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# The Influence of Laboratory Diagnostics on Nursing Management of Respiratory Tract Infections: Review of Current Technologies and Their Implications for Patient Care

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## Abstract

*Respiratory tract infections (RTIs) represent a significant public health challenge due to their high prevalence and associated morbidity and mortality rates. Accurate and timely laboratory diagnostics are crucial for effective nursing management of these infections, ensuring appropriate treatment and minimizing the misuse of antimicrobials.This review synthesizes current literature on laboratory diagnostic technologies for RTIs, emphasizing the role of syndromic panels and molecular techniques in detecting bacterial and viral pathogens. It discusses the epidemiological trends of RTIs, diagnostic methodologies, and the implications for nursing management in clinical settings.Recent advancements in diagnostic technology, particularly molecular methods, have enhanced the accuracy and speed of identifying RTIs, which is essential for effective patient management. Syndromic panels allow for the simultaneous detection of multiple pathogens, facilitating rapid clinical decision-making. However, challenges remain, including the cost of molecular assays and the need for appropriate specimen collection and handling to ensure diagnostic reliability.The integration of advanced laboratory diagnostics into nursing practice is vital for improving outcomes in patients with RTIs. Nurses play a critical role in the diagnostic process, from specimen collection to interpreting results, which informs treatment decisions. Ongoing education and training are necessary to equip nursing professionals with the skills needed to utilize these advancements effectively.*

**Keywords:** *Respiratory Tract Infections, Laboratory Diagnostics, Nursing Management, Syndromic Panels, Molecular Techniques.*

## Introduction

Respiratory tract infections (RTIs) are a primary concern in public health due to their prevalence and the significant morbidity and death rates documented globally [1]. Respiratory tract infections (RTIs) are classified as disorders of infectious origin affecting the respiratory system [2]. The clinical spectrum varies from asymptomatic or moderate infections to severe or deadly diseases, with severity determined by the interplay of three variables: the causative agent, environmental circumstances, and the host [1]. These infections often manifest as acute diseases with a fast clinical start, occurring within hours to days post-infection, and presenting a range of symptoms including a cough, sore throat, fever, coryza, difficulty of breath, coughing, and/or respiratory distress [1]. The epidemiology of respiratory tract infections is continuously changing due to rapid sociodemographic shifts and climatic change. Respiratory tract infections (RTIs) are not only among the most lethal infectious diseases globally, particularly affecting children and the elderly, but they also represent the predominant cause for consultations or admissions to

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healthcare facilities and primary care [3,4]. Furthermore, they significantly contribute to the rising demand for medical evaluations in both outpatient clinics and emergency departments, as well as to the prescription of antimicrobials and hospitalizations [1,5]. Furthermore, recent epidemiological data underscore the significant effect of RTIs on life quality and expectancy, together with the grave danger they pose to communities and worldwide public health [4].

The epidemiological research of RTIs must adapt to the fast evolution of sociodemographic as well as climatic dynamics and requires ongoing updates to provide essential resources for health management and preventative measures. A swift and efficient laboratory evaluation of RTIs is essential to inform and direct clinical choices for suitable patient therapy, while also preventing the misuse of antimicrobials. The delay to determine the causative agent of respiratory tract infections may result in the emergence and proliferation of antimicrobial-resistant pathogens because of the inappropriate use of broad-spectrum medications, leading to suboptimal clinical outcomes, elevated mortality rates, and prolonged hospital stays [6-8].

Significant technical advancements have occurred over the years, yielding novel instruments for the detection of bacterial as well as viral respiratory infections, culminating in the creation of precise, rapid, and user-friendly diagnostic procedures [9]. Molecular approaches are now extensively accessible in diagnostic labs. Molecular-based approaches provide accurate and highly specific identification of bacterial and viral nucleic acids immediately in clinical specimens and cell culture supernatants, eliminating the requirement for the prolonged incubation time required for bacterial or viral separation [9]. Molecular approaches need less technical skill than culture techniques and are effective for detecting "difficult to grow" bacteria and viruses that do not replicate in ordinary cell cultures [9].

The development of syndromic panels revolutionized diagnostic microbiology by offering a potent tool for detecting a wide range of pathogens that may collectively trigger a single medical syndrome, thereby addressing the demands for accuracy and reduced time-to-result [10]. This review presents a narrative summary of the primary etiological, medical, and epidemiological characteristics of respiratory tract infections (RTIs), emphasizing laboratory testing and the capabilities of syndromic panels.

*The Epidemiology of Respiratory Tract Infections*

Respiratory tract infections (RTIs) are the most lethal infectious illnesses and rank as the fourth highest cause of global mortality, with 2,603,913 fatalities recorded worldwide in 2019 [4,11]. Currently, there have been over 567 million confirmed instances, and more than 6.3 million fatalities documented worldwide due to the COVID-19 pandemic. This infection significantly contributes to reduced life expectancy (LE), with elevated annual estimates of disability-adjusted life years (DALYs) [4,11]. The illness burden of respiratory tract infections has an uneven distribution both demographically and geographically, varying significantly by age, gender, and across different nations and regions [4]. The detrimental effects of respiratory tract infections on quality of life are more pronounced in young children, newborns, and the elderly, who exhibit the greatest rates of mortality and morbidity, particularly in middle- and low-income countries [4,11,12].

The pediatric and elderly groups are identified as the most susceptible to respiratory tract infections globally, including death and loss of life expectancy. In the pediatric demographic, the highest death and Disability-Adjusted Life Year (DALY) rates are seen in children under one year of age [11,12]. Conversely, in the geriatric population, those over 70 years old represent the majority of fatalities and loss of life expectancy (LE). This demographic gap is also evident in the geographic distribution of RTIs, significantly influenced by the level of socioeconomic development. Low- and middle-income nations and territories are more vulnerable to respiratory tract infections, contributing to the greatest death and disability-adjusted life year rates. In high-income nations with elevated aging indices, a significant population of elderly individuals faces heightened susceptibility to infections and hospitalization, leading to a rising trend in mortality, morbidity, and loss of life expectancy owing to respiratory tract infections. In high-income nations, a considerable number of fatalities linked to respiratory tract infections (RTIs) occur in aged care institutions and nursing homes, indicating a substantial transmission rate of RTIs in these environments, along with large fatality rates and loss of life expectancy for the elderly. Likewise, the juvenile demographic in affluent

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nations is at significant risk of respiratory tract infections owing to their participation in childcare facilities and educational institutions, which serve as optimal settings for the spread of such infectious diseases [13].

*The Human Respiratory System and the Categorization of Respiratory Tract Infections*

The human respiratory system is segmented into two interconnected regions: the upper tract, including the tonsils, nasopharynx, oral cavity, oropharynx, as well as larynx, and the lower tract, which encompasses the trachea, bronchi, and lungs. Consequently, respiratory tract infections (RTIs) are categorized as upper respiratory infections (URIs) and lower respiratory infections (LRIs), depending on the affected segment of the respiratory tract [14-17]. This study will not address respiratory illnesses caused by mycobacteria, since such diseases are excluded from standard laboratory diagnostic procedures and syndromic panels.

*Laboratory Diagnosis*

The prompt and precise identification of a respiratory tract infection (RTI) is essential for optimal patient care, including the administration of suitable antiviral or antibacterial treatments, implementation of efficient infection control strategies, and minimization of hospital stay duration [18]. Furthermore, laboratory diagnosis ought to incorporate both microbiological as well as virological techniques to provide substantial insights for outbreak management, epidemiological monitoring, antibiotic susceptibility, and pattern typing [19]. Despite the crucial function of the medical laboratory, the microbiological and virological diagnosis of respiratory tract infections remains problematic due to the complexity of these illnesses. The quality and diversity of respiratory specimens, the challenging accessibility of specific anatomical respiratory frameworks, possible interactions from the oropharyngeal microbial populace, the extensive range of respiratory pathogens, and the intricate pathophysiology of respiratory tract infections present major obstacles to the preliminary identification of these pathogens [18,20].

The diagnosis of respiratory tract infections (RTIs) primarily entails an initial assessment of the relevant symptoms and signs to formulate the essential clinical question. This process enables the medical microbiologist to devise an appropriate diagnostic workflow, commencing with the selection of the suitable respiratory specimen [19]. The collection, transportation, storage, and processing of respiratory specimens are essential for the reliability of diagnostic results; thus, physicians and laboratory personnel must diligently adhere to reference standards to guarantee proper sample management [9,17,19].

The diagnostic process for respiratory tract infections (RTIs) has traditionally used several methods to identify the microbial and viral causes, including microscopic analysis, conventional culture techniques, conventional cell cultures, antigen identification, and serological assays [8,18,19]. The use of novel analytical techniques, including molecular methods, enables researchers to significantly enhance the initial identification of respiratory infections, particularly those that are difficult to identify and for which traditional culture methods are impractical. Furthermore, clinical microbiologists are now encountering substantial advancements in molecular diagnostic methodologies, including syndromic panels [21]. Respiratory syndromic panel-based tests enable the concurrent detection and identification of several infections linked to the most severe respiratory disorders [21]. The array of diagnostic procedures for viral and microbial identification is extensive, and understanding their respective benefits, restrictions, and time-to-results is essential for accurate result interpretation and effective integration into clinical care [9].

The identification of respiratory infections is significantly influenced by several preanalytical factors and, undoubtedly, by the kind and quality of the respiratory sample. Proper sample administration significantly influences laboratory diagnosis, therapeutic decisions, antibiotic stewardship, hospital and laboratory expenses patient care, clinical outcomes, and hospitalization duration; additionally, it enhances laboratory efficiency [17]. The time of collection is the primary need for ensuring precise microbiological diagnosis and the interpretability of data [18,22]. Specimens must be obtained promptly during the acute phase of an illness, ideally before the initiation of antibiotic or antiviral treatment [17,18,22]. Respiratory specimens must be obtained within 3 days of signs start and no later than 7 days, whilst the viral titer and bacterial load significantly decrease after 72 hours after clinical onset [23].

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The transportation method and sample storage are essential for maintaining the microbiological and viral properties of the sample [9,18]. The samples must be sent to the laboratory expeditiously. If the respiratory specimen cannot be transferred to the laboratory or analyzed within 1–2 hours, the recommendations advise storing it between −80 °C to −20 °C to maintain microbial community composition. If this is not feasible, the samples must be kept at 4 °C to 8 °C and analyzed either on the same day or the day afterward. Specimens may alternatively be collected in designated tubes comprising a preservation transport medium; if such instruments are accessible, the samples may be preserved for 24 hours at room temperature or at 4 °C [24,25]. Specimens for viral detection must be carried in appropriate transport medium tubes on wet ice at 2 °C to 8 °C and should be frozen at −80 °C if testing is postponed for more than 48 hours. The identification of respiratory tract infections, based on the hypothesized etiology—bacterial or viral—necessitates a particular specimen type and collection procedure, along with precise transit and storage conditions to enhance diagnostic yield [9,17]. While several respiratory specimens may be used to determine the microbial and viral pathogenesis of a respiratory tract infection (RTI) [18,20], only a limited number are readily accessible and endorsed for their diagnostic efficacy [17,18].

The diagnosis of URIs mostly relies on the assessment of the symptoms and signs presented by the patient [8,17,18]. While the identification of a URI is mostly medical, recommendations advocate for local microbiological collection anytime there is a clinical deterioration of the infection or when the patient presents signs and symptoms indicative with AP [8,17]. For the laboratory diagnosis of a URI, the suggested sample techniques include nasopharyngeal washes, nasopharyngeal aspirates, nasopharyngeal swabs, oropharyngeal swabs, and combined nasopharyngeal and oropharyngeal swabs [17,26]. Nasopharyngeal aspirate and nasopharyngeal wash are the preferred specimens for detecting respiratory viruses, as a substantial quantity of respiratory epithelial cells is collected during the procedure [17,18,26]. Nonetheless, the collection of nasopharyngeal aspirates or nasal washes is impractical for extensive clinical use, as it requires specialized suction apparatus and proficient personnel to acquire the specimens [18]. Conversely, the acquisition of nasopharyngeal or oropharyngeal swabs is simpler and non-invasive and may be conducted in non-hospital environments. A variety of commercial swabs is now accessible, including rayon-tipped swabs, polyester-tipped swabs (Dacron), and polyurethane sponges with wooden, plastic, or wire handles [18].

In cases of suspected viral upper respiratory infection, clinical samples are typically obtained using a Dacron swab and stored in a viral transit medium that includes antibiotics, a buffered saline solution, a proteinaceous component (such as albumin, gelatin, or serum), and a pH indicator [9]. Conversely, when a bacterial upper respiratory infection is believed to exist, Dacron or rayon swabs should be avoided for oropharyngeal sampling, as they retain minimal sample volumes (0.05 mL) and trap microbes within their fibers, thereby compromising the quality and quantity of the specimen collected [17]. The flocked nylon swab is the premier instrument for collecting respiratory specimens, particularly for the bacterial identification of a URI, because it facilitates the more effective expulsion of respiratory epithelial cells and salivary glands [17,18]. The flocked nylon swab facilitates the acquisition of bacteria and/or fungus on solid medium and enables a more uniform inoculum of the sample on the agar plate [17].

The specimens obtainable from the lower respiratory tract encompass spontaneous or, less accurately, produced sputum; bronchoscopy specimens; endotracheal aspirates; and, seldom, transthoracic lung aspiration. The collection of specimens, apart from sputum, from the lower respiratory tract may be restricted to clinically severe situations, including hospitalized and life-threatening patients, due to the requisite experience, technical abilities, and necessary equipment [23]. The acquisition of lower respiratory specimens is complicated by the presence of commensal bacteria in the oropharynx, which may contaminate the sample during collection and subsequently hinder the interpretation of the data. Consequently, samples from the lower respiratory tract need meticulous handling during collection [9,17], and invasive methods serve as effective and mostly sterile options for pathogen detection. Regarding sterile procedures, bronchoalveolar lavages (BAL) are the most often used.

Due to the likelihood of contamination during the collection of lower respiratory specimens, microscopy serves as an effective method for evaluating sample quality prior to culture, hence mitigating any misinterpretations of the data [18,22]. Furthermore, microscopy offers prompt and succinct insights into

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the infection, including the detection of elevated quantities of polymorphonuclear (PMN) cells as indicators of the inflammatory reaction, or the identification of bacteria exhibiting distinctive shape [18,22]. Microscopic inspection findings may provide preliminary insights about culture outcomes and inform treatment decisions [18,22].

Concerning microbial URIs, microscopy after Gram staining of upper respiratory specimens is effective for identifying PMN cells and some distinctive bacteria, such as C. Diphtheriae and B. pertussis, particularly in nasopharyngeal aspirate. Gram staining is typically not advised as a dependable method for identifying other bacteria, such as streptococci responsible for pharyngotonsillitis or N. meningitidis in healthy carriers, as these cannot be differentiated from the nonpathogenic colonizers of the upper respiratory tract's normal microbial flora. Alternative staining techniques include Loeffler's Methylene blue for C. Diphtheriae may be used when particular clinical suspicion is communicated to the laboratory [27]. In cases where P. jirovecii-associated pneumonia is suspected, the preferred staining methods are direct or indirect immunofluorescence tests, which demonstrate good sensitivity and specificity for various life stages, contingent upon the antibody used [28].

Gram staining and microscopic analysis of the material from a patient with LRI is strongly advised to assess its appropriateness. The quality of a lower respiratory sample is primarily assessed by evaluating the quantity of squamous epithelial cells (SECs) and polymorphonuclear (PMN) cells in a Gram-stained smear of the sample [18,22]. The presence of a low quantity of SECs and a high quantity of PMN cells per low-power field signifies a high-quality specimen; conversely, samples with comparatively small numbers of PMN cells and elevated numbers of SECs are likely indicative of oropharyngeal contamination and should be rejected for conventional culture [18,22]. A count of SECs/100× perspective microscopic field above 10 indicates the sputum sample includes saliva and is thus inappropriate; likewise, the detection of >1% SECs signifies contamination from the upper respiratory tract's commensal microbiota, rendering the sample unsatisfactory. Specimens from the lower respiratory tract are analyzed for inflammatory cells, bacterial presence and characteristics, including Gram staining, morphology, arrangement, quantity, intracellular or extracellular location, and the dominance of a specific microbial population [27]. The stained smears from those suffering from aspiration pneumonia exhibit many polymorphonuclear neutrophils and a diverse array of intracellular respiratory flora, mostly consisting of streptococci and anaerobes, and must be differentiated from the invading respiratory microbiota. Detection of intracellular microorganisms in alveolar macrophages from bronchoalveolar lavage exhibits great specificity and sensitivity for diagnosing ventilator-associated pneumonia (VAP). Based on Gram staining, bacteria resembling the most prevalent respiratory bacterial infections should be taken into account when interpreting data, and their existence should be communicated to doctors to inform prospective practical treatment. If bacteria are present in inadequate quantities or lack Gram-staining properties indicative of a possible pathogen, they should be classified as typical respiratory flora [27].

Microscopy has been a crucial instrument in the domain of viral respiratory tract infections. Electron microscopy has been crucial, even in contemporary contexts, in finding new viral strains responsible for epidemics, such as the first human coronavirus linked with severe acute respiratory syndrome (SARS) in the early 2000s [17,29,30]. Nonetheless, despite its numerous advantages, the application of electron microscopy in diagnosing viral respiratory infections presents certain limitations: it is labor-intensive, time-consuming, and necessitates significant technical expertise for precise analysis, along with stringent control of the experimental setting and an elevated level of viral particles (>105 mL), with a turnaround time varying from 3 to 16 hours (including specimen preparation) [17,31,32]. Consequently, electron microscopy is not advised as a standard diagnostic technique for respiratory infections in clinical samples; instead, it should be used for identifying viruses that induce a cytopathic impact during viral culture [9].

Bacterial culture now serves as the gold standard for isolating and detecting respiratory infections in both the upper and lower respiratory tracts, including atypical bacteria. Nevertheless, it is regarded as a labor-intensive approach that needs substantial technical proficiency and extended time to get results. Moreover, the reliability of this approach is not always assured, since it largely depends on the specimen's quality, which may be compromised by contamination during sampling. Furthermore, the culture findings may be misconstrued, particularly when specimens are obtained after the initiation of antibiotic treatment. The

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proliferation of bacterial colonies is subsequently accompanied by their identification through biochemical assays or, more recently, through matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) mass spectrometry and antimicrobial susceptibility testing (AST) utilizing various manual or automated techniques, with a turnaround time of 48–96 hours [18]. Consequently, culture-based pathogen identification is insufficient for facilitating timely diagnosis and tailored antibiotic treatment, essential for optimum patient care [18].

Pharyngeal samples for URIs are routinely cultured for Streptococcus pyogenes on 5% sheep blood agar or Group A Streptococcus selective blood agar, the latter of which facilitates visualization by inhibiting competing flora but prolongs colony appearance. The plates are examined for β-hemolytic colonies. Various infections may induce pharyngotonsillitis or colonized the upper respiratory tract asymptomatically, and their identification may be significant in patients with otolaryngological conditions [27]. Nasopharyngeal specimens are valuable for diagnosing B. infection. whooping cough, C. Diphtheriae and Chlamydophila species, as well as for the identification of N. Neisseria meningitidis, S. Aureus, and S. Carriers of pyogenes. Samples are typically put onto sheep blood agar or chocolate agar and then incubated aerobically at 37 °C in a 5% CO2 atmosphere for 48 hours. Upon infection with B. pertussis or Bordetella. If parapertussis is suspected, samples ought to be inoculated onto Regan-Lowe charcoal agar supplemented with ten percent horse blood and cephalexin, then aerobically incubated beneath moist conditions at 35 °C for a duration of 5 to 7 days [27]. The specimens that may contain N. Meningitidis should be cultured in Thayer–Martin or another selected medium that facilitates the development of this microbe while suppressing the normal flora of the upper respiratory tract (5% CO2 at 35 °C for 72 hours) [33].

For LRIs, a qualitative, quantitative, or semiquantitative culture may be conducted. To qualitatively culture common bacteria, sputum, BAS, or BAL specimens are inoculated onto sheep blood agar as well as MacConkey's agar at 35 °C with 5% CO2 for 24–48 hours. Additionally, BAL samples may be cultured anaerobically on *Brucella* blood agar, laked blood supplemented with kanamycin as well as vancomycin, and Canada colistin-nalidixic acid. Selective media ought to be utilized for atypical bacteria, such as *Hemophilus* spp. *Legionella* spp. cultured on chocolate agar at 35 °C with 5% CO2 for 24–48 hours [34].

*Chlamydophila* as well as *Mycoplasma* species are infrequently cultured in clinical microbiology facilities for testing purposes due to their prolonged growth period, lack of straightforward methodologies, and the consequent delay in diagnosis, which heightens the risk of severe pneumonia; thus, molecular tests for their identification are favored [35]. Quantitative cultures are essential for diagnosing ventilator-associated pneumonia, aspiration pneumonia, particularly pneumonia in immunocompromised patients or those having cystic fibrosis. The detection of ≥106 CFU in the initial BAS specimen/mL indicates a current infection, while lower numbers suggest potential cross-contamination. In BAL samples, a recovery of <104 bacteria/mL presumably signifies contamination, while >105 bacteria/mL indicates an active infection. The identification of 104 to 105 bacteria/mL represents a "gray zone" [27].

Monitoring and confirmation of the cytopathic impact in cell culture is regarded as the gold-standard approach for detecting primary respiratory viruses, including ADV, FLU A/B, RSV, and human PIV [9]. In relation to RTIs, cell culture is advised for certain patient demographics, including immunocompromised individuals, children under 5 years exhibiting respiratory symptoms, and critically sick pediatric patients [9]. Cell culture entails inoculating many cell lines with clinical samples to establish an appropriate host for any current virus. The selection of cell culture wells, including their quantity and kinds, is determined by the clinical specimen type, specimen source, and anticipated viral agents. Viral culture wells then undergo incubation for a duration ranging from days to weeks, dependent upon the specimen source and the putative virus(es) [9]. Cell monolayers undergo daily microscopic screening to assess the potential for viral proliferation [9]. The microscopic analysis is conducted through putting the plate on the stage of a conventional light microscope and seeing the cells via the glass wall of the well using the low-power (10×) objective [9]. The discovery of degenerative alterations in monolayer cells indicates the presence of a virus [9]. The variety of morphological alterations include cell swelling, shrinkage, rounding, aggregation, syncytium development, and, in some instances, total obliteration of the monolayer. The alterations are collectively referred to as the cytopathogenic or cytopathic impact (CPE) of the virus [9].

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While the conventional cell culture technique is beneficial for cultivating diverse viruses, such as new or unidentified strains, and serves as the sole reference laboratory method capable of demonstrating viral infectivity, it requires days or even weeks to yield results, thereby impacting patient management and leading to suboptimal clinical outcomes [9,18].

Throughout the years, various modified cell culture techniques have been introduced to decrease the turnaround within 24 hours. Although rapid cell culture methods, such as shell vial culture, demonstrated comparable responsiveness for PIV 1-3 (87 percent versus eighty-three percent as well as influenza A/B, they exhibited significantly enhanced sensitivity for RSV. Nonetheless, numerous clinically significant viruses, such as RV and Co-V, remain challenging to cultivate and may yield inconclusive results. Furthermore, the utilization and upkeep of many cell lines want technological proficiency, rendering this procedure labor-intensive and viable just in select specialist facilities. Consequently, in contrast to molecular tests, conventional or altered cell culture techniques are labor-intensive, demonstrate elevated false-negative rates, and entail extended turnaround times, rendering viral culture less therapeutically relevant [18,36].

Rapid immunoassays are cost-effective, simple to execute, and may provide results in under 30 minutes; they are often referred to as Rapid Diagnostic Tests (RDTs). Consequently, they are indispensable in ambulatory primary care, emergencies, and low-resource environments [18,37]. Immunochromatographic tests are regarded as the most adaptable and widely used approach among several immunoassays [18]. Presently, commercially available rapid diagnostic tests (RDTs) for viral identification are mostly restricted to influenza A and B viruses, as well as respiratory syncytial virus (RSV). Although several studies have shown that rapid diagnostic tests (RDTs) have generally low sensitivity for influenza (FLU) and respiratory syncytial virus (RSV) (44–95%), they possess a better median selectivity (90 to 95 percent) in comparison to cell culture. Furthermore, the specificity of RSV immunoassays is notably greater in children (81%) than in adults (29%). Throughout the COVID-19 pandemic, many specialized rapid diagnostic tests (RDTs) for the recognition of SARS-CoV-2 were created and employed as point-of-care assays; nevertheless, their application is exclusively confined to the identification of this pathogen in nasal or pharyngeal swabs [38].

Concerning microorganisms, such tests facilitate the rapid identification of pathogens using respiratory, blood, or urine specimens, primarily for *S. pneumoniae*, *S. pyogenes*, *C. pneumoniae*, *M. pneumoniae*, and *Legionella*. The sensitivity for identifying group A Streptococcus ranges from 60% to 95%, with some tests exhibiting a sensitivity as low as 31%. Immunochromatographic tests for the identification of Legionella species. Urinary antigens provide speedy results within 15 minutes; nonetheless, they facilitate the diagnosis of serogroup 1 exclusively. The urine recognition of the polysaccharidic antigen C, found in all pneumococcal serotypes, demonstrated high sensitivity for confirmed invasive pneumococcal infection; however, the method's ability to differentiate between children with genuine pneumococcal diseases and those with rhinopharyngeal carriage remains contentious [27]. The use of such assays needs confirmation tests for a definitive diagnosis, particularly when a negative result is recorded during the respiratory infection season, contingent upon their sensitivity and specificity.

The serological assessment of particular antibody reactions has little use for the etiological diagnosis of respiratory tract infections, since diagnostic outcomes are only accessible retrospectively. Attempts have been undertaken to identify infections induced by slowly proliferating or challenging microbes by serological methods. This is especially true for M. pneumoniae, *C. Pneumoniae*, *Legionella* infections, and viruses. The most dependable serologic indication of an active infection is a fourfold rise in the titer of IgG (or IgG plus IgM) antibodies throughout the course of the disease, determined from two serum samples collected 7 to 10 days apart or longer, and/or the emergence of IgM antibodies throughout the disease progression. IgM assays often exhibit lower sensitivity and specificity compared to fourfold variations in antibody titers between matched specimens collected many weeks apart [39]. Historically, serological assays have been used to identify "difficult to isolate" respiratory infections, depending on the identification of IgM during the acute phase of the illness or the evidence of seroconversion [19].

Serology facilitates the detection of antibodies against various respiratory pathogens, including RSV, ADV, FLU A and B, along with PIV 1-3 viruses, in the context of viral respiratory tract infections. It can also identify mixed infections; however, specific antibodies generally emerge approximately two weeks post-

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infection [18,40]. Conversely, it has been shown that serological tests exhibit markedly lower sensitivity for the identification of PIV as well as ADV in comparison to molecular techniques [18,41]. Serum samples for diagnosing respiratory infections need careful consideration; the findings of diagnostic tests may be challenging to interpret due to the immune response elicited by prior exposure to the same pathogen [27]. Furthermore, serology is contraindicated for immunosuppressed people, neonates, or newborns due to their compromised immunological responses [27].

*The Role of Nurses in Managing Respiratory Tract Infections*

Nurses are integral to the management of respiratory tract infections (RTIs), playing a multifaceted role that encompasses patient assessment, specimen collection, and coordination of care. Their contributions are crucial in ensuring timely diagnosis and effective treatment, which are essential for improving patient outcomes [42]. One of the primary responsibilities of nurses is to perform thorough assessments of patients presenting with symptoms of RTIs. This includes obtaining a detailed medical history, assessing vital signs, and identifying risk factors such as age, comorbidities, and recent exposure to infectious agents. By recognizing the clinical manifestations of RTIs early, nurses can facilitate prompt laboratory evaluations, which are critical for establishing accurate diagnoses [43].

In the context of laboratory diagnostics, nurses are responsible for the collection and handling of respiratory specimens. They must adhere to strict protocols for specimen collection, ensuring that samples are obtained at the right time and stored appropriately to preserve their integrity. This attention to detail is vital, as the quality of the specimen directly influences the reliability of diagnostic results. Additionally, nurses must be knowledgeable about the various diagnostic tests available, including molecular techniques and syndromic panels, to provide accurate information to the healthcare team [44,45].

Nurses also play a key role in patient education and communication. They are responsible for explaining the purpose and process of diagnostic tests to patients, alleviating any concerns they may have. Furthermore, nurses must interpret laboratory results in collaboration with other healthcare professionals, using this information to inform treatment plans and monitor patient progress [46]. The role of nurses in managing respiratory tract infections extends beyond direct patient care to include vital responsibilities related to laboratory diagnostics. Their expertise in assessment, specimen handling, and patient education is essential for optimizing care and improving health outcomes for individuals affected by RTIs. Ongoing professional development and training in laboratory diagnostics will further empower nurses to meet the evolving challenges in the management of respiratory infections [47].

## Conclusions

This review examines the current technologies used for laboratory diagnosis of infectious respiratory diseases, highlighting that no single approach meets the needs of all diagnostic microbiology/virology laboratories in all clinical situations involving all types of bacteria/viruses. Clinical microbiologists and virologists must use the available technology that best fits the particular situation and yields the most useful results. As more sophisticated, yet simpler-to-use, broad-range molecular platforms become available, bacteria cultivation and/or virus isolation in cell culture may become mainly a research tool. Culture- and non-culture-based methods should be performed in parallel to optimize differential diagnosis of viral and microbial diseases.

The cost of molecular assays compared to conventional assays should be considered, with syndromic panels being expensive at about EUR 100–200 per sample. Conventional culture remains the gold-standard for detecting bacteria but suffers from several shortcomings, such as lower sensitivity and time-consuming results. Syndromic panels have the potential to be a powerful decision-making tool for patient management, especially in emergency departments. However, their use should be limited to symptomatic subjects, immunocompromised patients, children less than 5 years old, and the elderly, and avoided in asymptomatic subjects or mild infections.

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# تأثير التشخيصات المخبرية على إدارة التمريض للعدوى الجهاز التنفسي: مراجعة للتقنيات الحالية وآثارها على رعاية المرضى

**المستخلص**

**الخلفية :**تمثل عدوى الجهاز التنفسي تحدياً صحياً عاماً كبيراً بسبب انتشارها العالي ومعدلات المراضة والوفيات المرتبطة بها. التشخيصات المخبرية الدقيقة وفي الوقت المناسب ضرورية لإدارة التمريض الفعالة لهذه العدوى، مما يضمن العلاج المناسب ويقلل من سوء استخدام المضادات الحيوية.

**الطرق :**تستعرض هذه المراجعة الأدبيات الحالية حول تقنيات التشخيص المخبرية لعدوى الجهاز التنفسي، مع التركيز على دور الألواح المتلازمية والتقنيات الجزيئية في الكشف عن مسببات الأمراض البكتيرية والفيروسية. يناقش الاتجاهات الوبائية لعدوى الجهاز التنفسي، ومنهجيات التشخيص، وآثارها على إدارة التمريض في البيئات السريرية.

**النتائج :**ساهمت التطورات الأخيرة في تقنيات التشخيص، خاصةً الطرق الجزيئية، في تحسين دقة وسرعة تحديد عدوى الجهاز التنفسي، وهو أمر ضروري للإدارة الفعالة للمرضى. تتيح الألواح المتلازمية الكشف المتزامن عن العديد من مسببات الأمراض، مما يسهل اتخاذ القرارات السريرية السريعة. ومع ذلك، تبقى التحديات بما في ذلك تكلفة الفحوصات الجزيئية والحاجة إلى جمع العينات والتعامل معها بشكل مناسب لضمان موثوقية التشخيص.

**الخاتمة :**يعتبر دمج التشخيصات المخبرية المتقدمة في الممارسة التمريضية أمرًا حيويًا لتحسين النتائج للمرضى المصابين بعدوى الجهاز التنفسي. يلعب الممرضون دوراً حيوياً في عملية التشخيص، من جمع العينات إلى تفسير النتائج، مما يوجه قرارات العلاج. هناك حاجة مستمرة للتعليم والتدريب لتجهيز محترفي التمريض بالمهارات اللازمة لاستخدام هذه التطورات بفعالية.

**الكلمات المفتاحية :**عدوى الجهاز التنفسي، التشخيصات المخبرية، إدارة التمريض، الألواح المتلازمية، التقنيات الجزيئية.