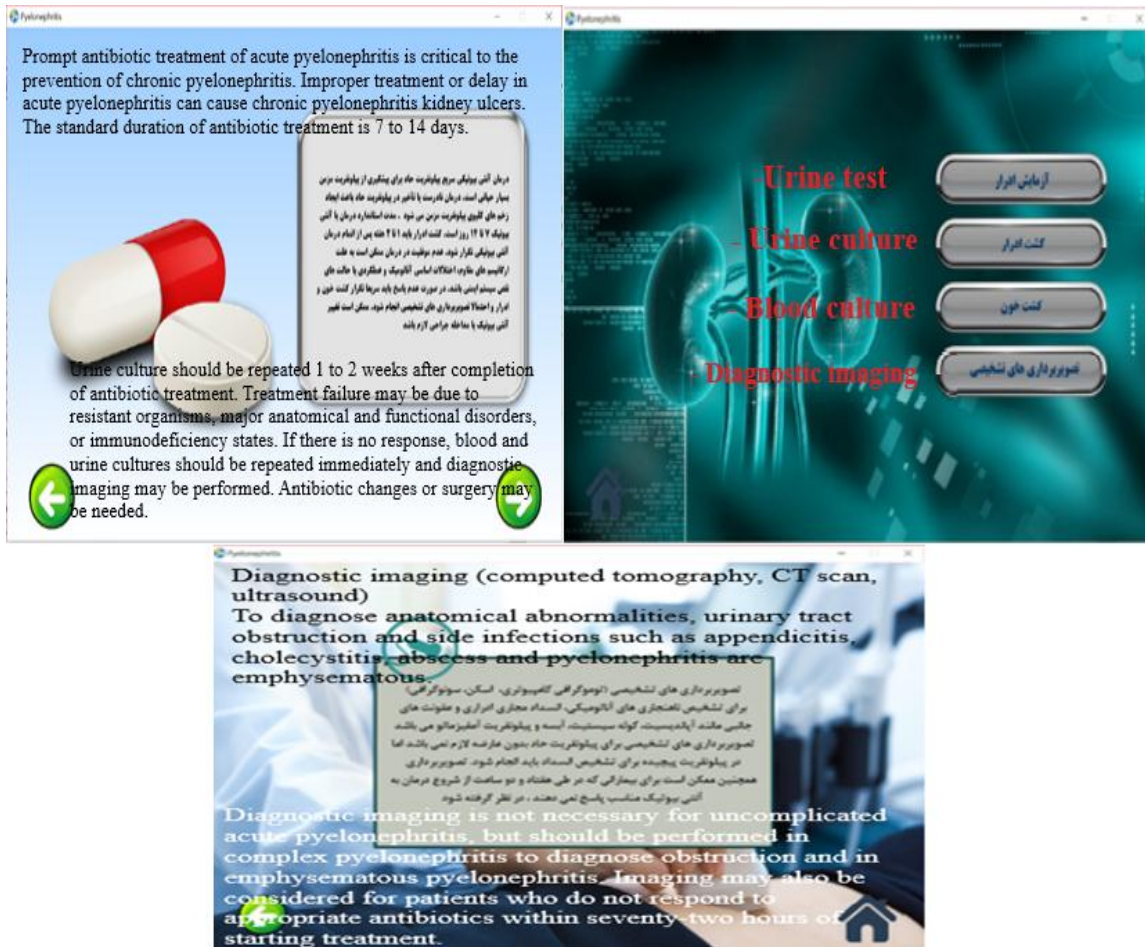
**Figure 7:** Examples of information about diagnosis and treatment

## 2. Usability evaluation of the educational multimedia package

After designing the educational multimedia package, this product was evaluated by various experts (four kidney and urinary tract specialists and eight experts in health information technology). The sample size in our study was selected from kidney and urinary tract specialists and experts of Sina Hospital Urology Research Center, and convenience sampling was used at this stage to select the sample size. Demographic characteristics of the participants who took part in the usability evaluation of the system are given in Figure 8.

The usability evaluation results for the "suitability for education" domain based on the isometric questionnaire 9241 part 10 are presented in Table 1. This domain consists of eight items with a minimum value of 4.2 and a maximum value of 4.9. The item; "explanations provided helps the user be more proficient in using the system" had the highest mean value and the lowest standard deviation.
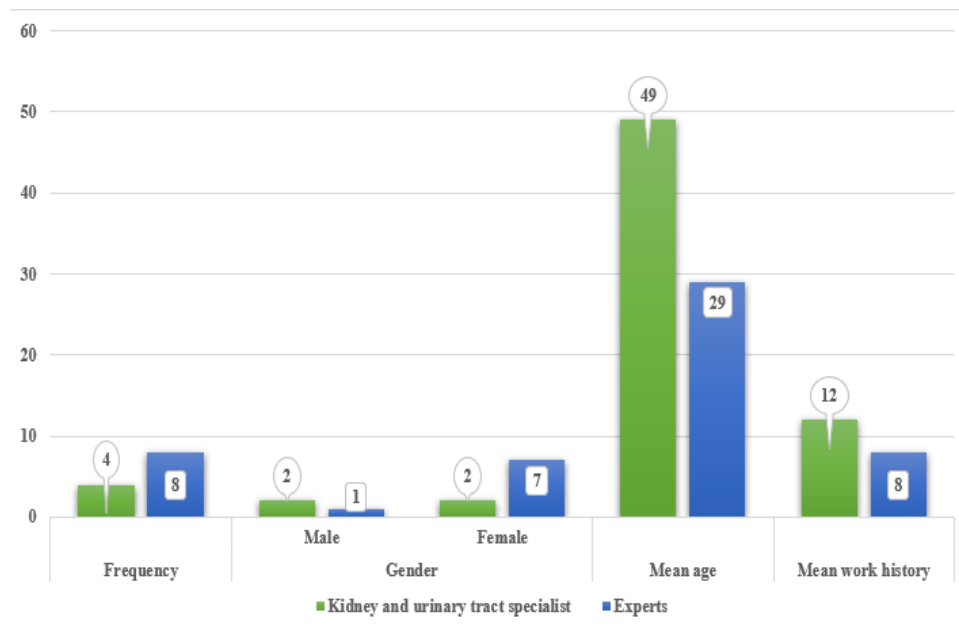
**Figure 8:** 'Participants' characteristics in usability evaluation

**Table 1:** Usability evaluation results

| Domain | Item | Mean | SD |
|---|---|---|---|
| *Suitability for training (8 questions)* | It takes a long time for the user to learn how to use the system. | 4.6 | 0.4 |
| | After not using the system for a long time, it is easy for the user to re-learn how to use it. | 4.2 | 0.3 |
| | The explanations provided help the user to become more proficient in using the system. | 4.9 | 0.1 |
| | There is no problem learning the rules for connecting to the system. (Such as data entry) | 4.8 | 0.2 |
| | From the beginning, the user can use the system properly without asking colleagues for help. | 4.2 | 0.5 |
| | The system encourages the user to test system performance by trial and error. | 4.7 | 0.4 |
| | To use the system properly, many details must be remembered. | 4.3 | 0.3 |
| | The system is easy to use. | 4.6 | 0.5 |

## Discussion

In this study, an educational multimedia package was designed to educate patients with pyelonephritis. This educational package introduces pyelonephritis, types of diseases, causes, ways of diagnosis, signs and symptoms, and treatment. This package was designed by AutoPlay Media Studio software and evaluated for usability by four kidney specialists and eight health information technology experts.

The usability evaluation results indicate that the item; "explanations provided helps the user to be more proficient in using the system" had the highest mean value (4.9) and the lowest standard deviation (0.1). The participants' satisfaction in the evaluation phase of the training package (in general) has been calculated with an average value of 4.53, which is at a good level.

According to the findings, educational

packages increase the quality of learning by having features such as easy access and a large amount of information. The educational package can be prepared in the form of audio, video, and multimedia. Preparing educational booklets, posters and pamphlets are examples of video training packages. In this research, an educational package was prepared in the form of multimedia. Educational multimedia packages in the field of education make it possible for the user to learn science without the presence of a teacher; the use of the multimedia package is an excellent alternative to face-to-face training (45).

Based on research results, increasing knowledge is possible through the use of various technologies such as websites and portals, training packages, and intelligent systems (a variety of information systems) (46-51). Educational software has the advantage over other training packages and allows user interaction through a properly simulated classroom. These software systems can simultaneously provide users with text, sound, and images (16, 52).

After reviewing some software packages, AutoPlay Media Studio software was used in this research. There are many software choices to build an autorun, such as AutoRun Pro Enterprise, Adobe Captivate, and AutoPlay Menu Builder (53). In line with our study, in these studies, powerful AutoPlay Media Studio software has been used to design the educational package (54-55).

In the educational multimedia package prepared in this research, the contents were selected to be largely understandable to the user and away from additional explanations in simple language. The pages have different wallpaper and appearance to create necessary attractiveness for the user. For better learning, related images have been placed on each page. The manufacturer's specifications are listed on one page. A menu list appears on one page, and clicking on any of them opens the corresponding page.

There is also a back button at the bottom of the pages that take the user back to the menu list. Same as our study, in the training packages developed by the Skills Center (56), the contents are arranged in such a way that the content presentation is clear and logical, the information is good and organized, the necessary definitions and examples are given in the required places, and appropriate images and examples are used. It also contains information about the specifications of the collector and producer, the titles of courses and sections, tests and exams, examples, diagrams, pictures, etc.

In some training packages, an audio file is used as a background song or description audio file, but no audio file is used in this educational package. In this research, an educational package was prepared to easily use it and have access to different parts of the package. Unlike the educational package designed in this research, in the training packages developed by the Skills Center (56), there are tests for the users to measure their learning. In other words, it enables user interaction.

In the study of Eghbeli et al. (57), same as our study, the training program contents were collected from the most up-to-date scientific sources based on needs assessments and the opinions of health education, diet, and diabetes specialists to be simple and have scientific credibility. Then, the contents of the program were designed based on the algorithm in the form of a multimedia training package that a computer can run with Windows 95 and higher. However, in contrast to the educational package designed by our team, the main format of the program was written in Delphi, but other software was used to prepare videos, images, graphics, slides, text, sound, and music (57).

In line with the present study, in the training package designed for pyelonephritis patients, the clinical information that has been provided to inform patients are complete, and various aspects are taught to patients (58). Our study does not mention how to prevent pyelonephritis, but measures to prevent this disease are mentioned on the Vali-asr Educational and Medical Center website. Some of the mentioned measures include drinking large amounts of fluids, urinating frequently, emptying the bladder after intercourse, and not using female products in the genital area.

In a study by Nezlena et al., a digital education package was designed to educate the elderly. In comparison with our study, the information contents of this package were extracted using previous studies, guidelines, and lifestyle of the elderly, and a questionnaire was used to evaluate the overall content of the training package, graphics, design, color, font size, user satisfaction and their acceptance level (59).

In some training packages, an audio file is used as a background song or description audio file, but no audio file is used in this educational package. This package includes contents that are thought to be needed by the user, and no survey was conducted to determine the content of the training package. However, in the training package prepared by Romeu Andre Piertiz, the contents of the training package have been collected from the most up-to-date scientific sources based on previous needs assessments and the opinions of experts (60).

This study had several strengths and methodological limitations. Strengths included searching four important databases with keywords, which led to the related number of articles. The first limitations of this study were that articles in the non-English language are not included. The second limitation of this study was that some renal and urinary tract specialists did not cooperate to complete the usability evaluation questionnaire. As a result, we had to meet more people to complete the questionnaire.

## Conclusion

Pyelonephritis is a kidney infection caused by a urinary tract infection that causes edema and kidney failure. Awareness of this disease and its causative factors can be effective in preventing the complications of this disease.

In this study, pyelonephritis and its cause, types of pyelonephritis, and related diagnosis and treatment methods were studied, and a multimedia training package was prepared to inform people about this disease.

According to the evaluation phase results, the participants' general opinion about the usability of the multimedia training package is at a "good" level. Multimedia educational packages are superior to traditional training methods, as they increase the quality of learning due to their easy access and not being limited to a specific time and place.

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