IFBLS

INTERNATIONAL JOURNAL OF BIOMEDICAL LABORATORY SCIENCE

Volume 13 • Number 1/2024 • Pages 1 - 76 • www.ijbls.org

Antimicrobial Resistant Trend of E. coli and ESKAPE Pathogens from Urine Cultures in Central Alabama

IJBLS e-Journal Published by International Federation of Biomedical Laboratory Science
Online ISSN: 2308-7706

INTERNATIONAL JOURNAL OF BIOMEDICAL LABORATORY SCIENCE

Published by IFBLS
International Federation of Biomedical Laboratory Science

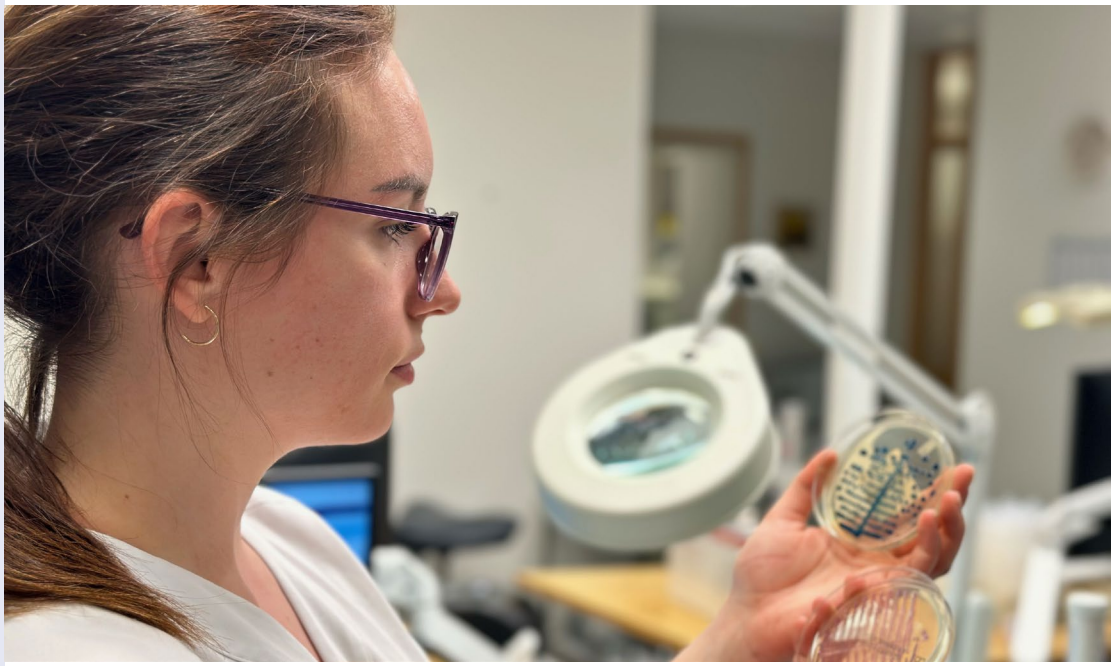
www.ifbls.org
communications@ifbls.org
Telephone: 001 905 667 8695
Fax: 001 905 528 4968
33 Wellington Street North
Hamilton, Ontario
L8R 1M7
CANADA

Online ISSN: 2308-7706

IJBLS is a free access on-line peer-reviewed journal, published bi-annually

Current issue: April 2024
Next issue: October 2024

Contents



- **Editorial** *Patricia Tille* Advancing the Laboratory Profession!.....Page 4
- **Research article** Generation of a Diagnostic Algorithm that Utilizes ESR and CRP Values in the Detection of Osteomyelitis in Patients with Comorbidities.....Pages 5 – 14
- **Research article** Using Simulation to Introduce Students to a Medical Laboratory Information System.....Pages 15 – 20
- **Research article** Antimicrobial Resistant Trend of E. coli and ESKAPE Pathogens from Urine Cultures in Central Alabama.....Pages 21 – 31
- **Research article** Influence of COVID-19 Pandemic on Breast Cancer Diagnosis and Treatment in Low Resource Setting: A Case Study of a Nigerian Tertiary Healthcare Facility.....Pages 32 – 40
- **Research article** Action Plan for the Future – the Situation for Biomedical Laboratory Scientists (BLS) in Denmark, Finland, Norway, and Sweden.....Pages 41 – 49
- **Research article** Social Support and Inclusion in Enhanced Adherence Counselling among High Viral Load HIV Seropositive Patients in Abuja, Nigeria.....Pages 50 – 63
- **Review article** Creating Psychological Safety in the Medical Laboratory Science Profession: From Workplace Culture to Education.....Pages 64 – 75

INTERNATIONAL JOURNAL OF BIOMEDICAL LABORATORY SCIENCE

IJBLS seeking reviewers!

As part of the International Journal of Biomedical Sciences commitment to providing opportunities for all authors to publish and share information across the globe, the editorial board is dedicated to promoting mentorship of new authors and editors. We are always seeking reviewers for submitted works to the journal. If you are interested in serving as a reviewer, please send a short cover letter with your area of interest and a resume or curriculum vitae to the editor in chief, Dr. Pat Tille.

IJBLS active reviewers

In addition to the associate editors, IJBLS would also like to acknowledge those additional professionals who currently serve as active reviewers for the journal.

- Stephanie Jacobson DCLS, MLS (ASCP)CM, AHI(AMT)
- Erin Rumpke MS MLS(ASCP)CM, AHI(AMT)
- Elizabeth Warning MS MLS(ASCP)CM, AHI(AMT)
- Adrienne E. Davis Zapfe, EdD, MHA, MLS (ASCP)CM, AHI (AMT)
- Demetra Castillo M.Ed. MLS (ASCP) AHI(AMT)
- Cathy Otto, PhD, MBA, MLS(ASCP)

Patricia Tille
editor-in-chief@ijbls.org

IJBLS for Biomedical Laboratory Scientists

The International Journal of Biomedical Laboratory Science (IJBLS) is an on-line peer-reviewed journal published bi-annually by International Federation of Biomedical Laboratory Sciences (IFBLS).

The journal is intended to disseminate information and knowledge to the international laboratory community by accepting a variety of manuscripts for publication. Those manuscripts should be original research articles, literature or mini-reviews, case studies, brief communications and letters to the editor describing original investigations in all fields of biomedical laboratory sciences.

This journal is the ideal place for all Biomedical Laboratory Scientists, whether recognized experts in the field or starting their career, to publish their findings.

The Editor and Editorial Board are here to help you publish your work.

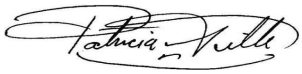
Editorial

Advancing the Laboratory Profession!

Patricia Tille Ph.D MLS(ASCP) AHI (AMT) FASCs
IJBLS Editor in Chief

The laboratory science profession has struggled for decades with defining the value of the laboratory along with advancing the profession in health care. This past year, the Centers for Medicare and Medicaid Services in the United States (US) made significant changes to the Clinical Laboratory Improvement Amendments (CLIA). The ruling covers several major points. 1) Changed the definition of the traditional continuing medical education (CME) credits to include other opportunities for continuing education. This supports the role of others outside of medical doctors serving as laboratory directors. 2) Removed physical science as a qualifying degree for laboratory science. 3) Strengthened the language regarding those qualified to perform moderate and high complexity laboratory testing. 4) Removed nursing as a degree to qualify for a laboratory director under § 493.1405(b). 5) Support the standardization in nomenclature within the United States for baccalaureate degree professionals as medical laboratory scientists. 6) Supported and confirmed that the Doctor of Clinical Laboratory Scientist (DCLS) is a qualifying degree for a high complexity laboratory director (HCLD) provided they have the requisite experience and past a certification exam. These are all major milestones that will elevate the laboratory profession within the US health system.

Let's look at the DCLS a little closer. The DCLS is a clinical professional doctoral program designed to prepare graduate laboratory professionals with prior clinical training for advanced clinical practice and teaching careers in medical laboratory science. "The DCLS increases diagnostic efficiency, facilitates patient management outcomes, and improves timely access to accurate and appropriate laboratory information by participating directly in patient care decisions, monitoring laboratory utilization, and conducting research on the diagnostic process." Individuals with a DCLS are experts in clinical laboratory testing. The DCLS contributes to increasing laboratory efficiency, improves timely access to accurate and appropriate laboratory information through appropriate test selection and interpretation of test results; monitoring laboratory data and testing processes, and directs laboratory operations to comply with all state and Federal laws and regulations. A DCLS plays a critical role in ensuring high quality, appropriate patient care by overseeing the clinical, scientific and related operational aspects of the diagnostic laboratory. The scope of laboratories has become increasingly complex requiring an HCLD to have a combination of technical and medical knowledge related to laboratory methods and the limitations to ensure quality and accuracy of laboratory results. The advancement of the laboratory profession will continue to grow with the increasing demand for a higher level of knowledge and practitioners. It is also important to acknowledge that we have multiple masters level practitioners and Doctor of Philosophy (Ph.D.) professionals that have been working throughout the field of laboratory science for many decades. The DCLS does not replace the expertise and value provided by those professionals, it expands and strengthens the professional expertise across all clinically relevant fields. Now is the time for the laboratory profession to continue to grow and for others in health care and the public to understand the significant role laboratory plays in their daily care!



Patricia Tille Ph.D. MLS(ASCP) AHI(AMT) FACSc

Research article

Generation of a Diagnostic Algorithm that Utilizes ESR and CRP Values in the Detection of Osteomyelitis in Patients with Comorbidities

Mindy Manek[1], Vicki S. Freeman[1], Jose H. Salazar[1], Juan U. Rojo[1*]

[1] Department of Clinical Laboratory Sciences, School of Health Professions, University of Texas Medical Branch, Galveston, Texas, USA

Background: **Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) tests are routinely ordered for differentiating osteomyelitis from cellulitis. However, ESR and CRP values are often overlooked and clinical decisions for diagnosis and treatment of osteomyelitis are primarily based on results of imaging exams. Furthermore, current clinical guidelines do not recommend the use of ESR and CRP as markers for osteomyelitis. Nonetheless, ESR and CRP continue being incorporated in the panel of tests ordered in patients suspected of having osteomyelitis. This practice leads to overutilization and unnecessary testing which can delay proper diagnosis and treatment. In an effort to reduce unnecessary ordering of ESR and CRP tests by providing evidence-based guidelines, this study identified a patient population for which ESR and CRP laboratory values may be clinically significant in detecting osteomyelitis.**

Methods: **A retrospective study from medical records of patients diagnosed with cellulitis and osteomyelitis was completed. Laboratory values of white blood cell (WBC) count, ESR, and CRP were compared between patients presenting with comorbidities and without comorbidities. Optimal cutoff values for ESR and CRP were identified, and a diagnostic algorithm was generated. A second population was utilized to test the performance of the algorithm in differentiating osteomyelitis from cellulitis by utilizing ESR and CRP test results.**

Results: **WBC, ESR and CRP did not provide clinically significant results to identify osteomyelitis in the total patient cohort. However, when grouping patients based on the presence or absence of comorbidities, a cutoff value of > 90 mm/hr for ESR and a value of >10.0 mg/dL for CRP was statistically significant only in the group of patients with comorbidities. Based on the established cutoffs, a diagnostic algorithm was generated which, when tested, demonstrated the ability to correctly identify 97.1% of test patients with a diagnosis of osteomyelitis.**

Conclusion: **The results provide guidelines for the possible better utilization of ESR and CRP when evaluating patients suspected of osteomyelitis. This study suggests the use of a diagnostic algorithm to effectively utilize ESR and CRP test results in a population where the values were demonstrated to be clinically significant.**

Keywords: ESR, CRP, diagnostic algorithm, comorbidities, osteomyelitis, and cellulitis

---

Accepted: December 10, 2023

*Corresponding author: Juan U. Rojo. E-mail: jurojo@utmb.edu.
Tel: 1+(409)772-9476; 301 University Blvd., Galveston, TX, 77555-0128, USA.

Introduction

Accurate and timely diagnosis of osteomyelitis is critical as bone infections are associated with surgeries, amputations, extended exposure to antibiotics, gastrointestinal complications, and acute kidney injury.[1] If osteomyelitis is not properly diagnosed and differentiated from cellulitis, the infection can spread to other parts of the body hence increasing the risk for amputation and septic shock. While the optimal procedure to diagnose osteomyelitis is with bone biopsy results, the practice is not routinely performed due to the invasive nature of the procedure.[2,3] Instead, less invasive methods such as imaging exams, WBC count, ESR, and CRP are the preferred tests for the diagnosis of osteomyelitis.[4,5] However, WBC count, ESR, and CRP are not specific markers for osteomyelitis as they assess overall inflammation regardless of cause.[6–10] Moreover, recommenddations by the Infectious Disease Society of America (IDSA) do not include ESR and CRP testing when evaluating patients for osteomyelitis, rather, the 2012 IDSA Clinical Practice Guidelines suggest the diagnosis of osteomyelitis should be determined by clinical examination and imaging studies.[11]

Despite the IDSA recommendations, ESR and CRP continue being part of the routine testing in the evaluation of patients suspected with osteomyelitis.[12] And, often times, regardless of ESR and CRP values, diagnosticians rely on advanced imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) studies when there is a high index of suspicion for osteomyelitis.[1] Thus, it is important to reassess the diagnostic utility of ESR and CRP when the values are often overlooked and higher diagnostic utility is applied to imaging reports.[12,13]

The practice of discontinuing the use of ESR and CRP for the diagnosis of osteomyelitis may not be immediately possible. Thus, better guidelines can be implemented to improve the clinical utility and continued use when appropriate. Several studies identified ESR and CRP to be of diagnostic utility in diagnosing osteomyelitis of the foot in patients with diabetes.[1,14,15] The variability of ESR and CRP levels observed may be due to the presence of comorbidities or due to other non-infectious inflammatory conditions.[16] Most studies that have evaluated the clinical significance of ESR and CRP have primarily focused on patients with diabetes. Hence, further studies that consider other types of comorbidities are needed to better understand how predisposing conditions may have an impact on the clinical value of ESR and CRP tests.

The purpose of this study was to evaluate the diagnostic utility of ESR and CRP to detect osteomyelitis and determine if there are differences in patient populations that could benefit from the use of the tests. This study is a retrospective analysis of laboratory values from patients diagnosed with cellulitis or osteomyelitis at an academic teaching hospital. ESR and CRP cutoff values to distinguish osteomyelitis from cellulitis in patients with and without comorbidities were established to generate a diagnostic algorithm. Then, a second population was utilized to test the accuracy of the algorithm in identifying patients with osteomyelitis. It is intended that having clear ESR and CRP cutoff values, along with a decision tree, can be an effective method to evaluate patients suspected of osteomyelitis.

Methodology

After obtaining IRB approval (IRB# 23-0013), a non-experimental, quantitative, retrospective, non-blinded study was performed using EPIC to retrieve medical records of patients diagnosed with cellulitis (ICD-10 L03) or osteomyelitis (ICD-10 M86) from January 1, 2018, to December 31, 2022, admitted at an 800-bed academic hospital. Demographic data of age, sex, and race/ethnicity were included to assess relationship on outcome measures. Laboratory values included in the analysis comprised of WBC count, CRP, and ESR values obtained within 72 hours of hospital admission. Comorbidities were defined as patients

presenting with a current or previous diagnosis of cardiac disease (ICD-10 151.9), peripheral vascular disease (ICD-10 173.9), diabetes mellitus (ICD-10 E08), and/or chronic inflammatory disease (ICD-10 G61; K50; K51; J44). Pregnant patients, patients with history of immunosuppressive therapy, autoimmune diseases and immunodeficiencies were excluded as well as patients who did not have an ESR or CRP test performed within 72 hours of admission. Test results for high-sensitivity CRP (hs-CRP) were not included in this study.

A *priori* power analysis and review of previous research was used to determine the appropriate sample size. A two-tailed test with a type I error set at α = 0.05 and a power of 0.95 using *t* test in G*Power software estimated a *priori* sample size of 54 participants for the generation of the algorithm. Contingency tables were created to organize statistical variables that included comparison of factors between patients with cellulitis and with osteomyelitis as well as reliability of WBC, ESR, and CRP for identifying osteomyelitis. Patient demographics and comorbidities were analyzed using Student's *t* test and Mann-Whitney *U* test for continuous variables; x^2 test for homogeneity and Fisher exact test for categorical variables. Receiver operating characteristic (ROC) curve analysis and descriptive statistical analysis were used to determine the performance of WBC, ESR, and CRP tests. Optimal cutoff values were established using maximum Youden's value for WBC, ESR, and CRP in detecting osteomyelitis. Cohen's *d* test was utilized to convert the ROC area under the curve (AUC) value to measure the effect size.[17-19] A *p-value* of ≤0.05 was used to determine the statical significance of the data analyzed.

Results

Establishing the optimal cutoff values for WBC, ESR and CRP

Data from medical records of patients diagnosed with cellulitis or osteomyelitis from January 1, 2018, through June 30, 2022, was used as a data subset to establish optimal cutoff values for WBC, ESR and CRP. A total of 264 patients were identified out of which 127 had a diagnosis of cellulitis and 137 of osteomyelitis (Table 1).

Table 1. Comparison of factors between patients with cellulitis or osteomyelitis. Descriptive statistics were used to calculate frequencies, median values and IQR between 25th and 75th quartiles. Sex, race/ethnicity, and comorbidities are presented for n and percentage of specified group. Percentages are displayed in parentheses. IQR = interquartile range, WBC = white blood cell, CRP = C-reactive protein, ESR = erythrocyte sedimentation rate. *p-value determined using Student's t test and Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables

.

Parameter	Total Cohort n = 264		Cellulitis n = 127		Osteomyelitis n = 137		
	Median	IQR	Median	IQR	Median	IQR	*p* value*
Age; median years	61.1	50.050 - 70.025	61.5	49.900 - 71.500	60.8	50.100 - 68.450	0.784
Sex; n (%)							
Male	191	(72.3)	87	(68.5)	104	(75.9)	0.215
Female	73	(27.7)	40	(31.5)	33	(24.1)	0.215
Race/Ethnicity; n (%)							
Caucasian/White	141	(53.4)	71	(55.9)	70	(51.1)	0.460
Black or African American	45	(17.0)	21	(16.5)	24	(17.5)	0.871
Hispanic or Latino	75	(28.4)	33	(26.0)	42	(30.7)	0.416
American Indian or Alaskan Native	2	(0.8)	1	(0.8)	1	(0.7)	1.000
Asian	1	(0.4)	1	(0.8)	0	(0.0)	0.481
Comorbidities; n (%)							
Cardiovascular disease	27	(10.2)	14	(11.0)	13	(9.5)	0.690
Peripheral vascular disease	72	(27.3)	24	(18.9)	48	(35.0)	0.004
Diabetes mellitus	87	(33.0)	22	(17.3)	65	(47.4)	<0.001
Chronic inflammatory disease	10	(3.8)	4	(3.1)	6	(4.4)	0.751
Laboratory values							
WBC (10^3/μL) (baseline)	9.97	7.23 - 13.83	10.69	7.22 - 13.93	9.46	7.21 - 13.75	0.280
CRP (mg/dL)	7.8	2.23 - 16.85	7.8	2.40 - 16.60	7.8	2.00 - 16.95	0.444
ESR (mm/h)	65	40.00 - 99.75	58	31.0 - 91.0	80	46.0 - 107.5	0.001

Age comparison of patients demonstrated no statistically significant difference in age with a total cohort mean age of 61.1 years old. No significant difference in the occurrence of cellulitis and osteomyelitis based on sex was observed. The study population consisted of 53.4% Caucasian/White patients, followed by 28.4% Hispanic/Latino, 17.0% Black/African American, 0.8% American Indian, and 0.4% Asian patients.

Diabetes mellitus was the predominant comorbidity in the total study population with an overall prevalence of 33% followed by 27.3% with peripheral vascular disease, 10.2% with cardiovascular disease, and 3.8% with chronic inflammatory disease. The total study population was categorized to identify patients diagnosed with cellulitis or osteomyelitis presenting with or without comorbidities (**Figure 1**). A total of 49 patients presented with cellulitis and comorbidities, 78 with cellulitis without comorbidities, 94 with osteomyelitis with comorbidities, and 43 with osteomyelitis

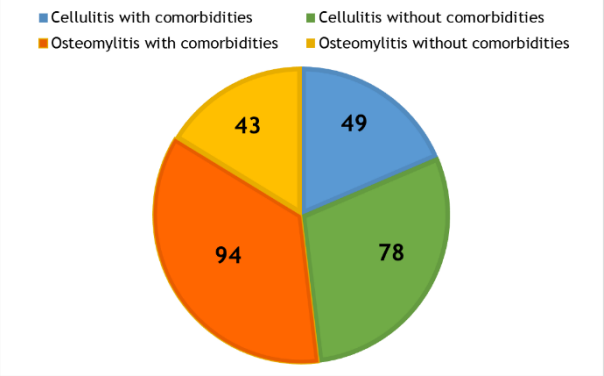
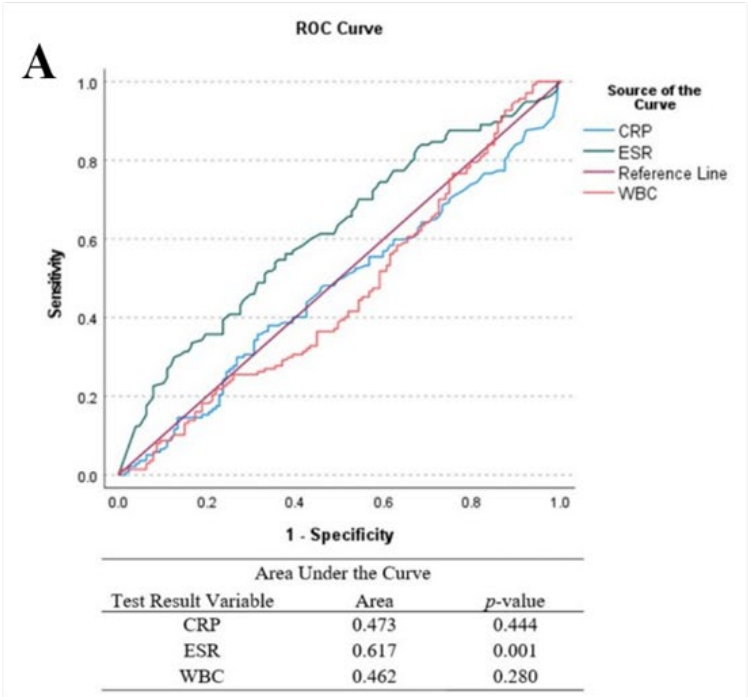


Figure 1. Classification of total cohort of patients. Orange = patients diagnosed with osteomyelitis and comorbidities, green = patients diagnosed with cellulitis without comorbidities, blue = patients diagnosed with cellulitis with comorbidities, and yellow = patients diagnosed with osteomyelitis without comorbidities.

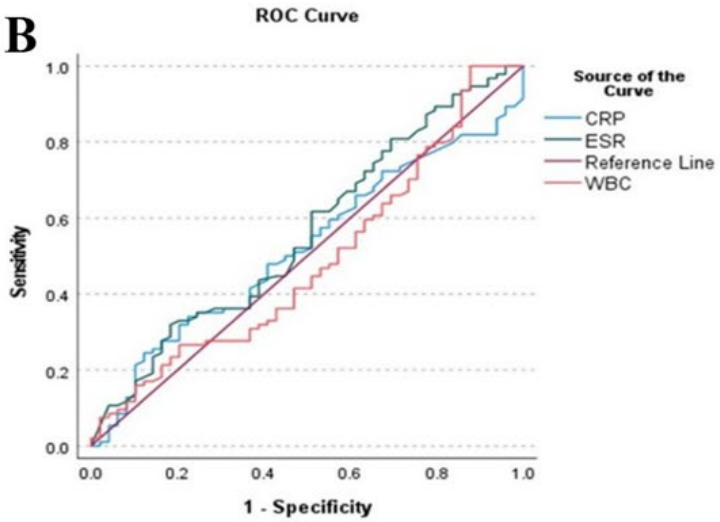
ROC curves were used to determine test performance of WBC, CRP, and ESR in the total cohort, patients with comorbidities, and patients without comorbidities (**Figure 2**). In the total cohort which included patients with and without comorbidities (**Figure 2A**), ESR gave a sensitivity of 61.7% (95% CI 55.0-68.5). The AUC was converted to Cohen's *d* giving a small effect size for ESR.[17] CRP and WBC gave overall sensitivities of 47.3% (95% CI 40.3-54.2) and 46.2% (95% CI 39.1-53.2), respectively. For CRP and WBC, the AUC was below 0.5 and therefore provided no discriminatory ability in detecting osteomyelitis. The ROC in the patients with comorbidities group (**Figure 2B**) showed ESR to have an overall sensitivity of 56.1% (95% CI 46.1-66.1). This converted to Cohen's *d* gave a small effect size of 0.217.[17] CRP and WBC gave overall sensitivities of 51.9% (95% CI 42.3-61.6) and 48.6% (95% CI 38.5-58.8), respectively. The AUC was calculated for CRP and converted to Cohen's *d* gave a negligible effect size of 0.067. The AUC for WBC had no discriminatory ability as it was below 0.5 and the effect size could not be evaluated. For the group of patients without comorbidities (**Figure 2C**), the ESR had an overall sensitivity of 61.2% (95% CI 49.7-72.6) which converted to Cohen's *d* gave a small effect size of 0.402. CRP and WBC gave overall sensitivities of 45.0% (95% CI 34.0-56.1) and 44.1% (95% CI 33.6-54.7), respectively. The AUC of CRP and WBC had no discriminatory ability to differentiate osteomyelitis from cellulitis in patients with comorbidities as they were below 0.5.

Contingency tables were created to detect optimal cutoff values for WBC, ESR, and CRP. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive and negative likelihood ratios (LR+ and LR-), odds ratios, and 95% CI were established for the total cohort (**Table 2**), patients with comorbidities (**Table 3**), and patients without comorbidities (**Table 4**). In the total cohort, an ESR value of >70 mm/hr gave an overall sensitivity of 70.2% with a specificity of 50.0%. However, WBC and CRP performed poorly. In patients with comorbidities, odds ratios and 95% CI demonstrated an ESR level of > 90 mm/hr and CRP level of > 10.0 mg/dL to have the greatest values for detecting osteomyelitis in patients with comorbidities. For patients without comorbidities, the data calculated did not provide significant results in establishing optimal cutoff to differentiate osteomyelitis from cellulitis. Similarly, WBC count could not



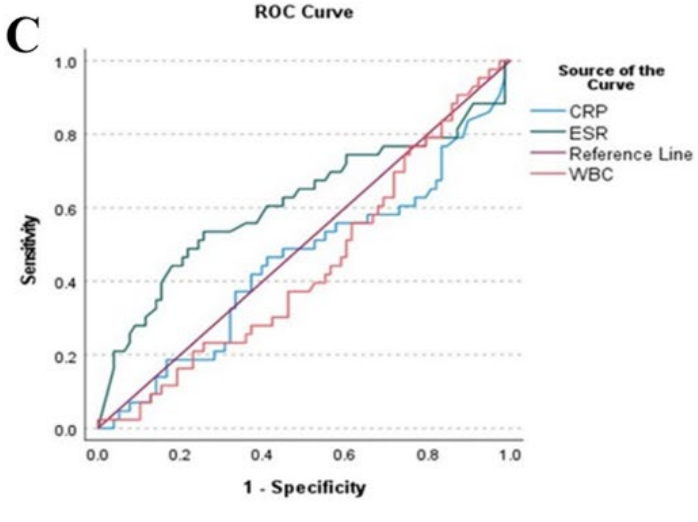
Area Under the Curve

Test Result Variable	Area	*p*-value
CRP	0.473	0.444
ESR	0.617	0.001
WBC	0.462	0.280



Area Under the Curve

Test Result Variable	Area	*p*-value
CRP	0.519	0.694
ESR	0.561	0.230
WBC	0.486	0.793



Area Under the Curve

Test Result Variable	Area	*p*-value
CRP	0.450	0.379
ESR	0.612	0.056
WBC	0.441	0.275

Figure 2. Receiver operating characteristic (ROC) curves for C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cell (WBC) count to detect osteomyelitis. A) Total cohort. B) Patients with comorbidities. C) Patients without comorbidities.

provide significant values for establishing cutoff values in any of the groups. The results from the contingency tables were used to construct an algorithm based on the presence or absence of comorbidities and utilizing ESR and CRP values for the detection of osteomyelitis (**Figure 3**).

Testing the performance of the diagnostic algorithm

A second population of 35 patients diagnosed with osteomyelitis or cellulitis from July 1, 2022, to December 31, 2022, was utilized to test the accuracy of the generated algorithm. A two-tailed test with a type I error set at $\alpha = 0.05$ and power of 0.95 in G*Power software demonstrated the study population of 35 patients to meet the minimum effect size criteria with a power of 81.65%. Each of the 35

patients was individually tested by following the algorithm guidelines in which presence or absence of comorbidities defined the need to look up associated ESR or CRP values. If ESR value was > 90 mm/hr, CRP test results were evaluated in which values > 10.0 mg/dL indicated a diagnosis of osteomyelitis. The patient classification by the algorithm was compared to the actual medical records and final diagnosis notes. Following this approach, 34 of the 35 patients tested were correctly identified by the algorithm (**Table 5**). The patients tested had an even representation across ESR and CRP values as well as both patient groups with and without comorbidities were represented.

Table 2. Diagnostic reliability of WBC, ESR, and CRP values for distinguishing osteomyelitis from cellulitis in total cohort including patients with and without comorbidities. WBC = white blood cell; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; OR = odds ratio; CI = confidence interval.

Parameter	Sensitivity	Specificity	PPV	NPV	LR+	LR-	OR	95% CI
Laboratory value:								
WBC (x10^3/μL)								
>10	0.443	0.442	0.473	0.452	0.892	1.211	0.887	0.310 - 0.575
>15	0.529	0.444	0.513	0.517	1.043	0.929	1.140	0.350 - 0.708
>20	0.528	0.444	0.529	0.526	1.125	0.9	1.106	0.095 - 0.960
ESR (mm/hr)								
>20	0.223	0.385	0.375	0.341	0.600	1.733	0.716	0.000 - 0.458
>30	0.547	0.458	0.537	0.527	1.163	0.897	1.028	0.272 - 0.822
>40	0.536	0.583	0.545	0.538	1.163	0.838	1.063	0.320 - 0.753
>50	0.667	0.545	0.579	0.590	1.375	0.698	1.223	0.439 - 0.894
>60	0.698	0.250	0.609	0.563	1.556	0.778	1.321	0.483 - 0.914
>70	0.702	0.500	0.600	0.593	1.464	0.686	1.251	0.405 - 1.000
>80	0.450	0.500	0.466	0.470	0.875	1.071	0.911	0.195 - 0.705
>90	0.618	0.516	0.581	0.607	1.388	0.646	1.046	0.497 - 0.740
CRP (mg/dL)								
>1.0	0.491	0.522	0.497	0.502	0.990	0.994	0.905	0.326 - 0.655
>3.0	0.509	0.400	0.517	0.535	1.071	0.868	1.115	0.278 - 0.740
>6.0	0.480	0.600	0.444	0.444	0.800	0.667	0.148	0.070 - 0.890
>7.0	0.595	0.444	0.563	0.559	1.286	0.788	3.173	0.306 - 0.885
>8.0	0.580	0.667	0.556	0.571	1.250	0.750	2.103	0.337 - 0.823
>10.0	0.599	0.618	0.569	0.550	1.321	0.773	1.289	0.400 - 0.799
>15.0	0.369	0.333	0.420	0.430	0.724	1.324	0.676	0.112 - 0.626
>20.0	0.497	0.500	0.478	0.490	0.914	1.036	0.988	0.324 - 0.670

Table 3. Diagnostic reliability of WBC, ESR, and CRP values for distinguishing osteomyelitis from cellulitis in patients with comorbidities. WBC = white blood cell; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; OR = odds ratio; CI = confidence interval.

Parameter	Sensitivity	Specificity	PPV	NPV	LR+	LR-	OR	95% CI
Laboratory value:								
WBC (x10^3/μL)								
>10	0.465	0.444	0.487	0.455	0.926	1.200	1.053	0.685 - 1.619
>15	0.587	0.625	0.552	0.529	1.204	0.857	0.851	0.573 - 1.265
ESR (mm/hr)								
>20	0.565	0.571	0.534	0.545	1.130	0.818	0.967	0.837 - 1.117
>40	0.539	0.545	0.520	0.514	1.083	0.941	0.977	0.864 - 1.105
>70	0.429	0.286	0.483	0.439	0.933	1.167	1.072	0.866 - 1.329
>90	0.632	0.500	0.581	0.607	1.385	0.586	0.943	0.881 - 1.009
CRP (mg/dL)								
>1.0	0.536	0.500	0.530	0.523	1.089	0.897	1.138	0.287 - 4.519
>3.0	0.607	0.571	0.565	0.560	1.275	0.786	0.685	0.281 - 1.671
>7.0	0.538	0.500	0.530	0.550	1.094	0.821	0.735	0.281 - 1.919
>10.0	0.753	0.700	0.667	0.636	1.613	0.571	0.690	0.486 - 0.980
>20.0	0.400	0.400	0.435	0.444	0.769	1.202	1.039	0.946 - 1.141

Table 4. Diagnostic reliability of WBC, ESR, and CRP values for distinguishing osteomyelitis from cellulitis in patients without comorbidities. WBC = white blood cell; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; OR = odds ratio; CI = confidence interval.

Parameter	Sensitivity	Specificity	PPV	NPV	LR+	LR-	OR	95% CI
Laboratory value:								
WBC (x10^3/µL)								
>10	0.378	0.440	0.417	0.429	0.714	1.328	1.393	0.755 - 2.570
>15	0.392	0.474	0.438	0.435	0.768	1.299	1.032	0.888 - 1.198
ESR (mm/hr)								
>20	0.403	0.556	0.429	0.470	0.750	1.129	1.093	0.762 - 1.568
>40	0.438	0.500	0.471	0.455	0.873	1.100	1.027	0.853 - 1.237
>60	0.458	0.583	0.382	0.467	0.619	1.143	1.166	0.617 - 2.203
>70	0.556	0.444	0.529	0.571	1.125	0.750	0.975	0.816 - 1.164
>90	0.570	0.500	0.533	0.550	1.146	0.819	0.974	0.910 - 1.041
CRP (mg/dL)								
>1.0	0.424	0.444	0.360	0.471	0.563	1.125	1.593	0.238 -10.654
>3.0	0.385	0.462	0.421	0.457	0.731	1.192	1.738	0.396 - 7.624
>7.0	0.273	0.455	0.157	0.397	0.229	1.519	6.331	0.257-155.746
>10.0	0.486	0.563	0.506	0.504	1.026	0.971	1.009	0.813 - 1.250
>20.0	0.533	0.474	0.504	0.503	1.018	0.990	0.992	0.903 - 1.089

Table 5. Performance of the proposed diagnostic algorithm in identifying patients with osteomyelitis. Percentages are displayed in parenthesis. ESR = erythrocyte sedimentation rate; CRP = C-reactive protein.

	Comorbidities n = 12		No Comorbidities n = 23		Met Algorithm Requirements n = 34		Failed Algorithm Requirements n = 1	
Laboratory value, n (%)								
ESR < 40 mm/hr	3	(8.6)	5	(14.3)	7	(20.0)	1	(2.9)
ESR 40 - 90 mm/hr	3	(8.6)	9	(25.7)	12	(34.3)	0	(0)
ESR > 90 mm/hr	6	(17.1)	9	(25.7)	15	(42.9)	0	(0)
CRP ≤ 10.0 mg/dL	4	(11.4)	11	(31.4)	15	(42.9)	0	(0)
CRP > 10.0 mg/dL	8	(22.9)	12	(34.3)	20	(57.1)	0	(0)
Overall algorithm performance, n (%)					34	(97.1)	1	(2.9)

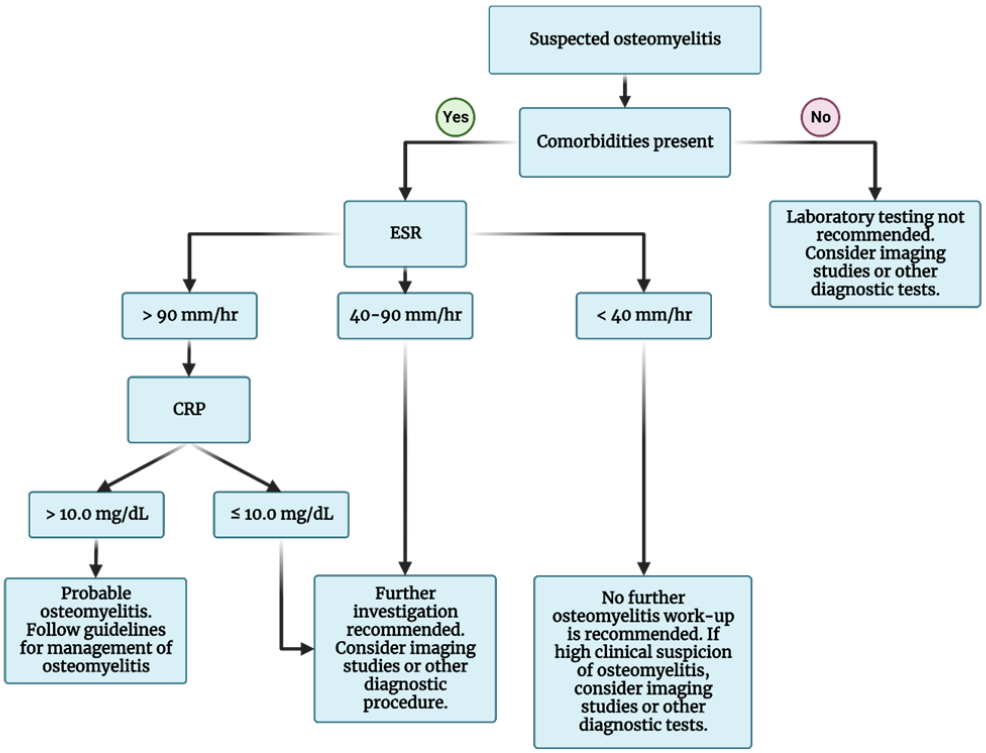


Figure 3. Proposed diagnostic algorithm for the recommended approach to utilizing ESR and CRP in the diagnosis of osteomyelitis. Graphic designed with Biorender.com. ESR = erythrocyte sedimentation rate; CRP = C-reactive protein.

Discussion

In order to establish clear guidelines for the proper utilization of laboratory tests, cutoff values for ESR and CRP were evaluated by comparing patients that present comorbidities and those without. When evaluating ESR and CRP results from the total cohort in detecting osteomyelitis, ESR demonstrated fair performance when > 70 mm/hr and CRP performed poorly at all interval values which correlates with previous studies that report the diagnostic limitations of ESR and CRP tests.[20] However, after the total cohort patient population was grouped into those that present comorbidities (cardiac disease, peripheral vascular disease, diabetes mellitus, or chronic inflammatory disease) and those who do not present comorbidities, the ROC AUC demonstrated ESR to be able to detect osteomyelitis in the patients with comorbidities group only. Likewise, using contingency tables, the diagnostic reliability of ESR and CRP for distinguishing osteomyelitis from cellulitis was found to be statistically significant when ESR > 90 mm/hr and CRP > 10.0 mg/dL in the group of patients that presented comorbidities.

Having clear cutoff values for non-specific inflammatory markers can improve patient outcomes. Based on an evaluation of the current literature, the diagnostic value of establishing cutoff values for ESR and CRP improved patient outcomes. In the diagnosis of periprosthetic infection, ROC analysis and contingency tables demonstrated ESR and CRP to have a sensitivity of 94.3% and 91.1% respectively when an ESR threshold of 30 mm/hr and a CRP cutoff of 10 mg/L were used.[21] In another study, an ESR specific cutoff of 25-30 mm/hr was shown to be useful in the assessment of systemic lupus erythematosus (SLE).[22] Likewise, a CRP cutoff value of > 20 mg/dL was utilized as a risk factor indicator for septic arthritis in children.[23] It is indicated that when used appropriately, ESR and CRP can be highly effective at detecting certain conditions.

Based on the cutoff values obtained from this study, a diagnostic algorithm to detect osteomyelitis was created to guide the diagnostician in selecting appropriate testing by taking into consideration the presence or absence of comorbidities. This algorithm was able to correctly identify 97.1% of the subjects as diagnosed with osteomyelitis. The study presented here appears to be the first to propose a diagnostic algorithm detailing the use of ESR and CRP for the identification of osteomyelitis associated with the presence of comorbidities.

The data presented in this study suggest that patients without comorbidities do not benefit from having an ESR or CRP test performed. Only patients with comorbidities should have an ESR test completed, and if results are greater than 90 mm/hr, follow up with a CRP test, in which only a value >10 mg/dL would suggest osteomyelitis. This is in agreement with other studies that demonstrated ESR and CRP to have little diagnostic utility in detecting osteomyelitis of the foot in nondiabetic patients, but in the case of patients with diabetes, an ESR > 60 mm/hr and CRP > 7.9 mg/dL were found to be optimal cutoff values to initiate treatment for osteomyelitis.[1]

Having clear cutoff values along with an algorithm can benefit diagnosticians in making clinical decisions and reduce overutilization of laboratory tests. As an example, the London Health Sciences Center (LHSC), a tertiary-care hospital located in Ontario, Canada, implemented an educational bulletin and a clinical decision support system to decrease by 40% unnecessary ESR testing which translated to a cost savings of $11,000 Canadian Dollars (CAD) per year.[12]

Similar approaches that derive from utilizing statistical methods such as ROC and contingency tables should be further explored when defining cutoff values. Likewise, establishing specific values or thresholds should be determined for laboratory tests and include consideration of the patients' conditions. The results presented herein suggest that patient comorbidities should be considered before

ordering ESR and CRP test. Ultimately, a diagnostic approach that derives from evidence-based medicine will lead to improved guidelines that can improve health care costs and improve health outcomes.[24]

Limitations

One of the major limitations of this study is the use of retrospective data. In addition, the study population is limited to patients admitted to a single institution. A more comprehensive study should be completed with data from multiple clinical sites. Prior treatment and the use of anti-inflammatory drugs at the time of admission was not evaluated which may have affected baseline ESR and CRP levels.

Conclusion

The results from this study suggest that ESR and CRP are not useful in the diagnosis of osteomyelitis in the general population of hospitalized patients suspected of having osteomyelitis. However, when comorbidities are taken into consideration, ESR and CRP can have clinical value as indicators of osteomyelitis. An improvement in guidelines for the use of ESR and CRP such as the diagnostic algorithm proposed here can help diagnosticians make practical use of the tests and emphasize cutoff values when diagnosing osteomyelitis.

Acknowledgements

The authors would like to thank Dr. Efstathia Polychronopoulou for the retrieval of data from medical records and the Clinical Laboratory Sciences Department faculty and staff at the University of Texas Medical Branch for their continued support.

Institutional Review Board Statement

The Institutional Review Board (IRB) at our institution reviewed this study and determined the project to be a quality assessment/quality improvement study that met the criteria for exemption from review or oversight (IRB #23-0013).

References

1. Lavery LA, Ahn J, Ryan EC, et al. What are the Optimal Cutoff Values for ESR and CRP to Diagnose Osteomyelitis in Patients with Diabetes-related Foot Infections? Clin Orthop Relat Res. 2019;477(7):1594-1602. doi:10.1097/CORR.0000000000000718

2. van Asten SA, Jupiter DC, Mithani M, La Fontaine J, Davis KE, Lavery LA. Erythrocyte sedimentation rate and C-reactive protein to monitor treatment outcomes in diabetic foot osteomyelitis. Int Wound J. 2017;14(1):142-148. doi:10.1111/iwj.12574

3. Van Asten SA, Nichols A, La Fontaine J, Bhavan K, Peters EJ, Lavery LA. The value of inflammatory markers to diagnose and monitor diabetic foot osteomyelitis. Int Wound J. 2017;14(1):40-45. doi:10.1111/iwj.12545

4. Fritz JM, McDonald JR. Osteomyelitis: Approach to Diagnosis and Treatment. Phys Sportsmed. 2008;36(1):nihpa116823. doi:10.3810/psm.2008.12.11

5. Bury DC, Rogers TS, Dickman MM. Osteomyelitis: Diagnosis and Treatment. Am Fam Physician. 2021;104(4):395-402.

6. Michail M, Jude E, Liaskos C, et al. The performance of serum inflammatory markers for the diagnosis and follow-up of patients with osteomyelitis. Int J Low Extrem Wounds. 2013;12(2):94-99. doi:10.1177/1534734613486152

7. Brenner DR, Scherer D, Muir K, et al. A review of the application of inflammatory biomarkers in epidemiologic cancer research. Cancer Epidemiol Biomarkers Prev. 2014;23(9):1729-1751. doi:10.1158/1055-9965.EPI-14-0064

8. Alende-Castro V, Alonso-Sampedro M, Vazquez-Temprano N, et al. Factors influencing erythrocyte sedimentation rate in adults: New evidence for an old test. Medicine (Baltimore). 2019;98(34):e16816. doi:10.1097/MD.0000000000016816

9. Lelubre C, Anselin S, Zouaoui Boudjeltia K, Biston P, Piagnerelli M. Interpretation of C-Reactive Protein Concentrations in Critically Ill Patients. Biomed Res Int. 2013;2013:124021. doi:10.1155/2013/124021
10. Markanday A. Acute Phase Reactants in Infections: Evidence-Based Review and a Guide for Clinicians. Open Forum Infect Dis. 2015;2(3):ofv098. doi:10.1093/ofid/ofv098
11. Lipsky BA, Berendt AR, Cornia PB, et al. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. Clin Infect Dis. 2012;54(12):e132-173. doi:10.1093/cid/cis346
12. Gottheil S, Khemani E, Copley K, et al. Reducing inappropriate ESR testing with computerized clinical decision support. BMJ Qual Improv Rep. 2016;5(1):u211376.w4582. doi:10.1136/bmjquality.u211376.w4582
13. Bartlett KJ, Vo AP, Rueckert J, et al. Promoting appropriate utilisation of laboratory tests for inflammation at an academic medical centre. BMJ Open Qual. 2020;9(1):e000788. doi:10.1136/bmjoq-2019-000788
14. Ryan EC, Ahn J, Wukich DK, Kim PJ, La Fontaine J, Lavery LA. Diagnostic Utility of Erythrocyte Sedimentation Rate and C-Reactive Protein in Osteomyelitis of the Foot in Persons Without Diabetes. J Foot Ankle Surg. 2019;58(3):484-488. doi:10.1053/j.jfas.2018.09.025
15. Dryden M, Baguneid M, Eckmann C, et al. Pathophysiology and burden of infection in patients with diabetes mellitus and peripheral vascular disease: focus on skin and soft-tissue infections. Clin Microbiol Infect. 2015;21 Suppl 2:S27-32. doi:10.1016/j.cmi.2015.03.024
16. Sen P, Demirdal T, Emir B. Meta-analysis of risk factors for amputation in diabetic foot infections. Diabetes Metab Res Rev. 2019;35(7):e3165. doi:10.1002/dmrr.3165
17. Salgado JF. Transforming the Area under the Normal Curve (AUC) into Cohen's d, Pearson's rpb, Odds-Ratio, and Natural Log Odds-Ratio: Two Conversion Tables: La transformación del área bajo la curva normal (ACN) en la d de Cohen, la rbp de Pearson, la razón de probabilidad y la razón de probabilidad con logaritmos naturales: dos tablas de conversión. European Journal of Psychology Applied to Legal Context. 2018;10(1):35-47. doi:10.5093/ejpalc2018a5
18. Ialongo C. Understanding the effect size and its measures. Biochem Med (Zagreb). 2016;26(2):150-163. doi:10.11613/BM.2016.015
19. Trevethan R. Sensitivity, Specificity, and Predictive Values: Foundations, Pliabilities, and Pitfalls in Research and Practice. Frontiers in Public Health. 2017;5. Accessed May 22, 2023. https://www.frontiersin.org/articles/10.3389/fpubh.2017.00307
20. David S, Shoenfeld Y. [ERYTHROCYTE SEDIMENTATION RATE - PURPOSEFUL REVIEW FOR CLINICAL APPLICATION]. Harefuah. 2022;161(9):552-555.
21. Ghanem E, Antoci V, Pulido L, Joshi A, Hozack W, Parvizi J. The use of receiver operating characteristics analysis in determining erythrocyte sedimentation rate and C-reactive protein levels in diagnosing periprosthetic infection prior to revision total hip arthroplasty. Int J Infect Dis. 2009;13(6):e444-449. doi:10.1016/j.ijid.2009.02.017
22. Dima A, Opris D, Jurcut C, Baicus C. Is there still a place for erythrocyte sedimentation rate and C-reactive protein in systemic lupus erythematosus? Lupus. 2016;25(11):1173-1179. doi:10.1177/0961203316651742
23. Singhal R, Perry DC, Khan FN, et al. The use of CRP within a clinical prediction algorithm for the differentiation of septic arthritis and transient synovitis in children. J Bone Joint Surg Br. 2011;93(11):1556-1561. doi:10.1302/0301-620X.93B11.26857
24. Beriault DR, Gilmour JA, Hicks LK. Overutilization in laboratory medicine: tackling the problem with quality improvement science. Crit Rev Clin Lab Sci. 2021;58(6):430-446. doi:10.1080/10408363.2021.1893642

Research article

Using Simulation to Introduce Students to a Medical Laboratory Information System

John Jimenez[1], Tamera Alpaugh[1*]

[1] *University of Minnesota, 420 Delaware St SE, MMC 714 Mayo, Minneapolis, MN 55455, USA*

Purpose: **The incorporation of simulation-based learning activities is not a new concept in the field of medical laboratory science. Studies have shown that simulation experiences incorporated into academic curricula provide students with a safe learning environment while developing their skills and boosting self-confidence. Currently, no studies are available in the literature related to exposure to or experience with Laboratory Information Systems (LIS) for Medical Laboratory Science students during their program coursework. This study focused on using an LIS to supplement the education of Medical Laboratory Science students at a large public university in the United States.**
Materials & Methods: **The LIS simulation activity was integrated into the students' hematology laboratory course during two separate sessions. The first part of the activity served as an introduction to the purpose and function of the LIS in the clinical laboratory. The second part focused on result entry and manual review of the hematology instrument into the LIS. To assess the effectiveness of the simulation activity, student responses from pre- and post-activity surveys were analyzed using the Wilcoxon signed-rank test and thematic analysis.**
Results: **The results obtained from the Wilcoxon signed rank test showed a significant improvement in students' understanding of LIS functionality after completing part 1 of the activity. Results also indicated that students' understanding of how diagnostic tests are ordered in the laboratory significantly improved. Student responses were overwhelmingly positive when asked if students were looking forward to using this LIS for future laboratory courses.**
Conclusion: **The LIS simulation activity effectively introduced students to the purpose and functionality of an LIS in the clinical laboratory. Future recommendations for research include incorporating additional simulation-based learning experiences into the curriculum to prepare students for workforce entry upon graduation from the program.**

Keywords: Simulation, Medical Laboratory Science (MLS), Education, Laboratory Information System (LIS), Student Experience

---

Accepted: January 18, 2024

*Corresponding author: Tamera Alpaugh. E-mail: talpaugh@umn.edu. Tel: +1 (612) 626 3452.

Introduction

The incorporation of simulation-based learning activities is not a new concept in the field of medical laboratory science (MLS). Studies have shown that when simulation activities are incorporated into the curricula, student confidence and self-perception increase following the activity.[1] Virtual simulation provides students with a safe learning environment where there can be no direct harm to patients.[2] Although the incorporation of simulation has been on the rise in various areas of education, the inclusion of simulation in MLS education is still a growing area of study.[3] The COVID-19 pandemic drastically changed the method of delivery for higher-level education, in which most coursework was presented in a face-to-face format. E-learning education methods were adopted throughout many educational systems to protect students and the greater community against possible infection. Studies have shown that students had a positive perception of the e-learning format.[4] E-learning has become widely adopted following the COVID-19 pandemic due to educators' positive results and students' positive perceptions of this method. Other studies have shown that synchronous distance education did not differ greatly from traditional education, resulting in higher satisfaction rates among students enrolled in these online courses in some cases.[5] A flexible learning environment allows students to take in material at their own pace, without the stressors of time and space constraints. As e-learning methods continue to expand in health science curricula, there is a growing need to provide students with a new way to learn material away from the classroom. Simulation-based laboratories may provide the solution to fill the gap when students are not actively engaged in a traditional classroom setting.

Simulation is a method to expose students to concepts that can be further elucidated in a real-world scenario. These simulation experiences have become quite advanced, providing students with an effective means of honing their skills online, incorporating the concepts of e-learning and laboratory simulation.[2,6] Experiential learning through practice with simulation has been recommended for students in the field of nursing as preparation for new graduates.[7] The concept of simulation has been shown throughout the literature as an effective means of enhancing student knowledge, and it can be a valuable tool to support student retention and lead to higher exam scores.[8]

No studies related to Laboratory Information System (LIS) exposure or experience for MLS students during program coursework were found in the literature. While students may feel ready to engage with new and different technology, their understanding of the use of technology in a hospital setting and medical laboratory is extremely limited. Feedback from prior graduates indicated a need for more information and experience related to the purpose and use of an LIS before their clinical practicum experience. This study focuses on the effectiveness of an LIS simulation to supplement the education of senior MLS students.

Materials and Methods

The Institutional Review Board approved this project (STUDY00019137). A simulation activety using the LIS was developed and integrated as part of the coursework for the hematology laboratory course. Students completed preparatory work online and then engaged in a hands-on LIS simulation activity during two separate laboratory sessions. The first part of the activity introduced students to the LIS and pre-analytical components of the laboratory exercise, where students were tasked with creating a requisition, documenting the collection time of their specimen, and printing a laboratory barcode label. The second part involved post-analytical components of the laboratory exercise, which was a continuation of the first part of the LIS simulation activity, where students used the LIS to manually enter and review patient results. Both parts of the LIS simulation activity were accompanied by a short video and a written procedure that the students were instructed to review before

attending the laboratory session associated with each part. The video for part 1 and part 2 of the simulation LIS activity, along with the written procedure for each part, demonstrated how to use our LIS program and provided additional information on the functionality of LIS. The goal of providing materials for students before the lab session was to help them feel prepared and more comfortable using the LIS, having already been exposed to it through video presentations and written procedures.

The effectiveness of the preparatory work and the overall simulation experience were assessed using a mixed methods approach. Survey questionnaires were developed using Qualtrics™ to assess students' understanding of the role of the LIS in the medical laboratory. Relevant research studies on student perceptions of simulation activities in health or science courses were used to guide the development and design of the pre and post-surveys, including how the survey questions were written and presented to the students.[1,2,9] Pre- and post-activity surveys were integrated as part of the coursework for the students currently enrolled in the hematology didactic course. The surveys were developed for the course to understand prior student experience and their understanding of LIS in the laboratory and assess their learning and confidence using it following the simulation activity. These surveys followed a five-point Likert scale, with five indicating a response of strongly agree and one indicating a response of strongly disagree. Surveys also included open-ended questions where students could provide additional information about their experience in the LIS simulation.

Table 1: Wilcoxon Signed Rank Test of Student Responses
This table shows selected questions from pre- and post-activity surveys, Z-scores, and corresponding p values.

	Negative Ranks			Positive Ranks					
	n	Mean rank	Sum of ranks	n	Mean rank	Sum of ranks	Ties	Z	p
(Activity helped me understand purpose/ function after Part 1)-(Before Part 1)	2	6	12	20	12.05	241	6	-3.788[b]	<0.001[a]
(LIS activity helped select/order tests after Part 1)-(Understanding lab test ordering before Part 1)	3	8.67	26	22	13.59	299	3	-3.725[b]	<0.001[a]
(Self-confidence after Part 2)-(After Part 1)	4	11.25	45	13	8.31	108	11	-1.576[b]	0.115
(Desire to use LIS after Part 1)-(Before part 1)	5	5	25	4	5	20	19	-0.333[c]	0.739
(Understanding reference ranges after Part 2)-(Before Part 2)	17	10.94	186	3	8	24	8	-3.189[c]	0.001[a]
(Activity helped better understand LIS after Part 2)-(After Part 1)	2	5.5	11	9	6.11	55	17	-2.138[b]	0.033[a]
(Understanding of Critical Values after Part 2)-(Before Part 2)	17	10.29	175	2	7.5	15	9	-3.386[b]	<0.001[a]
(Desire to use LIS after Part 2)-(After Part 1)	5	5.5	27.5	5	5.5	27.5	18	0.000[d]	1

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks
c. Based on positive ranks
d. The sum of negative ranks equals the sum of positive ranks

Due to the small sample size and non-parametric nature of the data, analysis was performed using the Wilcoxon signed-rank test through the statistical analysis software IBM SPSS (v 28). A total of 29 students were enrolled in the course and participated in the LIS simulation activity. However, one student was excluded from this study as they had not completed all the assigned surveys as part of the course requirements, so the sample size for this study was 28 students.

Results

Prior to data analysis, inclusion criteria were established. Data was de-identified to allow for correlation of student responses between the pre and post-survey data. Students who did not complete all assigned pre and post-surveys related to the LIS simulation were excluded from any data analyses. The final sample size for this project included 28 students.

Students responded very well to the activity, and they demonstrated an improved understanding of the value of the LIS in the laboratory and a desire to use it for future laboratory activities, as shown in Table 1. In particular, there was a significant improvement in their understanding of the purpose and function of the LIS, laboratory test ordering processes, and their understanding of reference ranges and critical patient results. The majority of students found the simulation activity useful and agreed that it integrated well into the hematology laboratory course (Table 2).

The surveys assigned to the students as part of the laboratory course also included open-ended questions where feedback on the LIS simulation activity could be provided. Many of the students touched on similar themes. Students particularly enjoyed the manual entry of their complete blood count (CBC) results, allowing them to apply the concepts they learned in their MLS lecture courses in the laboratory. Many students mentioned that the length of time between both parts of the activity may have been detrimental to their learning, suggesting that the two parts be scheduled in a closer timeframe. Other students suggested working with multiple samples instead of one, which would provide additional evidence to evaluate students' comfort level working with the LIS

Table 2: Median Student Responses to Survey Questions

Students responded to survey questions using a Likert scale, with 5 indicating strongly agree and 1 indicating strongly disagree. Most students agreed the activity was useful and integrated well with the hematology lab session.

Survey Question	Median ± SEM (IQR) -	Survey Question
I am looking forward to using this LIS for my future laboratory courses in the MLS program	4 ± 0.107 (1)	4 ± 0.107 (1)
The pre-lab handout and tutorial video effectively prepared me for the LIS activity	4 ± 0.104 (0.25)	4 ± 0.108 (1)
The LIS simulation experience integrated well with the laboratory course material	4 ± 0.104 (1)	4.5 ± 0.109 (1)
The LIS simulation experience helped my self-confidence as a future MLS	4 ± 0.166 (1)	4 ± 0.132 (1)

Discussion

In general, students responded very well to the LIS simulation activity. Participation in the activity significantly improved students' understanding of the purpose and function of the LIS in laboratory practice. Regarding the self-confidence ratings in their skills as Medical Laboratory Scientists, student opinions did not differ much between both parts of the simulation activity. Students felt confident in their skills, as noted during the simulation activity. The MLS faculty indicated that the students appeared well-prepared to complete the simulation activity, and their responses to the pre-activity materials were also positive.

Limitations of this study include the sample size and time constraints. This simulation activity involved 28 students in a Medical Laboratory Science program. Future recommendations include expanding this study to incorporate additional universities and MLS programs to increase the sample size. Another limitation was not validating the surveys used to assess student learning outcomes due to time constraints associated with the project. Survey questions for the pre and post-simulation assignments were developed using previous research studies as a guide. Validation of these surveys in the future may help standardize student responses and minimize any confusion students may have had regarding questions. Obtained results in this study may have also suffered from distortion effects, such as central tendency bias or social desirability bias. Different survey methods may also be explored in the future to mitigate any perceived biases by students in their responses.

Many students mentioned that the length of time between both parts of the activity (3 weeks) may have been detrimental to their learning and suggested that the two parts be scheduled in a closer timeframe. Other students suggested working with multiple samples instead of on a single sample, providing additional evidence to evaluate students' comfort level working with the LIS.

Students provided valuable feedback and suggestions to improve the activity and assignments for future students in the course. The data demonstrated that most students agreed that the activity incorporated well into their current MLS program curricula. Most students agreed that the opportunity to engage in the LIS simulation activity improved their confidence in using an LIS and helped them look forward to future opportunities using it.

Conclusion

The findings suggest that incorporating a simulation-based learning activity to introduce students to the purpose and function of an LIS was effective.

Acknowledgments

This paper and research project would not have been possible without the support of Christine Maleck and Andrew Yue. Thank you for your work to integrate the LIS simulation in the hematology laboratory course and for providing this beneficial experience to our students. We thank Dr. Janice Conway-Klaassen for supporting this research project and completing a manuscript review. Finally, we would like to acknowledge the engagement and enthusiasm of the MLS program students who participated in the LIS simulation. Dr. Alpaugh was awarded the American Society of Clinical Pathology (ASCP) Program Director's Grant to purchase a LIS for the MLS student laboratory in 2021. This LIS system was used during the simulation activity described in this research project. Existing MLS student laboratory equipment was used as the LIS simulation project took place during the required MLS hematology laboratory course.

References

1. Goolsby CA, Goodwin TL, Vest RM. Hybrid simulation improves medical student procedural confidence during EM clerkship. Mil Med. 2014 Nov;179(11):1223-7. doi: 10.7205/MILMED-D-14-00072.
2. Kok YY, Er HM, Nadarajah VD. An analysis of health science students' preparedness and perception of interactive virtual laboratory simulation. Med Sci Educ. 2021 Sep 8;31(6):1919-1929. doi: 10.1007/s40670-021-01364-1.
3. Webb TL, McGahee J, Brown MR. A scoping review of medical laboratory science and simulation: promoting a path forward with best practices. Lab Med. 2022 May 5;53(3):e51-e58. doi: 10.1093/labmed/lmab087.
4. Naciri A, Radid M, Kharbach A, Chemsi G. E-learning in health professions education during the COVID-19 pandemic: a systematic review. J Educ Eval Health Prof. 2021;18:27. doi: 10.3352/jeehp.2021.18.27.
5. He L, Yang N, Xu L, Ping F, Li W, Sun Q et al. Synchronous distance education vs traditional education for health science students: A systematic review and meta-analysis. Med Educ. 2021 Mar;55(3):293-308. doi: 10.1111/medu.14364.
6. de Vries LE, May M. Virtual laboratory simulation in the education of laboratory technicians-motivation and study intensity. Biochem Mol Biol Educ. 2019 May;47(3):257-262. doi: 10.1002/bmb.21221.
7. Mabry J, Lee E, Roberts T, Garrett R. Virtual Simulation to Increase Self-efficacy Through Deliberate Practice. Nurse Educ. 2020 Jul/Aug;45(4):202-205. doi: 10.1097/NNE.0000000000000758.
8. Donkin R, Askew E, Stevenson H. Video feedback and e-learning enhances laboratory skills and engagement in medical laboratory science students. BMC Med Educ. 2019 Aug 14; 19(1):310. doi: 10.1186/s12909-019-1745-1.
9. Olson J, Rinehart J, Spiegel JJ, Al-Nakkash L. Student perception on the integration of simulation experiences into human physiology curricula. Adv Physiol Educ. 2019 Sep 1;43(3):332-338. doi: 10.1152/advan.00202. 2018

Research article

Antimicrobial Resistant Trend of *E. coli* and ESKAPE Pathogens from Urine Cultures in Central Alabama

Tracy Camara[1*], Li Qian[2], Angelique Korbecki[2], Ngoc Le[2], Ann Chambers[2]

[1] Baptist Health, Montgomery, AL, USA
[2]Medical & Clinical Laboratory Sciences, Auburn University at Montgomery, AL, USA

The purpose of this research is to identify the antimicrobial resistant pattern to provide scientific evidence for improving antimicrobial therapy for *Escherichia coli* and ESKAPE organisms in urine samples recovered from Central Alabama in 2020. A total of 3498 organisms were identified by matrix assisted laser desorption ionization time of flight mass spectrometry (MALDI-TOF MS) and the sensitivities were performed on MicroScan WalkAway 96 by using the Clinical Laboratory Science Institute (CLSI) microdilution method. The identified organisms were from clean-catch midstream, foley catheter, and straight catheterized urine. For the 69.4% of *E. coli* isolates, ampicillin/sulbactam had the lowest sensitivity at 54%. Among the 920 ESKAPE pathogens, *Enterococcus faecium* was most resistant to ampicillin with sensitivity at 8%. *Staphylococcus aureus* was most resistant to penicillin with sensitivity at 7%; *Klebsiella pneumoniae* was most resistant to nitrofurantoin at 35%; *Acinetobacter baumannii* lacked samples for statistical analysis; *Pseudomonas aeruginosa* was most resistant to levofloxacin with sensitivity at 68%; *Enterobacter species* was most resistant to ertapenem at 83%. Overall, the resistant patterns of *E. coli* and the ESKAPE organisms isolated in the hospital system were comparable to those reported globally and nationally; however, because these organisms are becoming resistant faster than new antibiotics are being introduced to the market, diligence must take place to conserve and appropriately use current antibiotics in patient treatments.

Keywords: Antimicrobial resistance, urine cultures, E. coli, ESKAPE pathogens

---

Accepted: January 31, 2024
*Corresponding author: Tracy Camara, E-mail TLCamara@baptistfirst.org

Introduction

Urinary tract infections (UTIs) have been identified as the fifth most common type of healthcare-associated infection with an estimated 62,700 urinary infections occurring in acute care settings and an estimated 150 million UTIs occurring annually worldwide.[1,2,3] Majority of urinary infections that occur is predominantly caused by uropathogenic *Escherichia coli* (UPEC), which contributes to 80% of all UTIs, with 83.9% sensitive to extended-spectrum cephalosporins, 65.2% sensitive to fluoroquinolones, and 98.9% sensitive to carbapenems.[4,5]

Urinary tract infections are classified as either complicated or uncomplicated. Complicated UTIs occur due to urinary obstructions, urinary retention, kidney calculi, renal failure, renal transplants, pregnancy, or indwelling devices. [2,6,7] In addition, complicated UTIs have a higher risk of treatment failure and may require longer courses of antibiotic treatment.[8] Uncomplicated UTIs most frequently occur in healthy individuals as a result of cystitis, sexual activity, diabetes, and obesity.[2, 9,10] Complicated and uncomplicated UTIs are most often caused by *Candida species, Enterococcus faecalis, Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus saprophyticus,* and *Streptococcus agalactiae*, also known as group B *Streptococcus* (GBS).[2,7,11-15] The most commonly isolated organism for both complicated and uncomplicated UTIs is UPEC.[2]

The treatment of complicated and uncomplicated UTIs can have undesirable effects. The use of antibiotics can alter gastrointestinal and vaginal normal flora, which can lead to drug resistant organisms.[2, 16] The replacement of normal flora with antimicrobial resistant microorganism can cause colonization resulting in treatment failures.[2] Most patients with uncomplicated UTIs, are treated with broad-spectrum antibiotics and recover without any issues. However, individuals with complicated UTIs become more difficult to treat due to increased antibiotic resistance.[8] In fact, there is a 25% risk that a bacteriuria will become a complicated UTI.[8] In the United States, it has been reported that over 626,000 hospital admissions occur annually due to complicated UTIs.[8]

Enterococcus species, Klebsiella pneumoniae, Staphylococcus aureus, and *Pseudomonas aeruginosa* are commonly found in both complicated and uncomplicated UTIs and are part of an emerging group of antimicrobial resistant organisms called the ESKAPE pathogens. The ESKAPE pathogens were defined, in 2008 by the Infectious Disease Society of America, as a group of pathogenic organisms that causes hospital infections which escapes antimicrobial therapies.[17,18,19] The ESKAPE organisms are *Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter species*. Included in this group are the vancomycin-resistant enterococci (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), extended spectrum beta-lactamase (ESBL), and carbapenem-resistant enterobacteriaceae (CRE).[19, 20]

In majority of clinical settings, patients are initially treated empirically for UTIs without knowing the identification or susceptibility of the causative organism; therefore, understanding the resistance patterns of the ESKAPE and UPEC organisms is beneficial especially in cases of complicated UTIs. Accordingly, this study was performed to determine the percent recovery and resistance patterns for the ESKAPE and UPEC organisms from three hospitals in Central Alabama. Findings from this study will provide scientific evidence to physicians and antibiotic stewardship programs to improve initial experiential treatment for uropathogens.

Materials and Methods

This study was performed by retrospective analysis of inpatient urine culture data from three teaching hospitals within a hospital system in Central Alabama between January-December 2020. This hospital system has an estimated 207 admissions per month or seven admissions per day. Urine cultures were

collected from clean-catch, midstream, foley and straight catheter, pediatric, and other sources, such as suprapubic collection. The antimicrobial susceptibility results were reported based on the CLSI minimum inhibitory concentration (MIC) breakpoints.

The twenty-three antimicrobials included in this study were from the classes' aminoglycosides (gentamicin, tobramycin), other beta-lactams (ampicillin/sulbactam, ampicillin, amoxicillin/clavulanate, oxacillin, penicillin, piperacillin/tazobactam), carbapenems (ertapenem, meropenem), cephalosporins (cefepime, ceftriaxone, ceftazidime, cefazolin, cefuroxime), fluoroquinolones (ciprofloxacin, levofloxacin), and others (trimethoprim/sulfamethoxazole, tetracycline, nitrofurantoin, linezolid, vancomycin, and daptomycin). Quality control was performed weekly using the organisms *P. aeruginosa* ATCC 27853, *E. coli* ATCC 35218 and 25922, *K. pneumoniae* ATCC 700603, *E. faecalis* ATCC 29212, *S. aureus* ATCC 29213 and BAA-977, MRSA ATCC 43300, and VRE ATCC 51299. The CLSI (M100) performance standards for antimicrobial susceptibility testing served as interpretive criteria for each antimicrobial and organism evaluated. Chi-square test or Fisher's exact *t-test* was used to determine the significant difference in antimicrobial sensitivity on IBM SPSS for Windows (version 28 software package).[21] The level of significant difference was defined at $p \leq 0.05$.

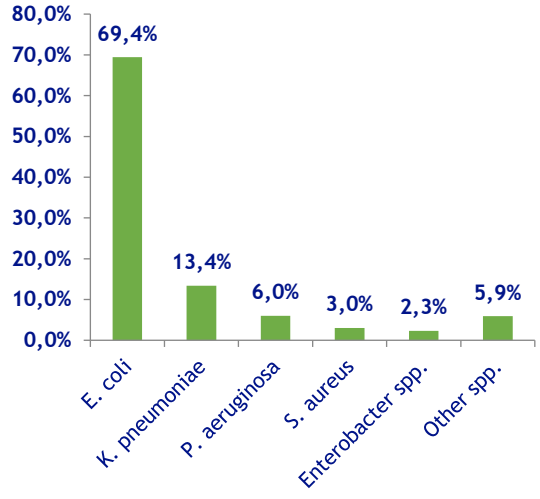


Figure 1. Frequency Distribution of Pathogens Isolated from Urine Cultures

Results

A total of 3498 organisms (Figure 1), from urine cultures performed between January and December 2020 from a Central Alabama hospital system, were identified by MALDI-TOF MS. Antimicrobial sensitivities were performed by MicroScan WalkAway 96 based on the CLSI microdilution method. Among the 3498 identified organisms (Figure 2), 83.2% were isolated from clean-catch midstream urine specimens, 10.5% from foley catheter urine, 5.5% from straight catheterized urine, and 0.8% from pediatric urine and other sources.

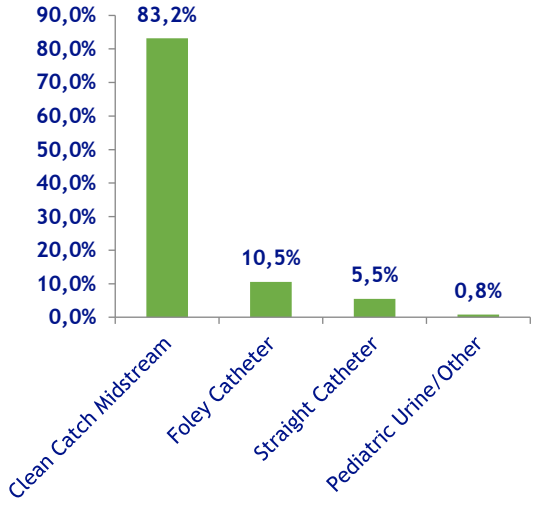


Figure 2. Frequency Distribution of Types of Urine Specimens

The results (Figure 1) demonstrated that *E. coli* contributed to 69.4% of all the infections, followed by *K. pneumoniae* (13.4%), *P. aeruginosa* (6.0%), *S. aureus* (3.0%), *Enterobacter species* (2.3%), and other species (*Acinetobacter species, Enterococcus species, Klebsiella species, and Pluralibacter gergoviae*, 5.9%). Among the 920 ESKAPE organisms identified (Figure 3), *K. pneumoniae* was the most common organism isolated at 50.9%, followed by *P. aeruginosa* (22.7%), *S. aureus* (11.3%), *Enterobacter species* (8.6%), *E. faecium* (5.7%), and *A. baumannii* (0.8%). For the 2428 *E. coli* isolates, cefepime, ertapenem, meropenem, ceftazidime, ceftriaxone, and piperacillin/tazobactam had the highest sensitivities at 99-100%, followed by nitrofurantoin (98.0%) and were most resistant to

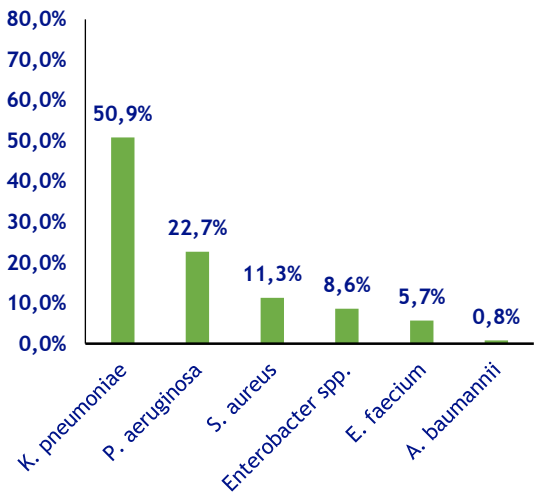


Figure 3. Frequency Distribution of the ESKAPE Organisms Isolated from Urine Cultures

ampicillin/sulbactam (54.0%). For the ESKAPE pathogens, *E. faecium* was most sensitive to daptomycin (100%) and most resistant to ampicillin (8.0%). *S. aureus* was most sensitive to vancomycin, ceftriaxone, and cefazolin (100%) and most resistant to penicillin (7.0%); *K. pneumoniae* was most sensitive to cephalosporins, aminoglycosides, and quinolones (97-100%) and most resistant to nitrofurantoin (35.0%); *A. baumannii* was sensitive to the antibiotics tested, but there were not enough samples for statistical analysis with sensitivities ranging from 86% to100%; *P. aeruginosa*

Table 1. Antibiotic Spectrum (%) of *E. coli* and ESKAPE Pathogens from Urine Cultures in Central Alabama.

Antibiotic agent	E. coli		K. pneumoniae		P. aeruginosa		S. aureus		E. faecium		Enterobacter spp.		A. baumannii	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R
Aminoglycosides														
Gentamicin	92	8	99	1	72	28	--	--	--	--	97	3	100	0
Tobramycin	95	5	99	1	96	4	--	--	--	--	--	--	100	0
Other ß-lactams														
Ampicillin/Sulbactam	54	46	86	14	--	--	--	--	--	--	--	--	100	0
Ampicillin	--	--	--	--	--	--	--	--	8	92	--	--	--	--
Amoxicillin/Clavulanate	87	13	96	4	--	--	--	--	--	--	--	--	--	--
Oxacillin	--	--	--	--	--	--	53	47	--	--	--	--	--	--
Penicillin	--	--	--	--	--	--	7	93	--	--	--	--	--	--
Piperacillin/Tazobactam	99	1	97	3	93	7	--	--	--	--	--	--	--	--
Carbapenems														
Ertapenem	100	0	97	3	--	--	--	--	--	--	83	17	--	--
Meropenem	100	0	98	2	90	10	--	--	--	--	100	0	100	0
Cephalosporins														
Cefepime	100	0	100	0	90	10	--	--	--	--	92	8	86	14
Ceftriaxone	99	1	100	0	--	--	100	0	--	--	--	--	--	--
Ceftazidime	99	1	100	0	82	18	--	--	--	--	--	--	100	0
Cefazolin	92	8	97	3	--	--	100	0	--	--	--	--	--	--
Cefuroxime	97	3	97	3	--	--	--	--	--	--	--	--	--	--
Fluoroquinolones														
Ciprofloxacin	82	18	98	2	70	30	--	--	--	--	92	8	100	0
Levofloxacin	83	17	98	2	68	32	--	--	--	--	92	8	100	0
Others														
Trimethoprim/ Sulfamethoxazole	73	27	92	8	--	--	98	2	--	--	--	--	--	--
Tetracycline	80	20	85	15	--	--	--	--	--	--	--	--	--	--
Nitrofurantoin	98	2	35	65	--	--	--	--	30	70	--	--	--	--
Linezolid	--	--	--	--	--	--	--	--	97	3	--	--	--	--
Vancomycin	--	--	--	--	--	--	100	0	30	70	--	--	--	--
Daptomycin	--	--	--	--	--	--	--	--	100	0	--	--	--	--

S= sensitive; R=resistant

Table 2. Percent Sensitivity Comparison for ESKAPE Organisms Isolated from Urine Cultures

	Central Alabama	NHSH*	Karlowsky, Hoban, et. al.
Enterococcus faecium			
Vancomycin	30.0%	14.9%	---
Staphylococcus aureus			
Oxacillin	53.0%	---	---
Oxacillin/Methicillin/Cefoxitin	---	48.0%	---
Klebsiella pneumoniae			
Cefepime, Ceftriaxone, Ceftazidime	100%	---	48.9%
Cefepime, Cefotaxime, Ceftriaxone, Ceftazidime	---	77.5%	---
Levofloxacin	98.0%	---	57.3%
Ertapenem	97.0%	---	---
Meropenem	98.0%		
Imipenem, Meropenem, Doripenem	---	90.5%	---
Ertapenem, Imipenem	---	---	78.5%
Acinetobacter baumannii			
Cefepime, Ceftriaxone, Ceftazidime	99.3%	---	13.9%
Levofloxacin	100%	---	11.6%
Meropenem	100%	---	---
Imipenem, Meropenem, Doripenem	--	36.0%	---
Imipenem	---	---	18.6%
Pseudomonas aeruginosa			
Gentamicin	72.0%	---	---
Tobramycin	96.0%	---	---
Amikacin, Gentamicin, Tobramycin	---	78.9%	
Amikacin	---	---	75.2%
Levofloxacin	68.0%	---	55.2%
Ciprofloxacin, Levofloxacin	--	67.4%	---
Meropenem	90.0%	---	---
Imipenem	---	---	60.0%
Imipenem, Meropenem, Doripenem	---	76.1%	---
Enterobacter species			
Cefepime	92.0%	---	---
Cefepime, Cefotaxime, Ceftriaxone, Ceftazidime	---	59.5%	---
Cefepime, Ceftriaxone, Ceftazidime	---	---	61.0%
Ertapenem	83.0%	---	79.4%
Meropenem	100%	---	---
Imipenem, Meropenem, Doripenem	---	93.5%	---
Imipenem	---	---	86.1%
Levofloxacin	92.0%	---	76.4%
Escherichia coli			
Cefepime, Ceftriaxone, Ceftazidime	99.0%	---	---
Cefepime, Cefotaxime, Ceftriaxone, Ceftazidime	---	83.9%	---
Ciprofloxacin	82.0%	---	---
Levofloxacin	83.0%	---	---
Ciprofloxacin, Levofloxacin, Moxifloxacin	---	65.2%	---
Ertapenem, Meropenem	100%	---	---
Imipenem, Meropenem, Doripenem	---	98.9%	---

**NHSN comparison susceptibility data from year 2014.*

was most sensitive to tobramycin (96.0%) and most resistant to levofloxacin (68.0%); *Enterobacter species* had the highest sensitivity to meropenem (100%), and the lowest sensitivity to ertapenem (83.0%). The antibiotic spectrum for *E. coli* and the ESKAPE organisms is summarized in Table 1.

Discussion

Findings of this study were compared with published literature from the National Healthcare Safety Network (NHSN) at the Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), and others; and no previous studies were found on antimicrobial resistance of *E. coli* or ESKAPE pathogens in Central Alabama. There may be limitations in this study as the NHSN reported pathogens from catheter associated urinary tract infections (CAUTI) whereas this study evaluated *E. coli* and ESKAPE organisms from all urine culture isolates. However, a comparison can be made between isolates recovered in Central Alabama and those on a national and global level as shown in Table 2.

During 2011-2014, *Enterococcus faecium* accounted for 3.7% of all pathogens reported to the NHSN, with 2.7% occurring in CAUTIs.[5] In addition, 14.9% were reported as sensitive to

vancomycin.[5] In comparison, this study demonstrated that *E. faecium* was isolated 1.5% from all urine specimens with 30.0% of them sensitive to vancomycin demonstrating a lower isolation and resistance rate.

Enterococci can have a high-level of acquired vancomycin resistance due to the alteration of the peptidoglycan cell wall precursors by amino acid substitution that causes D-alanyl-D-alanine dipeptide to become D-alanyl-D-lactate depsipeptide.[22] The *vanA* gene encodes for this amino acid substitution which causes reduced ability of vancomycin to bind to the bacterial cell wall.[22] *E. faecium* strains with this type of vancomycin high level resistance are classified as class A resistance. This type of resistance can be shared with other gram positive organisms through conjugation.[22] On the other hand, strains of *E. faecium* that have high to low levels of vancomycin resistance are classified as class B resistance. This level of resistance is caused by the *van*B gene and can be shared through conjugation with other *Enterococcus* strains.[22] Other non-faecium enterococci strains, such as *Enterococcus gallinarium, Enterococcus casseliflavus*, and *Enterococcus flavescens* have low levels of vancomycin resistance and are designated as class C resistance.[22] This type of resistance is caused by the genes *van*C_1, *van*C_2, and *van*C_3. *E. faecium* also has resistance to beta-lactam drugs, such as ampicillin, due to the alteration of the target enzyme penicillin-binding protein 5 (PBP5), which is the main resistance determinant for this organism.[23] In addition, resistance to quinupristin-dalfopristin occurs in *E. faecium* by enzymatic inhibition, efflux, and target modification.[22]

NHSN reported *Staphylococcus aureus* accounted for 11.8% of all urine cultures reported with 1.6% occurring in CAUTIs.[5] Of the *S. aureus* isolated from CAUTIs, 48.0% were sensitive to oxacillin, methicillin, and cefoxitin.[5] In this study, 3.0% of the *S. aureus* was isolated from all urine cultures with 7.0% sensitive to penicillin and 53.0% sensitive to oxacillin, which is lower than the total number of isolates reported to the NHSN, but comparable to the susceptibility rate for beta-lactams. There were no vancomycin intermediate *Staphylococcus aureus* (VISA), or vancomycin resistant *Staphylococcus aureus* (VRSA) isolates identified in this study or in the NHSN study.

It has been documented that urinary catheterization is the most important risk factor for MRSA in complicated UTIs.[4,24,25] The cause of MRSA is due to the *mec*A gene, which encodes for penicillin binding protein 2A (PBP2A).[22] The PBP2A protein has a low affinity for beta-lactam antibiotics, which causes resistance to methicillin, nafcillin, oxacillin, and cephalosporins.[22] *S. aureus* not only has resistance due to the alteration of the target enzyme PBP2A protein, but also due to penicillinase production otherwise known as beta-lactamase. Since vancomycin is the drug of choice in the treatment of MRSA, vancomycin intermediate and vancomycin resistant strains have been observed. The first VRSA was isolated in 2002.[22] VRSA occurs due to the sharing of *van*A genes from VRE through a plasmid-mediated transfer.[22] VISA occurs as a result of bacterial cell wall thickening, which binds the drug and prevents it from reaching its designated target.[22]

Klebsiella pneumoniae has been isolated an average of 7.0% from both complicated and uncomplicated UTIs.[2] *K. pneumoniae* has demonstrated antibiotic resistance to the extended spectrum cephalosporins, fluoroquinolones, and aminoglycosides.[5, 26] In this study, *K. pneumoniae* was isolated 13.4% from all urines with 100% sensitive to the extended spectrum cephalosporins, 98.0% sensitive to levofloxacin, and 97.5% sensitive to carbapenems. In comparison, the NHSN's study grouped *K. pneumoniae* and *Klebsiella oxytoca* together with 10.1% isolated and 77.5% sensitive to the extended spectrum cephalosporins, and 90.5% sensitive to carbapenems.[5] Another study by Karlowsky, Hoban, and et. al, reported 48.9% of *K. pneumoniae* sensitive to the extended spectrum cephalosporins, 57.3% were sensitive to levofloxacin, and 78.5% sensitive to carbapenems.[26] *K. pneumoniae* isolated from

urine cultures in Central Alabama were more sensitive when compared to those reported in the NHSN and the Karlowsky, Hoban, et. al. study and had a higher isolation rate when compared to the NHSN.

Klebsiella pneumoniae resistance to beta-lactam drugs occurs due to enzyme inhibition of penicillinases, ESBL, and carbapenemases (i.e., New Delhi metallo-beta-lactamase (NDM-1)), as well as through decreased outer membrane permeability.[22] The NDM-1 enzyme is encoded by bla_{NDM-1}, which contributes to the increased presence of carbapenem-resistant *Klebsiella pneumoniae* (KPC) infections.[27] The decrease in outer membrane permeability is due to the reduction of porins, which are used by antibiotics to enter the bacterial cell. The reduction in porins causes beta-lactam resistance. The resistance to fluoroquinolones occurs due to the alteration of target enzymes, efflux, and target site protection.[22] DNA gyrase (bacterial topoisomerase II) is a target enzyme that plays a role in the cell division of gram negative organisms. This enzyme is encoded by *gyr*A and when mutated, resistance to fluoroquinolones occurs.[22] Another gene, *qnr,* is a plasmid-mediated fluoroquinolone resistance gene that produces binding proteins to the DNA gyrase antibiotic target site; therefore, protecting this enzyme from binding to fluoroquinolones,[22] allows *K. pneumoniae* to be resistant to the inhibitory effects of this drug class. Aminoglycoside resistance occurs due to enzymatic inhibition and alteration of ribosomal targets. Enzymatic inhibition is caused by aminoglycoside-modifying enzymes that confer resistance through *N*-acetylation, *O*-nucleotidylation, and *O*-phosphorylation of the drug as it transported across the bacterial cytoplasmic membrane.[22] The alteration of the ribosomal target occurs due to the methylation of the 16s rRNA, which is where aminoglycosides bind to stop protein synthesis.[22] The genes *armA, rmtA, rmtB, rmtC, rmtD, rmtE*, and *npmA*[22, 28] all contribute to this methylation.

Acinetobacter baumannii is commonly found in intensive care units and is intrinsically resistant to antibiotics due to outer membrane protection, efflux pump system, and reduction of porins.[29] In this study, *A. baumannii* was reported <1%; therefore, the validity of this study's analysis will be skewed. Of the seven *A. baumannii* isolates recovered, 99.3% were sensitive to the extended spectrum cephalosporins, 100% sensitive to levofloxacin, and 100% sensitive to carbapenems. In comparison, the NHSN reported a total of 276 isolates from CAUTIs with 36.0% sensitive to the carbapenems.[5] In the Karlowsky, Hoban, et. al. study, 43 isolates of *A. baumannii* reported 13.9% sensitive to extended spectrum cephalosporins, 11.6% sensitive to levofloxacin, and 18.6% sensitive to carbapenems.[26] This study indicated higher sensitivities than those of the NHSN and Karlowsky, Hoban, et. al, studies, which can be contributed to the low number of *A. baumannii* isolates recovered in this study. However, the CDC susceptibilities reported in 2017, 25.0% of *Acinetobacter* isolates were sensitive to any extended-spectrum beta-lactam and 11.0% were sensitive to any fluoroquinolone, which is comparable to the NHSN and the Karlowsky, Hoban, et. al studies.[30]

A. baumannii has become more resistant to antibiotic classes over the years due to beta-lactamases, enzyme inhibition by AmpC cephalosporinases, plasmid-acquired beta-lactamases of the TEM, SHV, Cefotaxime (CTX-M), PER, BEV families, metallo-beta-lactamases of the IMP (bla_{IMP}), VIM (bla_{VIM}), SIM families, and Oxacillin (OXA)-type serine carbapenemases (bla_{OXA}).[22, 26, 27] Aminoglycoside resistance and quinolones and tigecycline resistance also occurs due to enzymatic inhibition by aminoglycoside modifying enzymes and efflux pumps, respectively.[22]

Pseudomonas aeruginosa is known for its opportunistic infections in cystic fibrosis, cancer, and burn patients.[29] In this study, 6.0% of the Central Alabama urine isolates recovered *P. aeruginosa* with 72.0% sensitive to gentamicin, 96.0% sensitive to tobramycin, 68.0% sensitive to levofloxacin, and 90.0% sensitive to meropenem. In the NHSN study, *P.*

aeruginosa contributed to 10.3% of CAUTIs, with 78.9% sensitive to aminoglycosides, 67.4% sensitive to fluoroquinolones, and 76.1% sensitive to carbapenems.[5] In the Karlowsky, Hoban, et. al. study, 55.2% of *P. aeruginosa* isolates were sensitive to levofloxacin and 60.0% were sensitive to imipenem.[26] The aminoglycosides, gentamicin and tobramycin, had a combined sensitivity of 84.0% and is comparable to the NHSN study; however, the aminoglycoside sensitivities in the NHSN study were not separated out to determine if the susceptibility rate for the aminoglycosides was due to the disparity between gentamicin and tobramycin as seen in Central Alabama. In addition, Karlowsky, Hoban, and et. al. study only used amikacin reporting for aminoglycoside with a 75.2% sensitivity.[26] However, all three studies with aminoglycoside susceptibility are comparable. In contrast, when comparing the carbapenems, this study demonstrated a much higher sensitivity than what was reported in the other studies. Despite the higher sensitivity of *P. aeruginosa* in Central Alabama, concern over carbapenem-resistant strains must remain a top priority because 2.0% - 3.0% of carbapenem-resistant *P. aeruginosa* strains carry a mobile gene that is easily shared between bacteria resulting in increased resistance of this species.[30] In addition, *P. aeruginosa* resistance can also occur for other drugs. The beta-lactam drugs become resistant due to enzymatic inhibition by AmpC cephalosporinases, ESBL, and metallo-beta-lactamases; in addition, beta-lactam resistance occurs due to active efflux pump (MexAB) and reduced permeability of the outer membrane due to the loss of the OprD channel.[22] The MexAB pump is one of the largest multi-drug resistant pumps in *P. aeruginosa* and contributes to fluoroquinolone, tetracycline, and trimethoprim resistance.[22,31] The aminoglycosides have resistance to *P. aeruginosa* due to enzymatic inhibition caused by aminoglycoside modifying enzymes, efflux, and ribosomal methlyation.[22]

Enterobacter species are common isolates of UTIs and demonstrates resistance to antibiotics due to ESBLs and carbapenemases caused by VIM, OXA, metallo-beta-lactamases, and KPC (encoded by bla_{KPC}).[27] In this study, *Enterobacter species* was recovered at a rate of 2.3% with 92.0% sensitive to cefepime, 92.0% sensitive to levofloxacin, 83.0% sensitive to ertapenem, and 100% sensitive to meropenem. In the NHSN study, *Enterobacter species* contributed to 3.7% of CAUTIs with 59.5% sensitive to extended spectrum cephalosporins and 93.5% sensitive to carbapenems.[5] The Karlowsky, Hoban, et. al. study, reported 61.0% sensitive to cephalosporins, 79.4% sensitive to ertapenem, 86.1% sensitive to imipenem, and 76.4% sensitive to levofloxacin. This study only reported cefepime for the extended- spectrum cephalosporins, while the NHSN and Karlowsky, Hoban, et. al, studies reported cefepime, ceftazidime, and ceftriaxone for the extended spectrum cephalosporins, which can contribute to a discrepancy between the sensitivity of this study and published literature.

Escherichia coli is the most isolated organism from urine cultures.[5] In this study, *E. coli* was recovered at 69.4% with 99.0% sensitive to the extended spectrum cephalosporins, 82.5% sensitive to the fluoroquinolones, and 100% sensitive to the carbapenems. In the NHSN study, *E. coli* contributed to 23.9% of all CAUTIs with 83.9% sensitive to extended spectrum cephalosporins, 65.2% sensitive to fluoroquinolones, and 98.9% sensitive to the carbapenems. Central Alabama recovered a higher percentage of *E. coli*, which contributed to this study by encompassing all urine culture isolates instead of only CAUTIs as reported to the NHSN. In addition, the susceptibility of *E. coli* in Central Alabama appeared to be more sensitive to the fluoroquinolones than isolates reported to NHSN. This is understandable as CAUTIs are considered complicated infections and can result in longer treatment plans and treatment failures.[8] In the Global Antimicrobial Resistance and Use Surveillance System (GLASS) through the WHO, 8.4% to 92.9% of *E. coli* isolates are resistant to ciprofloxacin, which is

commonly used to treat UTIs.[32] In this study we observed that bacteria are more resistant to fluoroquinolones than to other antibiotic classes.

Conclusion

Escherichia coli was the most isolated organism from urine cultures submitted to a hospital system in Central Alabama and did not demonstrate an increased pattern of resistance when compared to other studies. Overall, we can say the resistant patterns of the ESKAPE organisms isolated in the hospital system were comparable to those reported globally and nationally. However, despite Central Alabama having slightly higher sensitivity rates for the ESKAPE organisms when compared to the NHSN and the Karlowsky, Hoban, and et. al studies, these organisms should still be treated with concern because they are becoming resistant faster than new antibiotics introduced to the market. Therefore, due diligence must take place to conserve and appropriately use current antibiotics by implementing antibiotic stewardship programs in hospitals and providing physicians with education on proper antibiotic use in ambulatory settings. By maintaining focus on these organisms and developing ways to reduce resistance, the rate of resistance can be diminished to prevent increased mortality or morbidity.

Acknowledgements

The authors would like to thank Dr. Melanie Hyte, Pharm D. for her assistance in obtaining the antibiotic susceptibility data.

References

1. Urinary Tract Infection (Catheter-Associated Urinary Tract Infection [CAUTI] and Non-Catheter-Associated Urinary Tract Infection [UTI]) Events. National Healthcare Safety Network. Center for Disease Control, January 2023. Available from: Urinary Tract Infection (cdc.gov)
2. Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. Nat Rev Microbiol. 2015 May;13(5):269-84. doi: 10.1038/nrmicro3432. Epub 2015 Apr 8. PMID: 25853778; PMCID: PMC4457377.
3. Stamm WE, Norrby SR. Urinary tract infections: disease panorama and challenges. J Infect Dis. 2001 Mar 1;183 Suppl 1: S1-4. doi: 10.1086/318850. PMID: 11171002.
4. Klein RD, Hultgren SJ. Urinary tract infections: microbial pathogenesis, host-pathogen interactions and new treatment strategies. Nat Rev Microbiol. 2020 Apr;18(4):211-226. doi: 10.1038/s41579-020-0324-0. Epub 2020 Feb 18. PMID: 32071440; PMCID: PMC7942789.
5. Weiner LM, Webb AK, Limbago B, Dudeck MA, Patel J, Kallen AJ, Edwards JR, Sievert DM. Antimicrobial-Resistant Pathogens Associated with Healthcare-Associated Infections: Summary of Data Reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2011-2014. Infect Control Hosp Epidemiol. 2016 Nov;37(11):1288-1301. doi: 10.1017/ice.2016.174. Epub 2016 Aug 30. PMID: 27573805; PMCID: PMC6857725.
6. Lichtenberger P, Hooton TM. Complicated urinary tract infections. Curr Infect Dis Rep. 2008 Nov;10(6):499-504. doi: 10.1007/s11908-008-0081-0. PMID: 18945392.
7. Levison ME, Kaye D. Treatment of complicated urinary tract infections with an emphasis on drug-resistant gram-negative uropathogens. Curr Infect Dis Rep. 2013 Apr;15(2):109-15. doi: 10.1007/s11908-013-0315-7. PMID: 23378123.
8. Sabih A, Leslie SW. Complicated Urinary Tract Infections. [Updated 2023 Jan 18]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK436013/
9. Nielubowicz GR, Mobley HL. Host-pathogen interactions in urinary tract infection. Nat Rev Urol. 2010 Aug;7(8):430-41.

doi: 10.1038/nrurol.2010.101. Epub 2010 Jul 20. PMID: 20647992.
10. Kline KA, Schwartz DJ, Lewis WG, Hultgren SJ, Lewis AL. Immune activation and suppression by group B streptococcus in a murine model of urinary tract infection. Infect Immun. 2011 Sep;79(9):3588-95. doi: 10.1128/IAI.00122-11. Epub 2011 Jun 20. PMID: 21690238; PMCID: PMC3165466.
11. Fisher JF, Kavanagh K, Sobel JD, Kauffman CA, Newman CA. Candida urinary tract infection: pathogenesis. Clin Infect Dis. 2011 May;52 Suppl 6: S437-51. doi: 10.1093/cid/cir110. PMID: 21498837.
12. Chen YH, Ko WC, Hsueh PR. Emerging resistance problems and future perspectives in pharmacotherapy for complicated urinary tract infections. Expert Opin Pharmacother. 2013 Apr;14(5):587-96. doi: 10.1517/14656566.2013.778827. PMID: 23480061.
13. Jacobsen SM, Stickler DJ, Mobley HL, Shirtliff ME. Complicated catheter-associated urinary tract infections due to Escherichia coli and Proteus mirabilis. Clin Microbiol Rev. 2008 Jan;21(1):26-59. doi: 10.1128/CMR.00019-07. PMID: 18202436; PMCID: PMC2223845.
14. Foxman B. Urinary tract infection syndromes: occurrence, recurrence, bacteriology, risk factors, and disease burden. Infect Dis Clin North Am. 2014 Mar;28(1):1-13. doi: 10.1016/j.idc.2013.09.003. Epub 2013 Dec 8. PMID: 24484571.
15. Hannan TJ, Totsika M, Mansfield KJ, Moore KH, Schembri MA, Hultgren SJ. Host-pathogen checkpoints and population bottlenecks in persistent and intracellular uropathogenic Escherichia coli bladder infection. FEMS Microbiol Rev. 2012 May;36(3):616-48. doi: 10.1111/j.1574-6976.2012.00339. x. PMID: 22404313; PMCID: PMC3675774.
16. Kostakioti M, Hultgren SJ, Hadjifrangiskou M. Molecular blueprint of uropathogenic Escherichia coli virulence provides clues toward the development of anti-virulence therapeutics. Virulence. 2012 Nov 15;3(7):592-4. doi: 10.4161/viru.22364. Epub 2012 Nov 15. PMID: 23154288; PMCID: PMC3545937.
17. Adler A, Friedman ND, Marchaim D. Multidrug-Resistant Gram-Negative Bacilli: Infection Control Implications. Infect Dis Clin North Am. 2016 Dec;30(4):967-997. doi: 10.1016/j.idc.2016.08.001. Epub 2016 Sep 19. PMID: 27660090.
18. Rice LB. Federal funding for the study of antimicrobial resistance in nosocomial pathogens: no ESKAPE. J Infect Dis. 2008 Apr 15;197(8):1079-81. doi: 10.1086/533452. PMID: 18419525.
19. Pogue JM, Kaye KS, Cohen DA, Marchaim D. Appropriate antimicrobial therapy in the era of multidrug-resistant human pathogens. Clin Microbiol Infect. 2015 Apr;21(4):302-12. doi: 10.1016/j.cmi.2014.12.025. Epub 2015 Jan 14. PMID: 25743999.
20. Bouch HW, Talbot GH, Bradley JS, Edwards JE, Gilbert D, Rice LB, et al. Bad bugs, no drugs, no ESKAPE! An update from the Infectious Diseases Society of America. Clin Infect Dis 2009 Jan 1;48(1):1-12, https://doi.org/10.1086/595011
21. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; 32nd edition. CLSI supplement M100. Clinical and Laboratory Standards Institute; January 2020.
22. Opal, SM, Pop-Vicas, A. 18-Molecular mechanisms of antibiotic resistance in bacteria.
Editor(s): John E. Bennett, Raphael Dolin, Martin J. Blaser, Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases (Eighth Edition). W.B. Saunders, 2015, Pages 235-251.e3, ISBN 9781455748013.
23. Montealegre MC, Roh JH, Rae M, Davlieva MG, Singh KV, Shamoo Y, Murray BE. Differential Penicillin-Binding Protein 5 (PBP5) Levels in the Enterococcus faecium Clades with Different Levels of Ampicillin Resistance. Antimicrob Agents Chemother. 2016 Dec 27;61(1):e02034-16. doi: 10.1128/AAC.02034-16. PMID: 27821450; PMCID: PMC5192164.

24. Al Mohajer M, Musher DM, Minard CG, Darouiche RO. Clinical significance of Staphylococcus aureus bacteriuria at a tertiary care hospital. Scand J Infect Dis. 2013 Sep;45(9):688-95. doi: 10.3109/00365548.2013.803291. Epub 2013 Jul 1. PMID: 23808717.
25. Routh JC, Alt AL, Ashley RA, Kramer SA, Boyce TG. Increasing prevalence and associated risk factors for methicillin resistant Staphylococcus aureus bacteriuria. J Urol. 2009 Apr;181(4):1694-8. doi: 10.1016/j.juro.2008.11.108. Epub 2009 Feb 23. PMID: 19233426.
26. Karlowsky JA, Hoban DJ, Hackel MA, Lob SH, Sahm DF. Resistance among gram-negative ESKAPE pathogens isolated from hospitalized patients with intra-abdominal and urinary tract infections in Latin American countries: SMART 2013-2015. Braz J Infect Dis 2017:21(3):343-348.
27. Santajit S, Indrawattana N. Mechanisms of Antimicrobial Resistance in ESKAPE Pathogens. Biomed Res Int. 2016; 2016:2475067. doi: 10.1155/2016/2475067. Epub 2016 May 5. PMID: 27274985; PMCID: PMC4871955.
28. Zhou Y, Yu H, Guo Q, Xu X, Ye X, Wu S, Guo Y, Wang M. Distribution of 16S rRNA methylases among different species of Gram-negative bacilli with high-level resistance to aminoglycosides. Eur J Clin Microbiol Infect Dis. 2010 Nov;29(11):1349-53. doi: 10.1007/s10096-010-1004-1. Epub 2010 Jul 8. PMID: 20614151.
29. Pendleton JN, Gorman SP, Gilmore BF. Clinical relevance of the ESKAPE pathogens. Expert Rev Anti Infect Ther. 2013 Mar;11(3):297-308. doi: 10.1586/eri.13.12. PMID: 23458769.
30. United States Department of Health and Human Services. Centers for Disease Control and Prevention. Antibiotic resistance threats in the United States. 2019. Available from: 2019 Antibiotic Resistance Threats Report | CDC
31. Pan YP, Xu YH, Wang ZX, Fang YP, Shen JL. Overexpression of MexAB-OprM efflux pump in carbapenem-resistant Pseudomonas aeruginosa. Arch Microbiol. 2016 Aug;198(6):565-71. doi: 10.1007/s00203-016-1215-7. Epub 2016 Apr 8. PMID: 27060003.
32. World Health Organization. Antimicrobial Resistance. November 17, 2021. Available from: Antimicrobial resistance (who.int)

Research article

Influence of COVID-19 Pandemic on Breast Cancer Diagnosis and Treatment in Low Resource Setting: A Case Study of a Nigerian Tertiary Healthcare Facility

Adesokan Joseph Oluwatobi[1], Sanni Olaniyi Felix[2*], Abiodun Olaiya Paul[3], Odunlade Adekola John[4]

[1]Physiotherapy Northern Lincolnshire and Goole NHS Foundation, UK. [2]Research and Development, Fescosof Data Solutions, Ogun State, Nigeria. [3]Public Health Department, Texila America University, Nicaragua. [4]Reablement care, Mersey Care NHS Foundation Trust, UK

Background: **The COVID-19 pandemic had a wide range of effects on healthcare services, from disrupting normal patient flow to healthcare facilities to stressing and overwhelming healthcare resources. This study aims to evaluate the influence of COVID-19 on breast cancer diagnosis in a tertiary healthcare facility in Nigeria.**
Methodology: **The study was a descriptive cross-sectional survey using data extraction. The study population comprised medical professionals at Lagos State University Teaching Hospital (LASUTH), including doctors, laboratory technicians, and scientists in the pathology, oncology, and general medicine departments. Data were analysed using IBM-SPSS for Windows version 28.0.**
Results: **The study comprised 36 participants. They were predominantly males (63.9%), aged 20-30 (47.2%), attained tertiary education (100%), Christians (88.9%), married (66.7%), medical laboratory scientists (33.3%), and had 1-5 years of experience (58.3%). Although 88.9% of the participants said they were at risk of contracting COVID-19 due to exposure to patients at work, 11% of them said they did not. Even though 27.8% of the participants said they are not experiencing a lack of proper supply diagnostics materials/supplies due to the pandemic, 72.2% said they are experiencing it. Some respondents gave 60% positive feedback on the satisfactory level of patients during the pandemic, while others rated the feedback they got as poor. Most participants agreed that the pandemic has resulted in several practical challenges for the facility, including a lack of funding, poor patient turnout, longer waiting times for results, and inadequate personal protective equipment (PPE).**
Conclusion: **This study showed that healthcare providers and patients were hampered by a lack of PPE, apprehension about contracting an infection, high costs, and incompetence during the pandemic.**

Keywords: COVID-19, LASUTH, Personal-Protective-Equipment (PPE), Diagnosis

---

Accepted: February 1, 2024
*Corresponding author: Olaniyi Felix Sanni. E-mail: fescosofanalysis@gmail.com

Introduction

Coronavirus disease 2019 (COVID-19) has been widespread at an alarming rate worldwide, and the tremendous load COVID-19 has placed on health systems has significant implications for cancer care.[1] Although data are sparse, patients with cancer appear to be more susceptible to infection-related complications, such as an increased requirement for ventilator support and increased fatality rates.[2-4] Also, diagnosis may be delayed since screening programs and diagnostic services have been reduced in several nations. People fearful of infection have been less willing to seek healthcare services.[5] Several clinical trials have been halted, limiting current treatment choices for patients who may have enrolled and jeopardising longer-term therapeutic development. [6] However, responding rapidly, healthcare professionals and management in several nations have reorganised cancer services and updated instructions for medical personnel and patients to limit the impact of COVID-19 on cancer care provision.[7]

Patients with cancer must attend healthcare facilities more frequently than patients with other diseases due to the nature of the disease and its treatment.[8] Treatment of cancer patients involves the active participation of multidisciplinary teams throughout the disease's course, from diagnosis through survivorship or end-of-life care.[8] Throughout the disease's course, patients require repeated hospital visits to be assessed by various doctors and to undergo numerous laboratory or imaging tests for diagnosis, staging, or monitoring therapy effects, in addition to various surgeries and therapies.[8] Besides medical professionals, cancer patients require the assistance of various other professionals, including social workers, psychologists, educators, and other support services.[8] Patients diagnosed with cancer require ongoing monitoring and assistance throughout and after treatment.[1] These services must operate in unison and on time, with a high level of dedication and compliance from patients to maximise patient benefit because any slight divergence from well-established standards may result in fragmented and low-quality treatment, as well as a worse patient outcome.[5,9]

The COVID-19 pandemic had a wide range of effects on healthcare services, from disrupting normal patient flow to healthcare facilities to stressing and overwhelming healthcare resources, and ultimately leading to the implementation of additional protective measures and social isolation through increased use of telehealth and virtual medicine.[10] Patients with cancer, including breast cancer, are a vulnerable demographic.[11] During pandemics, they face various risks, including increased susceptibility to life-threatening infections and interruptions in their treatment or regular medical care.[10] As a result, oncologists have faced significant difficulty balancing the administration of high-quality continuous unbroken cancer care to decrease patients' risk of exposure.[9,12] The pandemic's detrimental impact is most significant in low- and middle-income nations, where resources are scarce, infrastructure is inadequate, healthcare personnel and organized care teams are insufficient, medical supplies and PPE are low, and technology is scarce—resulting in a deficiency in the provision and delivery of critical care.[12,13] If left unchecked, the pandemic's access barriers to oncology care would exacerbate existing cancer-preventative, diagnostic, and treatment gaps, ultimately worsening the region's total cancer disease burden, morbidity, and death. This study aims to evaluate the influence of COVID-19 on breast cancer diagnosis in a tertiary healthcare facility in Nigeria.

Methodology

Study Design

This study design included the use of breast cytology and histopathology data, which were extracted from Lagos State University Teaching Hospital (LASUTH). These data were extracted to determine the trend and challenges of cancer diagnosis during COVID-19 compared to before the COVID-19 outbreak.

Study Location

The study was conducted at Lagos State University Teaching Hospital (LASUTH) in

Lagos, Nigeria. Lagos is the most populous state in Nigeria. The metropolitan area originated on islands, including Lagos Island, protected from the Atlantic Ocean by sand spits. However, the city has expanded onto the mainland west of the lagoon, with Ikeja, the capital of Lagos, and Agege over 25 miles northwest of Lagos Island. Lagos's population is estimated at 21 million, making it the largest African city.[14]

Study Population

The study population comprised medical professionals at LASUTH, including doctors, laboratory technicians, and scientists in the pathology, oncology, and general medicine departments.

Data Source

Existing data on breast cytology and histopathology from the facility were extracted to get information about the impact of the COVID-19 pandemic on breast cancer diagnosis.

Sample Size

The sample size for this study is comprised of 36 respondents randomly selected from three departments in the facility.

Data Analysis

After the extraction of data procedure, the data was processed using the IBM-Statistical Package for Social Sciences (IBM-SPSS) version 28.0 for Windows *IBM* Corp., Armonk, N.Y., USA. The descriptive data included the respondents' sociodemographic characteristics and the impacts the COVID-19 pandemic has had on cancer diagnosis. Data were described as percentages/proportions, mean/average, and standard deviation and presented as charts or tables.

Inclusion and Exclusion Criteria

Pathologists, technicians, doctors, and scientists that work at LASUTH are included in this study, while non-medical professionals and non-medical staff at LASUTH were excluded.

Ethical approval

Before the study commencement, authorizations were sought from the Lagos State University Teaching Hospital, the covered area's administrative and health authorities. The study received authorization with the approval number LREC/06/10/1913. Before participating in the study, the research team confirmed that all respondents willingly and with informed permission. Informed permission was established using signed consent forms securely stored with completed questionnaire forms. Skilled data collectors did each study with extensive experience collecting data in LASUTH. Additionally, all study supervisors and note-takers received training on research ethics and consent processes.

Results

Sociodemographic profile of the study respondents

As shown in Table 1, more than three-fifths of the respondents, 23 (63.9%), were male, and 13 (36.1%) were female. Half, 17 (47.2%) of the respondents were between 20 and 30 years, 36.1% were between 31 and 40 years, and 16.7% were between 41 and 50. All the respondents (100%) had tertiary education, 66.7% were married, and 33.3% were single.

Most of the respondents, 32 (88.9%), were Christian, and 11.1% Muslim; 6 (16.7%) were general medicine practitioners, 8.3% health administrators, 33.3% medical laboratory scientists, 11.1% nurses, 5.6% were an oncologist, 11.1% apathologist, and 13.9% a physiotherapist. More than half, 21 (58.3%) of respondents had 1–5 years of experience, 33.3% had 6–10 years of experience, and 8.3% had more than ten years of experience.

Impact of COVID-19 on diagnostic processes

As shown in Figure 1, 32 (88.9%) respondents said they were at risk of contracting COVID-19 due to their exposure to patients at work, while 4 (11.1%) did not.

Table 1. Sociodemographic profile of the study respondents

Variable	Parameters	Frequency	Percent
Gender	Female	13	36.1
	Male	23	63.9
Age	20 - 30 years	17	47.2
	31 - 40 years	13	36.1
	41 – 50 years	6	16.7
Education	Tertiary	36	100
Marital status	Married	24	66.7
	Single	12	33.3
Religion	Christianity	32	88.9
	Islam	4	11.1
Field of practice	General medicine	6	16.7
	Health Administration	3	8.3
	Medical Laboratory Science	12	33.3
	Nursing	4	11.1
	Oncology	2	5.6
	Pathology	4	11.1
	Physiotherapy	5	13.9
Years of experience	1 - 5 years	21	58.3
	6 - 10 years	12	33.3
	> 10 years	3	8.3
	> 10 years	3	8.3
Total		36	100.0

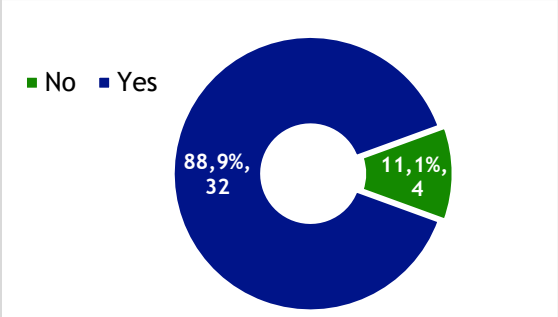


Figure 1. Respondents who see themselves at risk of contracting COVID-19 infection due to exposure to patients and others at work

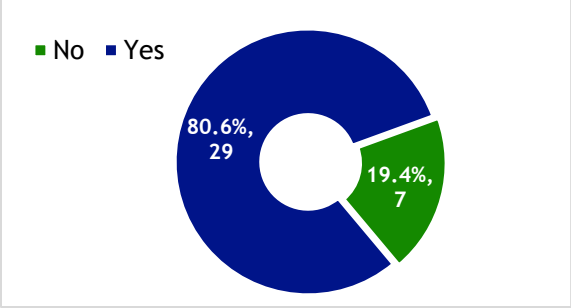


Figure 2. Facility breast samples diagnosis during the COVID-19 pandemic

Facility breast samples diagnosis during the COVID-19 pandemic

As shown in Figure 2, most respondents said the facility could continue with breast sample diagnosis even during the COVID-19 pandemic.

Effect of COVID-19 on the supplies of diagnostics materials

As shown in Figure 3, when asked if they are experiencing a lack of proper supply diagnostics materials/supplies due to the pandemic, 26 (72.2%) said yes, and 10 (27.8%) said no.

Analysis of breast data. Variation in breast sample diagnosis before and during the COVID-19 pandemic

As shown in Figure 4, the total breast samples tested increased by 39 (8.2%) from 2018 (474) to 513 in 2019. However, the number decreased by 172 (33.5%) in 2020 when the COVID-19 pandemic started, with a six-month lockdown. In 2021, the total number of breast

samples tested increased from 341 to 380, accounting for an 11.4% increase.

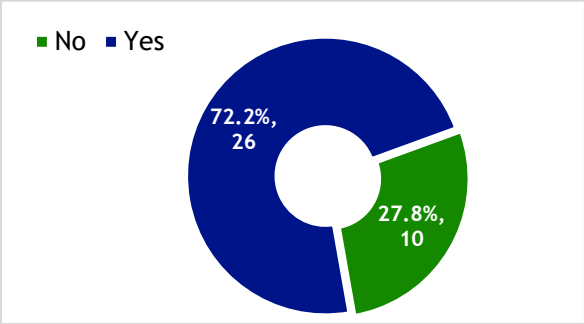


Figure 3. Effect of COVID-19 on the supplies of diagnostics materials

As shown in Table 2, a total of 1708 valid breast samples were tested in four years (2018-2019 - before and 2020-2021 – during the COVID-19 pandemic). Of this, more than half, 987 (57.8%) samples were tested before and 721 (42.2%) during the pandemic. Similarly, breast 514 (555.1%) malignant and 473 (61.0%) benign were diagnosed before COVID-19 compared to 44.9% malignant and 38.0% benign during the pandemic. The odds of cancer diagnosis were 1.28 (95% CI = 1.05 – 1.55, P = 0.013), higher than before the pandemic.

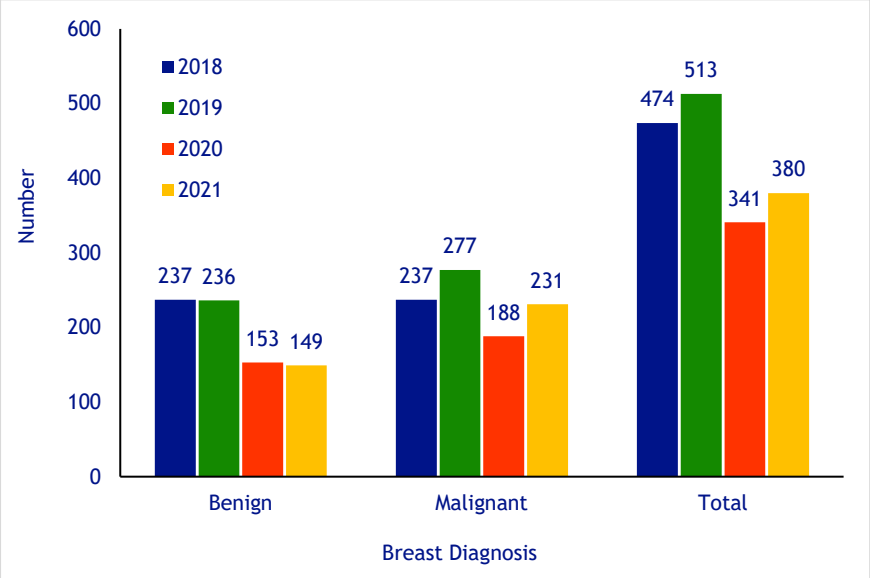


Figure 4. Variation in breast disease diagnosis with years (2018 – 2021)

The diagnosis results showed a steady decrease in breast benign from 237 in 2018 to 149 in 2021, representing a 37.1% decrease during the COVID-19 pandemic. Similarly, malignant cases increased from 237 in 2018 to 277 in 2019 but reduced to 188 in 2020 and 231 in 2021.

Table 2. Variation of breast disease diagnosis before and during the COVID-19 pandemic

Period	Diagnosis Benign (n=775)	Malignant (n=993)	Total (n=1708)	Odds ratio	P-value
Before COVID-19	473 (61.0)	514 (55.1)	987 (57.8)	1.00	0.013*
During COVID-19	302 (39.0)	419 (44.9)	721 (42.2)	1.28 (1.05-1.55)	

Discussion

The study's primary purpose was to investigate how COVID-19 affected cancer detection. The pandemic's interruptions to cancer services have been especially severe in low-resource contexts, such as many African nations and other low-middle income countries.[6,9,15,16] It is extremely challenging for medical oncologists to continue meeting the needs of their patients and staff during this unprecedented epidemic. Preliminary data reveals that cancer patients may be at a considerably higher risk of COVID-19-related disorders.[17] Most of the participants in this study are males between the ages of 20 and 30; they have all finished post-secondary education, are married with children, in general, practice medicine, and have between one and five years of experience. The selection process may contribute to the difference in socioeconomic status indices.

Impact of COVID-19 on diagnostic processes

When asked how they were exposed to the risk of contracting COVID-19, most respondents (88.9%)

highlighted their close interactions with patients during the cancer diagnostic process. Dhada et al.[18] reported a similar issue in their Systematic Review of cancer patients and carers, which is consistent with the current study's findings.[18] According to their findings, incomplete therapy, COVID-19-related issues, and the resulting consequences on participants' mental and emotional health were all sources of worry in the studies included in their meta-analysis.[18] As a result, cancer screenings were discontinued, regular oncology appointments were cancelled, and treatment was postponed, all of which contributed to increased stress and worry, demonstrating a terrible lack of disaster preparedness.[19]

Facility breast samples diagnosis during the COVID-19 pandemic

The outbreak is expected to influence the diagnosis of breast samples. On the other hand, the findings of this study suggested that the great majority of laboratories stayed open during the pandemic and continued testing on breast tissue samples. According to Elghobashy et al.[20] and Nnaji & Moodley[21], COVID-19 substantially influenced diagnosis, which contradicts their findings. Early detection programmes have been halted worldwide because of worries about the spread of COVID-19 in healthcare settings.[22,23] This effect is expected to be more evident in low-resource settings due to weak infection control strategies and resource constraints in providing PPE, cancer screening, and diagnostic services.[21] Due to the pandemic, routine breast sample procedures have been postponed in Ghana and Nigeria.[9,24] To minimise the spread of the COVID-19 virus and decrease demand for medical services, cancer patients are frequently encouraged to delay or postpone treatment, and hospitalization is discouraged.[5,9,25] However, this can be hazardous to patients' health since delays in cancer diagnosis or treatment have the potential to negatively impact patient outcomes, such as the chance of a late diagnosis, the spread of the illness, and the progression of a tumour from treatable to incurable.[26–28]

Effect of COVID-19 on the supplies of diagnostics materials and availability of PPE.

Participants in this research overwhelmingly blamed a lack of diagnostic equipment and personnel at the clinic during the outbreak. Furthermore, there were wide discrepancies in how much PPE was available at any one time during the pandemic. When asked about the availability and quantity of PPE, some respondents felt it was inadequate, while others felt it was fair or suitable. A rise in demand resulted in a shortage of PPE, which increased costs and reduced supply. Perhaps this is the result of travel bans that have hurt the economies of many nations. Similar results were found by Khot[29] when they investigated healthcare supply bottlenecks. Amid the widespread spread of COVID-19. Khot[29] claims that the COVID-19 epidemic has wreaked havoc on the global healthcare supply chain, leading to a scarcity of raw materials and significant price hikes. That's because, as Khot[29] explains, the worldwide grounding of aeroplanes and the prohibition of cross-border travel and cargo have seriously disrupted the global transportation infrastructure.[29] According to Reynolds[30]'s findings, the global supply chain has been significantly disrupted by the 68 nations that have banned shipments of personal protective equipment supplies owing to the pandemic.[30]

Variation in breast sample diagnosis before and during the COVID-19 pandemic

The findings of this study demonstrated substantial changes in the diagnostic accuracy of breast cancer samples collected before and after the COVID-19 outbreak. There was steady growth before the outbreak, despite more samples being analysed before the pandemic's commencement in 2020. Similarly, there was a 37.1 percent decrease in benign breast diagnoses throughout the outbreak. Malignant cases also declined throughout the pandemic, matching the trend seen before and after the epidemic. The lockdown may have deterred breast cancer women from obtaining medical treatment, explaining the disparity. People's

unjustified fear of contracting the virus may add to the disparity. Lowry et al.[31] reported that declines in cancer diagnoses during the pandemic were primarily due to declines in screen-detected cancers, which was consistent with previous work.[32–34] The pandemic had a greater impact on screening than diagnostic breast imaging. Although monthly screening levels recovered to normal by the summer of 2020, rescheduling missed mammography exams earlier in the pandemic would demand higher-than-average imaging volumes to compensate for the shortage in cancer diagnoses.[35] According to Angelini et al.[36], cancer screening and diagnosis were among the several medical services that had to be halted owing to the limitations imposed to battle the pandemic.[33,37] As a result, fewer cancer tests and detection would be performed during the outbreak. Cancer diagnoses and diagnostic tests exhibited a U-shaped declining trend during the pandemic, with a negative peak in April 2020, when most governments around the world instituted quarantine measures to limit the disease. Angelini et al.[36] discovered that the number of cancer diagnoses decreased by 37.3% between 2010 and 2012, while the number of diagnostic tests decreased by 27.0%.[36]

Limitations

It is possible that the findings of this study are not reflective of the breast cancer population in Nigeria. This study focused primarily on the influence of COVID-19 on breast cancer diagnosis and was carried out in an environment with limited resources. Consequently, further research should evaluate larger regions and the impacts of COVID-19 on breast cancer patients, such as those genetically susceptible to mental illness and clinical depression.

Conclusions

This study analysed the effects of the COVID-19 pandemic on breast cancer screening in a low-resource nation. The findings show that a shortage of medical staff frequently caused increased patient volume due to a lack of willingness to show up to work or a lack of proper medical equipment. Lack of PPE, fear of catching an illness, high prices, and inexperience inhibited healthcare providers and patients. As a result, it's crucial to furnish the healthcare industry with adequate funds, personnel, and supplies to suit the needs of patients and staff. In addition, information exchange and coordination among healthcare practitioners are vital for delivering high-quality patient treatment and decreasing workloads.

References

1. Turna H. The impact of the COVID-19 pandemic on cancer patients. Coronavirus Dis From Mol to Clin Perspect. 2021;225–35.
2. Liang W et al. Cancer patients in SARS-CoV-2 infection. Lancet Oncol. 2020;
3. Onder G, Rezza G, Brusaferro S. Case-Fatality Rate and Characteristics of Patients Dying in Relation to COVID-19 in Italy. JAMA - J Am Med Assoc. 2020;323(18):1775–6.
4. Wu Z, McGoogan JM. Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases from the Chinese Center for Disease Control and Prevention. JAMA - J Am Med Assoc. 2020;323(13):1239–42.
5. Olabumuyi AA, Ali-Gombe M, Biyi-Olutunde OA, Gbolahan O, Iwuji CO, Joseph AO, et al. Oncology practice in the COVID-19 pandemic: A report of a Nigerian expert panel discussion (oncology care in Nigeria during the COVID-19 pandemic). Pan Afr Med J. 2020;36:1–9.
6. Lombe D, Phiri M, Msadabwe S. Negative impact of the COVID-19 pandemic on the management of cervical cancer patients in Zambia. Ecancermedicalscience. 2020;14:14.
7. Okeke M, Oderinde O, Liu L, Kabula D. Oncology and COVID-19: Perspectives on cancer patients and oncologists in Africa. Ethics, Med Public Heal. 2020;14:14.

8. Silbermann M, Pitsillides B, Al-Alfi N, Omran S, Al-Jabri K, Elshamy K, et al. Multidisciplinary care team for cancer patients and its implementation in several middle Eastern countries. Ann Oncol. 2013;24(SUPPLEMENT7).
9. Kugbey N, Ohene-Oti N, Vanderpuye V. COVID-19 and its ramifications for cancer patients in low-resource settings: Ghana as a case study. Ecancermedicalscience. 2020;14.
10. Salako O, Okunade K, Allsop M, Habeebu M, Toye M, Oluyede G, et al. Upheaval in cancer care during the COVID-19 outbreak. Ecancermedicalscience. 2020;14.
11. Deboer RJ, Fadelu TA, Shulman LN, Van Loon K. Applying Lessons Learned from Low-Resource Settings to Prioritize Cancer Care in a Pandemic. JAMA Oncol. 2020;6(9):1429–33.
12. Elkhouly EA, Salem RH, Haggag M. Should cancer treatment be continued during the COVID-19 pandemic? A single Egyptian institution experience. Ecancermedicalscience. 2020;14:14.
13. Tsamakis K, Gavriatopoulou M, Schizas D, Stravodimou A, Mougkou A, Tsiptsios D, et al. Oncology during the COVID-19 pandemic: Challenges, dilemmas and the psychosocial impact on cancer patients (Review). Oncol Lett. 2020;20(1):441–7.
14. J. Campbell. This Is Africa's New Biggest City: Lagos, Nigeria, Population 21 Million - Atlantic Mobile. Atl. 2012;3–5.
15. Kartik A, Garg D, Singh RB. Implications of Reduced Health Care Services for Cancer Patients in India and Similar Resource-Limited Health Care Systems During COVID-19 Pandemic. Asia-Pacific J Public Heal. 2020;32(5):287–8.
16. Trehan A, Jain R, Bansal D. Oncology care in a lower middle-income country during the COVID-19 pandemic. Pediatr Blood Cancer. 2020;67(8):7323035 5.
17. Ürün Y, Hussain SA, Bakouny Z, Castellano D, Kılıçkap S, Morgan G, et al. Survey of the Impact of COVID-19 on Oncologists' Decision Making in Cancer. JCO Glob Oncol. 2020;6(6):1248–57.
18. Dhada S, Stewart D, Cheema E, Hadi MA, Paudyal V. Cancer services during the covid-19 pandemic: Systematic review of patient's and caregiver's experiences. Cancer Manag Res. 2021;13:5875–87.
19. IFRRS. International Federation of Red Cross and Red Crescent Societies. 2022;337–337.
20. Elghobashy M, Wahab L, Gunavardhan A, O'Sullivan E, Provenzano E, Deb R, et al. Impact of COVID-19 on the practice of breast pathologists: A survey of breast pathologists in the UK and Ireland. J Clin Pathol. 2023;2021-207725.
21. Nnaji CA, Moodley J. Impact of the COVID-19 pandemic on cancer diagnosis, treatment and research in African health systems: A review of current evidence and contextual perspectives. Ecancermedicalscience. 2020;15:1–10.
22. Amit M, Tam S, Bader T, Sorkin A, Benov A. Pausing cancer screening during the severe acute respiratory syndrome corona-virus 2pandemic: Should we revisit the reco-mmendations? Eur J Cancer. 2020;134:86–9.
23. Chou CP, Lin HS. Delayed breast cancer detection in an asian country (Taiwan) with low covid-19 incidence. Cancer Manag Res. 2021;13:5899–906.
24. Okunade KS, Okunowo AA, Ohazurike EO, Anorlu RI. Good clinical practice advice for the management of patients with gynaecological cancer during the covid-19 pandemic in nigeria and other resource-constrained countries. Ecancermedicalscience. 2020;14:14.
25. Amaoui B, Semghouli S, Benjaafar N. Organization of a radiotherapy service during the COVID-19 epidemic: Experience of Regional Center of Oncology of Agadir, Morocco. Radiography. 2020;26(4):e312–4.
26. Dalton M, Holzman E, Erwin E, Michelen S, Rositch AF, Kumar S, et al. Patient navigation services for cancer care in low-and middle-income countries: A scoping review. PLoS One. 2019;14(10):e0223537.
27. Moodley J, Cairncross L, Naiker T, Momberg M. Understanding pathways to

breast cancer diagnosis among women in the Western Cape Province, South Africa: A qualitative study. BMJ Open. 2016;6(1): e009905.
28. Christa L. Walker, Igor Rudan, Li Liu HN. Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. Ann Oncol. 2020;7(May):19–21.
29. Khot UN. Navigating Healthcare Supply Shortages During the COVID-19 Pandemic: A Cardiologist's Perspective. Circ Cardiovasc Qual Outcomes. 2020;13(6): E006801.
30. Reynolds C. Canada facing "major" medical gear shortage as 68 countries restrict exports. Can Press. 2020;
31. Lowry KP, Bissell MCS, Miglioretti DL, Kerlikowske K, Alsheik N, Macarol T, et al. Breast Biopsy Recommendations and Breast Cancers Diagnosed during the COVID-19 Pandemic. Radiology. 2022;303(2):287–94.
32. Nyante SJ, Benefield TS, Kuzmiak CM, Earnhardt K, Pritchard M, Henderson LM. Population-level impact of coronavirus disease 2019 on breast cancer screening and diagnostic procedures. Cancer. 2021;127(12):2111–21.
33. Song H, Bergman A, Chen AT, Ellis D, David G, Friedman AB, et al. Disruptions in preventive care: Mammograms during the COVID-19 pandemic. Health Serv Res. 2021;56(1):95–101.
34. Sprague BL, Lowry KP, Miglioretti DL, Alsheik N, Bowles EJA, Tosteson ANA, et al. Changes in Mammography Use by Women's Characteristics During the First 5 Months of the COVID-19 Pandemic. J Natl Cancer Inst. 2021;113(9):1161–7.
35. McBain RK, Cantor JH, Jena AB, Pera MF, Bravata DM, Whaley CM. Decline and Rebound in Routine Cancer Screening Rates During the COVID-19 Pandemic. J Gen Intern Med. 2021;36(6):1829–31.
36. Angelini M, Teglia F, Astolfi L, Casolari G, Boffetta P. Decrease of cancer diagnosis during COVID-19 pandemic: a systematic review and meta-analysis. Eur J Epidemiol. 2023;38(1):31–8.
37. Koca B, Yildirim M. Delay in breast cancer diagnosis and its clinical consequences during the coronavirus disease pandemic. J Surg Oncol. 2021;124(3):261–7.

Research article

Action Plan for the Future – the Situation for Biomedical Laboratory Scientists (BLS) in Denmark, Finland, Norway, and Sweden

Sophia Godau[1,2], Mette Lundstrøm Dahl[3], Åge Winje Brustad[4], Bente Alm[5], Kaija Sopenlehto[6], Gabriella Lillsunde Larsson[7,8,9*]

[1]Department of Laboratory Medicine, Karolinska Institute, Huddinge, Sweden. [2]Vårdförbundet - the Swedish Association of Health Professionals, Stockholm, Sweden. [3]NITO BFI – The Norwegian Institute of Biomedical Science, Oslo, Norway. [4]Department of Medical Biochemistry, Radiumhospitalet, Oslo University Hospital, Oslo, Norway. [5]Department of Biological Sciences Ålesund, Faculty of Natural Sciences, Norwegian University of Science and Technology (NTNU), Ålesund, Norway. [6]The Association of Biomedical Laboratory Scientists in Finland, Helsinki, Finland. [7]The Swedish Institute of Biomedical Laboratory Science (IBL), Stockholm, Sweden. [8]School of Health Sciences, Faculty of Medicine and Health, Örebro University, Örebro, Sweden. [9]Department of Laboratory Medicine, Faculty of Medicine and Health, Örebro University, Örebro, Sweden.

Objective: **The aim of this study was to investigate if there is a lack of professionals in the Nordic countries as well as the prognosis for the future in relation to educational output. In addition, the study aimed to investigate the Nordic professional's point of view on how to make the profession attractive, what career opportunities that are needed and what role the BLS should have in the future healthcare setting.**

Materials and methods: **Data for each country were provided from reports. Professionals present at the NML congress 2023 were invited to discuss questions related to the lack of BLS. Answers were collected, summarized, and grouped in themes.**

Results: **Three of four Nordic countries report current and future challenges in BLS workforce and a substantial amount of BLS in the Nordic countries are 50 years or older. Despite efforts where admissions to the universities have increased, the amount of examinates has not increased proportionally. Professionals identifies a need for making the profession more attractive highlighting career opportunities, professional visibility, salary increase, and task-shifting.**

Discussion: **We have identified several threats to the sustention of BLS in healthcare today and in the future in the Nordic countries. This includes high retirement numbers, drift towards working in the private sector, as well as low salaries and lack of career opportunities. In this study, the profession has provided useful insights on how to make the profession more attractive including increased visibility, provide career paths, and distinguish what the BLS competence is and**

Accepted: April 7, 2024

*Corresponding author: Gabriella Lillsunde Larsson. E.-mail: gabriella.lillsunde-larsson@oru.se. School of health sciences, Örebro University, Fakultetsgatan 1, SE-701 82 ÖREBRO, Sweden.

can be in the future.
Conclusion: **We have identified several future arenas for the profession that can attract students to educations, keep professionals in healthcare, and secure high quality in diagnostics. To succeed, we need stronger linkage between the profession itself, educational institutions, healthcare employers, and professional organizations.**

Abbreviations:
Biomedical laboratory scientist (BLS)
Nordisk Medisinsk Laboratoriegruppe (NML)

Keywords/MeSH terms:
Scandinavian and Nordic Countries, Medical Laboratory Personnel.

Introduction

A total of almost 28 million people reside in the Nordic Region (Sweden, Norway, Finland, Denmark, and Iceland). In the last 20 years or so, there has been an increase in the population by 13%. As in many other European countries, the populations are growing older and older. In 2022, 20% of the population was 65 years of age and above. This number is expected to rise to 25% in 2040. Hence, there are more citizens requiring healthcare and individuals are living longer.[1] A consequence of this is higher demands on healthcare and subsequently on laboratory testing and clinical physiological examinations.

In the Nordic countries, biomedical laboratory scientists (BLS) work in laboratory medicine as well as in clinical physiology. Qualifications after education are provided through a license to practice. This guarantees patient safety and qualifications to provide high quality diagnostic testing/examinations and reporting.[2] Biomedical laboratory medicine is a field that is developing rapidly due to improvements in medicine, methodology, and technology. Adaption to new scenarios, techniques and circumstances have shown to be crucial for the profession, especially in the context of the COVID-19 pandemic where BLS all over the world provided life-saving diagnostic testing. New methods and instrumentation were implemented rapidly, demanding skills in technology, validation, and adaptation.[3]

Educated within laboratory medicine or clinical physiology, Nordic BLS work in both specialized healthcare as well as community health centers and in single clinics. Professionals in laboratory medicine have competencies in different areas such as transfusion medicine, clinical chemistry, microbiology, immunology, pathology, genetics, and phlebotomy. Clinical physiology also includes knowledge and skills in ultrasound, neurophysiology, and nuclear medicine. Specialization requires further studies and experience but is defined different depending on the country.

A challenge and opportunity for the profession in healthcare is the concept of task shifting. This can include letting go of some tasks and including more specialized ones. Task shifting may be a natural consequence of a profession as it changes and develops throughhout the years. However, recent task shifting for the BLS profession has been a necessity due to shortage of personnel at many laboratories. Other professions may then come into the laboratory because there are problems in recruiting BLS but also because of separating specific tasks to other healthcare staff.

To keep professionals in healthcare, there is a need for clear pathways that should result in career development and salary increases.[4] Industry and private actors may recruit from well-educated and experienced professionals as well as from the younger generation that are eager for change and opportunities. Work life conditions also play a crucial role, where the reason for working part time has shifted from family reasons to stress and exhaustion.

As described, the Nordic countries have challenges ahead when it comes to diagnostic services, keeping professionals in the public healthcare as well as ensuring good work life conditions. In this study we aim to summarize the Nordic situation for BLS and discuss potential solutions.

Aim

The aim of this study was to investigate if there is a lack of professionals in the Nordic countries as well as the prognosis of professionals in the future in relation to educational output.

In addition, the study aimed to investigate the Nordic professional's point of view on how we can make the profession attractive, what career opportunities that are needed and what role the BLS should have in the future healthcare setting.

Material and methods

Data on professional workforce, education numbers and prognostic data for each country were provided from reports collected from each Nordic country (Denmark, Finland, Norway, and Sweden).

Professionals were invited to participate in a lecture and workshop at the Nordisk Medisinsk Laboratoriegruppe (NML) congress 2023 in Oslo Norway. The activities were hosted by the Swedish institute of biomedical laboratory science (IBL) and Vårdförbundet - the Swedish association of health professionals. As part of the program, participants were asked to answer the following mentimeter questions using www.menti.com:

- is there a shortage of BLS in your country?
- are BLS replaced by other professions?
- do you have good career possibilities for BLS in your country?

Following the lecture, round table discussions were held to discuss the following questions:

- what can we do to make the profession attractive?
- what should the BLS role be when other professions come into the laboratory?
- what career opportunities do we need in the profession?

Answers from the round table discussions were collected, summarized, and grouped according to themes.

Participation was voluntary and data collection anonymous. Initial mentimeter questioning was performed with no information on who participated. Round table discussions were performed in person, but the collected answers where not connected to table, participant, or country.

Results

Professionals in the Nordic countries

In total, there are almost 30,000 (29,687) educated BLS in Denmark, Finland, Norway, and Sweden. Among those, approx. 75% (22,176) work in healthcare (Table 1). In Denmark, 16% of BLS-positions have other professionals assigned and in Finland some regions have reported a shortage of BLS.[5,6] In Norway, the increase of BLS positions is less than the increased need of BLS and there is a shortage of BLS in all regions.[7] In Sweden, all regions (21 of 21) reported a lack of BLS in 2022.[8]

Table 1: Numbers of biomedical laboratory scientists in four Nordic countries

	Denmark[5]	Finland*	Norway[12]	Sweden[13]
Total workforce BLS	6700	5300	7482	10 205
BLS in healthcare	4975 (74%)	3900 (74%)	5423 (73%)	7878 (77%)

* Data collected from KEVA [Internet, cited 2023 nov 24] Available at https://www.keva.fi/en/

Future perspectives and retirements

Three of four Nordic countries report future challenges in BLS workforce. According to the Finnish report from KEVA, in 2023 the shortage of BLS was 778 BLS and in 2032 there will be a shortage of about 20%.[6] Predictions from Norway show that the shortage in 2040 will be between 800 and 1200 BLS.[9] Numbers from the Swedish higher education authority project a shortage of 20% by 2035.[10.]

In Denmark, 32% of the BLS are over 50 years of age and in Finland 26.5% are 55 years or older.[5,11] In Norway, 22% are 55 years or older and Swedish data show that 36% of the professionals are 55 or older.[12,13]

Professionals in Denmark are increasingly recruited to the private sector (industry) with an increase of 61% from 2005 to 2021.[5] In Finland, 38% of BLS work in private sector 2021.[11] In Norway, around 7% of BLS working in healthcare, are employed in private laboratories.[9] In Sweden, the trend for working in private healthcare has been relatively constant during 2007-2021. For working in the private sector in other areas there has been a sharp increase of over 200%.[13]

The number of professionals in health care who have part time positions is reported to be 20% in Denmark, 17% in Norway and 25% in Sweden.[5,12,14]

Education

There are six professional BLS bachelor educations in Denmark. Students study 3.5 years and during the last 13 years there has been an increase in applications and in accepted students (from 400 accepted students in 2013 to 500 students in 2023). More students graduate but not relatively compared to the increased numbers of acceptance. In 2022, 294 BLS graduated from the Danish educational programs.[15]

In Finland, BLS are trained in six universities of applied sciences, for 3.5 years. In 2022, 342 new students were accepted and 222 graduated. Statistics show that 60% of accepted students will graduate in 3.5 years, 68% in 4.5 years, and the examination rate is 73% after five years.[16] In Finland, admission numbers have increased recently, but the students have not yet graduated.

Until 2021, there were seven universities providing a three-year bachelor's and professional degrees in Norway. In 2021, yet another university started offering the program. From 2016 to 2020 there was a slight increase in the number of accepted students (8% increase from 380 to 410). The increase in accepted students did not provide a higher number of graduates. The graduation rate after three years of study was 68% in 2019, whereas in 2023, it was 63%. The drop-out rates were 20% and 26%, respectively. From 2021, there was an additional increase in the number of accepted students due to the newly offered program, and the number increased to 435. In 2023, there were a total of 480 new students accepted (an increase of 26% from 2016 to 2023).[17]

Swedish universities (n=11) provide a 3-year bachelor and professional degree and have increased the numbers of accepted students, from 370 students in 2006 to 580 students in 2020. The number of examined professionals has not followed this increase. Of students who started their studies in 2006, 70% of the women and 54% of the men were examined while of those starting 2016, 58% of the women and 50% of the men followed through until graduation.[18]

In all four countries there are options for further university education. A master's degree can be BLS topic-specific (Denmark, Sweden, Norway) or related to medicine, public health or other. PhD education is also possible but requires part of the master's level education according to the Bologna model of higher education.

The professionals' point of view

The following results are based on data from the lecture and workshop at the NML congress 2023 in Oslo Norway. First, participants were asked to answer three questions related to shortage of the profession using a mentimeter analysis tool.

All participants (n=52) stated that there was a lack of BLS in their country. Six out of 58 (10%) reported that BLS are replaced by other professionals. Approximately half of the participants (52%: 32/61) reported that there are career possibilities for the professions.

These findings inspired follow up questions that were discussed at a round table format. We encouraged participants to think outside of the box and discuss a desirable professional future. A total of 73 different suggestions in relation to the questions asked at the round table discussions were collected. The most

popular topic to be discussed was how can we make the profession attractive?

Increased visibility of the profession was mentioned in several groups, mainly towards the community in general. The profession itself needs to tell others about who they are and why the profession is great. A positive storytelling was mentioned and there were also interesting ideas such as rebranding of the profession and creating TV-shows. It was also mentioned that it would be interesting to show what will happen in the healthcare system without BLS, particularly in relation to the recent pandemic. Additional examples to enhance the visibility included to do more research projects, publish, and to introduce students to research early on.

Another noted theme among the responses was career opportunities such as introduction programs and clear career pathways. Retention of staff was mentioned by several groups and that it must be worthwhile to stay at the workplace. Salary increase should be coupled to competence and there should be differentiation between tasks and responsibility providing career development.

The expectations of students and younger colleagues was also discussed. There is a need to better understand the new generation and the demands on the workplace. Mentorship was also mentioned as a way of educating new colleagues and students.

Another interesting output from the discussions was a suggestion of a separate shorter technical education to complement BLS in the laboratories and that BLS could aim for a master's degree.

The second discussion topic related to, what should the BLS role be when other professions come into the laboratory? There was a consensus that tasks related to sample registration, sample transportation, ordering supplies and repacking could be performed by other professionals. Also, phlebotomy was an example of a task that could be vacated. It was clear from the discussions that quality control of laboratory procedures and testing was to remain a responsibility of the BLS. Diagnostic partnership was discussed as a potential new role for the BLS.

The third discussion topic was, what career opportunities do we need in the profession? Besides the concept of career pathways, the groups discussed positions such as lead scientist, manager, and combined positions between laboratory and academia. Continuous professional development (CPD) was considered important as well as trainee opportunities.

Discussion

This study aimed to investigate if there is a lack of professionals in the Nordic countries and to investigate the Nordic professional's point of view on the current and future situation of BLS.

The data indicates that there is a confirmed shortage of BLS today and in the future in Finland, Norway, and Sweden. There is no national data from Denmark supporting a shortage of BLS, but reports show that 16% of BLS-positions have other professionals assigned, indicating either a lack of professionals or a drift of workforce to other areas.[5] Working in the private sector is an option for the BLS, both in industry and in healthcare, and in Sweden there has been a sharp increase of over 200% (2007-2021) for working in the private sector (healthcare excluded).[13]

A substantial amount of BLS in the Nordic countries are 50 years or older, especially in Sweden where 36% of the professionals are 55 or older.[13] Hence, the growth and maintaining sufficient practicing BLS is strongly dependent on educating new professionals. Despite efforts in Denmark, Norway, and Sweden, where admissions to the universities have increased, the amount of examinates has not increased proportionally. A considerable amount of BLS work part time, between 17-25%.

Considering the data there are clearly identifiable challenges ahead. It is of utmost importance that BLS's are retained in healthcare, that students are recruited to educations and the profession be attractive enough for a stable career choice. Also, from the round table discussions, the professional voice emphasizes the need for making the profession

more attractive highlighting career opportunity and subsequently salary and responsibility increase.

Education and Career Development

Despite increased admissions to BLS programs, the numbers of examinates do not follow. Hence, only increasing the number of admissions seems not to be the way to solve the problem. A substantial number of students do not finish their studies and some need longer periods to do so. Language barriers and lack of study techniques have been discussed as contributing factors to this issue, unfortunately also leading to a lot of instructor or faculty effort being directed towards activities other than teaching of the biomedical laboratory sciences. It is also worth mentioning that if there is a desire to increase admissions there needs also to be clinical internships available. However, if there is a lack of BLS there is also a lack of internship supervisors. Teaching staff, laboratory facilities and finances also influence the possibility of more admissions.

There are options for further university education in all four countries. The absence of regulated specialist education in Sweden, despite positive attitudes from professionals and students, highlights a significant gap in career development opportunities for BLS.[4] In Norway and Denmark, BLS can do a master's program and there are a few programs especially suitable for BLS. In Finland, there are masters available but not yet specifically for the BLS profession. These educational opportunities are crucial for attracting more students to the BLS profession and retaining professionals in healthcare by offering clear pathways for career advancement. However, the lack of national regulation or recognition of these qualifications across regions can limit mobility and career progression for BLS, undermining the attractiveness of the profession.

Among the professionals that participated in answering questions on Mentimeter, 52% estimated career paths to be present for the profession. While this may encompass various forms of development beyond university education and specialist training, discussions underscored the importance of linking career paths with salary increases. The conditions for BLS, including low salaries and the absence of defined career paths and professional development opportunities, have led many professionals to leave the field for other careers. In a survey performed by IBL in 2022, professionals in private sector underscored that salary and career development is a significant reason for leaving the public sector.[19] In Sweden, BLS have lower salaries compared to other similar healthcare professionals as well as negative lifetime earnings, underscoring the urgency of addressing these disparities.[20] Such conditions not only devalue the profession, but also jeopardize the sustainability of healthcare services that rely on the critical functions performed by BLS. Salary is likely to be a significant factor, especially in retaining qualified BLS in the field.

In the study discussions, career development in terms of new roles as lead scientist, manager and combined positions between clinic and academia were discussed as possibilities that could attract and keep professionals in healthcare. It was also discussed that the younger professionals have different expectations on a future workplace. Young people may consider salary as the basis for their choice of study and the younger generation also values the opportunity to influence their own working hours (flexibility). While work still plays an important role, the younger generation expects a better work life balance. They are perhaps more direct on their expectations on a future workplace and may also be more open to changing careers and employers. If the laboratory profession is to attract the younger professionals, the profession needs to meet and include the younger generations in the shaping of the future healthcare.

Task Shifting

The need and the current practice of task shifting was discussed in relation to the BLS role when other professions come into the

laboratory. The concept of task shifting is not new but something that has been evident for several years, and in many disciplines. In pathology for example, task shifting has ensured patient treatment in small hospitals in Norway. In especially the northern part, there are long distances between hospitals and few BLS, therefore nurses or other trained health care professions do frozen sectioning and staining, followed by evaluation through telepathology/digital pathology.

Task shifting includes letting go of some tasks and well as taking on new ones. Sample registration, sample transportation, ordering supplies, and repacking were identified as tasks that could easily be performed by other professionals. Blood sample collection was also discussed as something that could be provided by other healthcare professionals and is already delegated to nurses and practical nurses in Norway and Finland. Additionally, and another example of task shifting is that porters in Norway are trained and tested in blood sampling. In Sweden, there are local initiatives where assistant nurses are provided with education and training to specialize in laboratory medicine. However, the pre-analytical knowledge is considered an important BLS competence. Other disciplines where task shifting, or interdisciplinary work is implemented are in medical genetics, nuclear medicine, and blood banking. The new roles can be seen as a result of technological and diagnostic progress. New explorative areas for the future BLS include working in municipality settings, diagnostic partnership, research work, and working with artificial intelligence (AI).

The concept of diagnostic partnership leverages BLS's specialized knowledge in laboratory analyses, sampling, handling, and storage of biological samples to ensure reliable diagnostic processes. Their expertise in quality assurance further guarantees that laboratory equipment and analytical results meet the applicable standards. As diagnostic partners, BLS can significantly contribute to healthcare teams by enhancing the quality of sampling, handling of biological samples, and ultimately improving patient care. This expanded role requires a reevaluation of the current task distribution within healthcare settings, advocating for BLS to undertake more specialized tasks that align with their expertise. It emphasizes the necessity for BLS education and training programs to incorporate modules on interprofessional collaboration, diagnostic decision-making, and communication skills.

The integration of AI and digitalization in healthcare presents unique opportunities and challenges for the BLS profession. AI applications in laboratory medicine can streamline workflows, enhance diagnostic accuracy, and predict patient outcomes more efficiently. However, this technological advancement also necessitates a shift in the skill set required from the BLS. To remain relevant and maximize the potential of AI and digital tools, BLS must acquire proficiency in digital literacy, data analysis, and the ethical considerations of AI use in healthcare. Educational programs for BLS might need to adapt to these changes by incorporating courses on information technology, data management, and AI applications in healthcare. This will prepare future BLS for a healthcare environment where digital tools are integral to laboratory operations and diagnostics. Additionally, continuous professional development opportunities in these areas should be available for current BLS to ensure the workforce is equipped to navigate the digital transformation in healthcare. Furthermore, the role of BLS in the development, validation, and implementation of AI-driven diagnostic tools highlights their potential as innovators in the field. By engaging BLS in interdisciplinary research teams focused on AI and digital health solutions, their expertise can inform the development of technologies that are both clinically relevant and aligned with laboratory practices.

Visibility

Increased visibility of the profession was thoroughly discussed from different aspects and in relation to making the profession more attractive. There were plenty of interesting suggestions and it was clear that this is not the sole responsibility of others but also of the

profession itself. If BLS cannot express their own value, how can one expect others to see it? Practicing BLS need to communicate the impact and value of having BLS in healthcare besides describing the risks associated with the absence of the profession. If the profession can show the diversity and highlight the many interesting disciplines within the profession, as well as allowing for research and advancement into leadership, this might be a way to promote and inspire. Actions such as media campaigns, TV-shows and rebranding might be difficult on an individual level, where instead leaders, professional organizations and unions need to be the voices advocating for the profession.

Conclusion

This study has identified several threats to the sustention of BLS in healthcare today and in the future in the Nordic countries. This includes educating too few students in combination with high retirement numbers, drift towards working in the private sector, as well as low salaries and lack of career opportunities. In this study, the professionals have provided useful insights on how to make the profession more attractive including the increase of visibility, provision of career paths, and clarification of the current and potential competencies of BLS for the future. Several future options for the profession have been identified that can attract students to the educational programs, retain professionals in healthcare, and ensure high-quality diagnostics. Strategies for attraction to the profession and retention in health care include:

- Establishing career development pathways within and across Nordic countries to enhance professional growth and mobility.
- Addressing salary disparities and ensuring competitive compensation that reflects the critical role of BLS in healthcare.
- Reevaluating task distribution within healthcare settings to ensure optimal use of BLS specialized skills, while also considering workload and job satisfaction.
- Implementing flexible working conditions that cater to the evolving expectations of the workforce, particularly the younger generation's desire for work-life balance.

To succeed, there needs to be a stronger linkage between the profession, educational institutions, healthcare employers, and professional organizations that can foster a more cohesive approach to addressing the challenges. By advocating for the profession, highlighting the critical contributions to healthcare, and ensuring BLS are equipped to thrive in their roles, stakeholders can enhance the profession's attractiveness and sustainability. Through strategic interventions focused on education, career development, compensation, and work-life balance, the Nordic countries can ensure a robust, satisfied, and future-ready BLS workforce.

Acknowledgements

We gratefully thank all participants in the lecture and workshop at the NML congress 2023 in Oslo Norway. We would also like to acknowledge Maysae Quttineh (The Swedish Institute of Biomedical Laboratory Science (IBL) and Department of Laboratory Medicine, Region Jönköping County, Sweden), Anne Lindgren (Vårdförbundet - the Swedish Association of Health Professionals) and Tanja Wijkmark (The Swedish Institute of Biomedical Laboratory Science (IBL) for their work with the actionplan idea and realization.

Also, we gratefully thank Nordic colleagues Jane Fyhn, Danske Bioanalytikere and Margrete Tennfjord, NITO BFI for help in retrieving data.

References

1. Nordens hus.org [Internet]. Copenhagen: The Nordic Council and the Nordic Councils of ministers; c2024 [cited 2024 Feb 28]. Available from https://www.norden.org/en/nordicstatistics
2. ifbls.org [Internet]. Hamilton: International federation of biomedical laboratory science; c2023 [cited 2024 Feb 28] Available from https://www.ifbls.org/index.php/statements/core-competence-core-curriculum)
3. Pearse C, Scott S. A Review of Clinical Laboratory Education, Training and Progression: Historical Challenges, the Impact of COVID-19 and Future Considerations. Br J Biomed Sci. 2023 Apr 12:80:11266.
4. Quttineh M, Heldestad V, Wijkmark T, Rehnberg M, Lillsunde Larsson G. Great interest in a Swedish nationally regulated specialist education among biomedical laboratory scientists and biomedical laboratory scientist students. Int. J. Bio. Lab. Sci 2021(10) 1:28-35.
5. Kommuner og regioners løndata [Internet, cited 2024 Feb 28]. Avaliable from www.krl.dk
6. Labour Force Barometer [Internet, cited 2024 Feb 28]. Available from www.tyovoimabarometri.fi
7. NITO BFI – The Norwegian Institute of Biomedical Science, Bioingeniørene – bærebjelke og mangelvare. Oslo, 3rd edition 2022.
8. National Board of Health and Welfare in Sweden. Nationella planeringsstödet 2023. Bedömning av tillgång och efterfrågan på legitimerad personal i hälso- och sjukvård samt tandvård; 2023. Report No.: 2024-3-8933.
9. Helse- og omsorgsdepartementet, Oslo Norway. Norges offentlige utredninger 2023: 4. Tid for handling. Personellet i en bærekraftig helse- omsorgstjeneste; 2023.
10. Report No. 2023:4. Statistics Sweden, Population and Welfare Department, Forecast Institute Solna, Sweden. Trends and Forecasts 2020 – population, education and labour market in Sweden, outlook to year 2035; 2021. Report No.: 1653-4085).
11. Finnish institute for health and welfarere [Internet, cited 2024 Feb 28]. Avaliable at: www.thl.fi
12. Statistics Norway [Internet, cited 2024 feb 28]. Avaliable at https://www.ssb.no/
13. National Board of Health and Welfare in Sweden. Statistikdatabas för hälso- och sjukvårdspersonal [Internet, cited 2024 Feb 28]. Avaliable at https://sdb.socialstyrelsen.se/if_per/val.aspx
14. Vårdförbundet – the Swedish Association of Health Professionals. Swedish Association of Health Professionals' part-time report 2023. Unpublished data.
15. The Danish Ministry of Health. Robusthedskommissions anbefalinger; 2023. Report No. ISBN 978-87-7601-420-7.
16. Vipunen. Education Statistics Finland. [Internet, cited 2024 Jan 15]. Available at: https://vipunen.fi/en-gb/
17. Direktoratet for høyere utdanning og kompetanse. Database for statistikk om høyere utdanning. [Internet, cited 2024 Feb 13]. Avaliable at https://dbh.hkdir.no/tall-og-statistikk/
18. National Board of Health and Welfare in Sweden. Nationella vårdkompetensrådet. Statistikbaserade flödesbeskrivningar för yrkesgruppen biomedicinska analytiker; 2021. Report No. 4.3-13549/2021-9.
19. Swedish institute of biomedical laboratory science (IBL). Survey to members 2022. Unpublished data.
20. Saco, Sveriges akademikers centralorganisation. Lönar sig högre utbildning? Livslönerapport 2020;2020. Report No. ISBN: 978-91-88019-47-9.

Research article

Optimizing Adherence: Social Support and Inclusion in HIV Counseling for High Viral Load Patients in Abuja, Nigeria

[1]Salami Aisha Oluwakemi, [2*]Sanni Olaniyi Felix, [3]Abiodun Paul Olaiya, [4]Salami Habeeb

[1]United State Department of Defense, Walter Reed Program Nigeria, and US Embassy Abuja Nigeria. [2]Research and Development Department, Fescosof Data Solution, Ogun State, Nigeria. [3]Faculty of Public Health, Texila America University, Guyana, South America. [4]Academy of Public Health, West Africa Institute of Public Health, Abuja, Nigeria.

Background: **Social support is generally defined as "the perception or experience that one is loved and cared for by others, esteemed and valued, and part of a social network of mutual assistance and obligation. This study examines the level of social support among high viral load HIV seropositive patients in EAC.**
Methods: **This study is a cross-sectional descriptive study that determine the level of social support among high viral load HIV seropositive patients enrolled in EAC in 063 Nigerian Airforce Hospital, Garki 1 Abuja, Nigeria. Data for this study was collected through a face-to-face interview by administering a structured questionnaire to both HIV clients enrolled in EAC and those that were not to compare the impact of social supports on ART adherence among the HIV clients.**
Results: **Based on this study's findings majority of respondents, 78.7%, 83.5, 74.7%, and 90.5%, disclosed their HIV status to family, were on three years on ART, and have been on EAC and have TB, respectively. However, the majority did not achieve viral load suppression. Also, almost all clients (87.2%) enrolled for EAC due to poor adherence. Based on the three-factor analysis of social support in this study, both items 3 and 10 contributed 60.6% each to the total variance of the SS. Item 2 contributed 67.2% of the total variance of esteem, and item 6 contributed 67.8% of the total self-esteem variance. The overall scale has a high correlation with the sub-scales "Esteem" and "Self-development" (r= 0.877 and 0.910 respectively) and a medium correlation with the sub-scale "Belonging" (r= 0.579). Furthermore, the overall scale for internal consistency for the three factors was 0.862, while the sub-scale "Belonging was 0.334, the sub-scale "Esteem" was 0.741, and the sub-scale "Self-development" was 0.834. Most respondents with the highest social support were male (94.2%), likewise, those who disclosed their HIV status to their family (92.3%). The level of perceived belonging (3.80 ± 0.87), esteem (3.75 ± 0.82), and self-development (3.58 ± 0.75) of PLWHIV included in EAC was significantly lower than those who were not (P<0.05).**
Conclusion: **Efforts should be made to increase social support and ART adherence through EAC among PLWHA.**

Keywords: antiretroviral therapy, viral load, social support, enhanced adherence counselling

---

Accepted: April 10, 2024
*Corresponding author: Olaniyi Felix Sanni. E-mail: fescosofanalysis@gmail.com

Introduction

Enhanced Adherence Counseling (EAC) is a structured support program that utilizes implementation tools such as a session guide, patient file, and register to engage virally unsuppressed patients in three monthly sessions.[1] EAC is done to investigate the obstacles to adherence and, in collaboration with the patients, develop strategies to overcome them with the goal of suppressing the disease.[1] Following the completion of EAC, the patient is scheduled for a follow-up viral load testing at the end of the fourth month of treatment. The viral load (described as the number of HIV RNA copies per millilitre of blood) in people living with HIV is a direct measure of viral replication.[2] Social support is generally defined as "the perception or experience that one is loved and cared for by others, esteemed and valued, and part of a social network of mutual assistance and obligations.[3] Conceptualizations of social support have also focused on the source of support, which can vary from family, spouse, friend, coworkers, doctor, and community ties/affiliations.[4] Higher viral loads are associated with a greater decline in CD4 cell count, which increases the likelihood of contracting an opportunistic infection.[5] It is critical to reduce the viral load in PLHIV (People Living with HIV) to less than 1000 copies/ml of blood (referred to as "viral suppression") to reduce morbidity, death, and transmission.[6] Antiretroviral therapy (ART) prevents HIV from replicating, transforming the disease from a fatal infection to a manageable chronic illness.[5] Currently, the World Health Organization (WHO) recommends periodic evaluation of viral loads (at least once a year) in all PLHIV on ART and the achievement of viral load suppression in those with high plasma viral loads (>1000 copies/ ml).[5] Poor adherence to ART is the most common cause of high viral load, and WHO advises EAC to address this issue.[7] Other typical causes of high viral load include medication resistance, malabsorption, drug-drug interactions, and drug-associated adverse effects.[8] Resolving these causes may necessitate a change in the antiretroviral therapy regimen.[8] If the viral load is high, the World Health Organization recommends performing an EAC, followed by a second/repeat viral load test after three months.[2] If the viral load levels remain high, it is assumed that virological treatment has failed, and the patient should be switched to a different ART regimen.[2] Studies have demonstrated that EAC can result in viral suppression in more than 70% of patients with high initial viral levels. [9,10] According to the WHO guidelines, Patient whose viral load (VL) are not suppressed at re-testing after undergoing the EAC session is categorized as having "virologic failure" due to likely drug resistance and are recommended to be moved to second- or third-line therapy.[11] Since poor adherence is the most prevalent cause of treatment failure, the WHO recommends three to six months of enhanced adherence counseling for individuals with a high viral load count before diagnosing first-line treatment failure.[12–14]

Furthermore, given that HIV/AIDS is a chronic illness requiring long-term care, constant social support from family, peers, and communities, among others, is essential for maintaining adherence to ART. [15,16] Spouse support and support groups are critical for HIV medication adherence and viral load suppression. Still, social support can fail when family members choose to stigmatize and discriminate against victims, as the stigma has been demonstrated to be a barrier to adherence to ART. [17] it is believed that social support can be employed positively or adversely.[18] Social support has been associated with enhanced medication adherence, quality of life, and viral load suppression in HIV-positive patients receiving ART in a variety of settings, most notably in Sub-Saharan Africa, where 90 percent of ART is prescribed.[19–21] Effective social support for medication adherence could involve a variety of approaches. For example, emotional suport promotes a favourable state of mind and directly increases self-efficacy to adhere.[22,23] In 2016, the Nigerian National Guideline for HIV Prevention and Treatment suggested that all

patients starting ART have their viral load measured after six months and then annually for those who have achieved viral suppression.[1,24] This study examines the level of social support among high viral load HIV seropositive patients in EAC.

Methodology

This study is a cross-sectional descriptive study to determine the level of social support among high viral load HIV seropositive patients enrolled in EAC in 063 Nigerian Airforce Hospital, Garki 1 Abuja, Nigeria. Data for this study was collected through a face-to-face interview by administering a structured questionnaire to both HIV clients enrolled in EAC and those that were not to compare the impact of social supports on ART adherence among the HIV clients.

Study location

The Federal Capital Territory (FCT), also known as Abuja Federal Capital Territory, was established as an administrative territory in central Nigeria in 1976. The new capital city was built and developed on the grass-covered Chukuku Hills in 1980. The area is located north of the Niger and Benue Rivers' confluence. It is bordered on the west and northwest by Niger, on the northeast by Kaduna, on the east and south by Nasarawa, and on the southwest by Kogi.[25] Additionally, Abuja is about 1810 feet (360 meters) above sea level and has a cooler climate and lower humidity than Lagos. The Federal Capital Territory consists of 6 different area Councils, namely: Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali. These six councils cover a total land area of approximately 7,290 km^2. [26] According to world population review statistics, Abuja has a population of 3 464,123.[27] According to the United Nations, Abuja increased by 139.7% between 2000 and 2010, making it the fastest-growing city.[28] As of 2015, the city is growing at a rate of at least 35% annually, maintaining its status as the fastest-growing metropolis on the African continent and one of the fastest-growing cities globally.[29] As of 2016, Abuja's metropolitan region was predicted to have six million people, ranking it second only to Lagos as Nigeria's most populated metro area. According to the national agency for the control of AIDS (NACA), Abuja has a total HIV/AIDS prevalence rate of 1.5%.[30]

The study population comprised HIV seropositive clients initiated on ART in 063 Nigerian Airforce Hospital, Garki 1Abuja. Both HIV clients on EAC and those who were not were used to form the study population. Currently, there are 2,222 clients in ART in both facilities from 2019 to 2020.

Study population

The study population comprised HIV seropositive clients initiated on ART in 063 Nigerian Airforce Hospital, Garki 1Abuja, Nigeria. Both HIV clients on EAC and those who were not, were used to form the study population.

Sample size calculation

The prevalence of viral load failure at six months on ART in the north-central was 36%.[31] The sample size was, however, calculated using the formula below;

$$n = \frac{Z^2 pq}{d^2}$$

Z = Standard normal deviate of alpha set at 1.96 corresponding to 95% confidence level.

p = the prevalence of viral load failure at 6months on ART in north central, Nigeria.

p = 0.36

d =level of precision =5% =0.05

q = 0.64

$$n = \frac{1.96^2 x\ 0.36\ x\ 0.64}{0.05^2};\ n = \frac{0.8851}{0.0025};\ n = 354.04$$

Therefore, the minimum sample size is 354. This formula was used because the recent prevalence of viral load failure in north-central Nigeria is known.

Data collection method

Data was collected through a structured questionnaire. Two trained research assistants administered the structured questionnaire to HIV clients to collect socio-support data. The

research tool for this study was adapted from the questionnaire used by Cortes et al. [32] on "development of the scale of perceived social support in HIV (PSS-HIV)". A pilot test was conducted using 10% (35) of the total respondents, and necessary corrections were made before administering the final version of the questionnaire. The questionnaire contains 23 items which were divided into two sections. The first section contains nine open and close-ended questions and 14 Likert scale questions used to determine the perceived social supports for PLHIV in Abuja.

Inclusion criteria

All clients on ART, aged 10 years and above, attending the HIV/AIDS clinics of the 063 Nigerian Airforce Hospital, Garki 1 Abuja, Nigeria were included in the interviews.

Exclusion criteria

Clients below 10 years were not included in the interview. Also, clients that are very ill and patients with any mental disorder were excluded as they may be unable to withstand the interview's stress.

Data analysis

The data collected were exported into IBM-SPSS version 28.0 data analysis. Descriptive statistics were performed, presenting outcomes as frequency tables, percentages, pie, and bar charts. Pearson chi-square test was used to compare variable proportions. factor analysis and Cronbach test were performed to determine the reliability, validity, and internal consistency., setting p-values below 0.05 as significant. For the measurement scale, fourteen items were used to address the support quality. Items were scored on a Likert scale from 1-5, from "strongly disagree" to "strongly agree". For most items, 3 indicates neutral, but a "neutral" answer to items 1, 2, 3, 7, 9, 10, and 12 indicates a lack of SS (see items in Appendix 1). For instance, a "neither agree nor disagree" answer to the item "I feel emotionally sheltered by my family" is evidence of a lack of shelter expected from the family. In these cases, a neutral answer was assigned 2 points, the same as "disagree".[33]

Ethical approval

The research and ethics committee of the ministry of health Abuja approved this study. Permission was also secured from the hospitals from which the participants were recruited. There were no physical or psychological hazards.

Results

Demographic profiles of the study respondent

Table 1 shows data on various demographic characteristics of respondents. The parameters listed include gender, age category, marital status, education, occupation, and religion. Out of 348 respondents, 155 (44.5%) were males, and 193 (55.5%) were females. Similarly, 49 (14.1%) were in the age range of 10–30 years, 238 (68.4%) were in the age range of 31–50 years, and 61 (17.5%) were above 50 years of age. The marital status parameter shows that 102 (29.3%) were single, 204 (58.6%) were married, and 42 (12.0%) were divorced or widowed.

Table 1. Demographic profiles of the study participant

Parameter	Frequency	Percent
Gender		
Male	155	44.5
Female	193	55.5
Age category		
10 - 30 years	49	14.1
31 - 50 years	238	68.4
Above 50	61	17.5
Marital status		
Single	102	29.3
Married	204	58.6
Divorced/Widowed	42	12.0
Education		
No formal education	28	8.0
Primary	90	25.9
Secondary	98	28.2
Tertiary	132	37.9

Out of 348 respondents, 28 (8.0%) had no formal education, 90 (24.9%) had primary education, 98 (28.1%) had secondary education,

and 132 (31.9%) had tertiary education. Also, 152 (43.7%) were civil servants, 145 (41.7%) were traders, and 51 (14.7%) were artisans. A high proportion of the respondents were Christians, 284 (81.6%), followed by 62 (17.8%) Muslims, and 2 (0.6%) were traditional. Finally, 278 (79.9%) were currently living with family, and 70 (20.1%) were not.

Respondents' HIV disclosure, ART and viral load status

Table 2 shows the respondent's HIV disclosure, ART and viral load status. A high proportion of participants have disclosed their HIV status to their family (78.7%). Among the participants, 83.5% have been on ART for over three years. Additionally, 58.9% did not experience unsuppressed viral load, 74.7% have not been on EAC, and 90.5% have no history of tuberculosis.

Table 2. Respondents' HIV disclosure, ART and viral load status

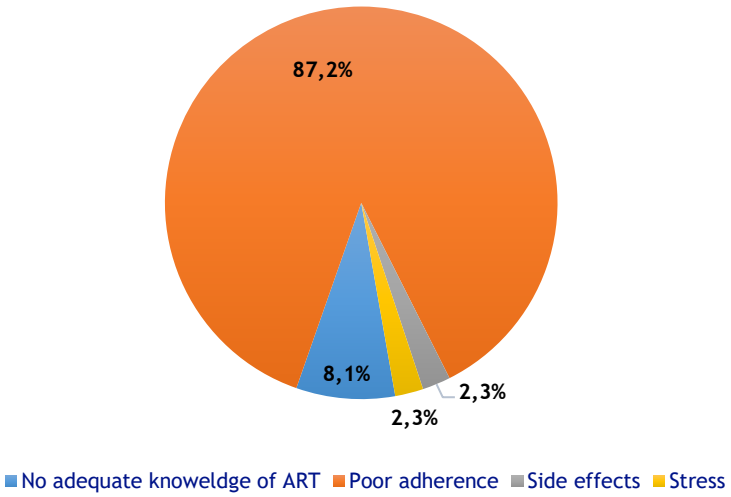
Parameter	Frequency	Percent
Occupation		
Civil servant	152	43.7
Trader	145	41.7
Artisan	51	14.7
Religion		
Christianity	284	81.6
Islam	62	17.8
Traditional	2	0.6
Currently living with family		
Yes	278	79.9
No	70	20.1

Reason for inclusion in EAS

As shown in Figure 1, most clients (87.2%) were enrolled in EAC due to poor adherence to ART, 81. % lacked adequate knowledge of ART, while 2.3% were enrolled due to side effects and stress.

Factor analysis to determine the reliability of social support variables

In the SS-PLWHIV, three factors were identified (Belonging, Esteem, and Self-development). A principal axis factoring was conducted, setting the Kaiser criterion (Eigenvalue as 1) to determine the number of relevant factors. All the items in the three



factors yielded loadings higher than 0.4. The contribution of each factor is shown in Table

Figure 1. Reasons for inclusion in EAC

3. Both items 3 and 10 contributed 60.6% each to the total variance of the SS. Item 2 contributed 67.2% of the total variance of esteem, and item 6 contributed 67.8% of the total self-esteem variance. No item eliminations are based on these criteria. The component values closer to one show the high reliability of the items for measuring SS-PLWHIV.

Table 3. Factor analysis pattern matrix for PLWHIV

Factor	Item	Components	% Contribution
Belonging			
	10	0.778	60.6%
	3	0.778	60.6%
Esteem			
	2	0.820	67.2%
	9	0.749	56.1%
	7	0.737	54.3%
	1	0.706	49.8%
Self-development			
	6	0.823	67.8%
	8	0.814	66.3%
	12	0.728	53.0%
	11	0.698	48.8%
	5	0.692	47.8%

Internal consistency of the SS-PLWHIV variables

Table 4 shows the internal consistency of SS for PLWHIV as measured by Cronbach's alpha.

The overall scale has an alpha of 0.862, the sub-scale "Belonging" has an alpha of 0.334, the sub-scale "Esteem" has an alpha of 0.741, and the sub-scale "Self-development" has an alpha of 0.834. These values indicate that the overall scale has good internal consistency and the sub-scale "Self-development" has excellent internal consistency. However, the sub-scale "Belonging" has a low internal consistency.

Table 4. Cronbach a SS-HIV on PLWHIV

Overall	Belonging	Esteem	Self-development
0.862	0.334	0.741	0.834

Table 5 shows the inter-correlations of the SS for PLHIV sub-scales. Each sub-scale score was correlated with the other sub-scales and the overall scale. The overall scale has a high correlation with the sub-scales "Esteem" and "Self-development" (r= 0.877 and 0.910 respectively) and a medium correlation with the sub-scale "Belonging" (r= 0.579). The sub-scale "Belonging" has a medium correlation with the sub-scales "Esteem" and "Self-development" (r= 0.449 and 0.336 respectively) and a high correlation with the overall scale (r= 0.579). The sub-scale "Esteem" has a high correlation with the overall scale and the sub-scale "Self-development" (r= 0.877 and 0.653 respectively) and a medium correlation with the sub-scale "Belonging" (r= 0.449). The sub-scale "Self-development" has a high correlation with the overall scale and the sub-scale "Esteem" (r= 0.910 and 0.653 respectively) and a medium correlation with the sub-scale "Belonging" (r= 0.336).

Table 5. Cronbach a SS-HIV on PLWHIV

	Overall	Belonging	Esteem	Self-development
Overall	1	0.579**	0.877**	0.910**
Belonging	0.579**	1	0.449**	0.336**
Esteem	0.877**	0.449**	1	0.653**
Self-development	0.910**	0.336**	0.653**	1

**Correlation is significant at the 0.01 level (2-tailed).

Factors associated with social support among PLWHIV

As shown in Table 6, the overall social support among the respondents was 89.9%. Only gender was significantly associated with social support (p = 0.018). The level of social support was significantly higher among males (94.2%) than females. The level of social support was above 80% in all age groups and was not statistically different (P>0.05). HIV clients that were not educated had the least social support (78.6%) compared to others with more than 90% levels of SS. Social support for PLWHIV was not significantly associated with marital status, occupation, and religion (P>0.05).

As shown in Table 7, a higher proportion of PLWHIV living with their families had high SS (90.3%) than 88.6% of those not living with their families. However, the difference was not statistically significant (P>0.05). HIV status disclosure was significantly associated with SS of PLWHIV as a higher proportion of those who disclosed (92.3%) had high SS than those who did not (81.1%), P<0.05. Other factors such as length on ART, previous unsuppressed viral load, previous inclusion on EAC, and HIV-TB coinfection were not significantly associated with SS for PLWHIV.

Table 8 shows a significant association between SS of PLWHIV and inclusion in EAC. The level of perceived belonging of PLWHIV included in EAC (3.80 ± 0.87) was significantly lower than those who were not (P<0.05). Similarly, those PLWHIV included in EAC exhibited a lower level of esteem (3.75 ± 0.82) and self-development (3.58 ± 0.75) than those who were not enrolled in EAC (4.04 ± 0.755 and 4.00 ± 0.80, respectively), p<0.05.

Discussion

This study examines the level of social support among high viral load HIV seropositive patients in EAC in Abuja. This study's findings show that a significant proportion of the HIV client disclosed their HIV status to their family members, have spent three years receiving

Table 6. Demographic factors associated with SS among PLWHIV

	High SS n (%)	Poor SS n (%)	X^2	P-value
Overall	313 (89.9)	35 (10.1)	-	-
Gender				
Male	146 (94.2)	9 (5.8)	5.583	0.018*
Female	167 (86.5)	26 (13.5)		
Age category				
10-30	42 (85.7)	7 (14.3)	3.588	0.166
31 – 50	219 (92.0)	19 (8.0)		
50 & above	52 (85.2)	35 (10.1)		
Education				
No formal education	22 (78.6)	6 (21.4)	4.533	0.209
Primary	82 (91.1)	8 (8.9)		
Secondary	90 (91.8)	8 (8.2)		
Tertiary	119 (90.2)	13 (9.8)		
Marital status				
Single	94 (92.2)	8 (7.8)	4.430	0.109
Married	185 (90.7)	19 (9.3)		
Divorced/Widowed	34 (81.0)	8 (19.0)		
Occupation				
Civil servant	132 (86.8)	20 (13.2)	3.220	0.200
Trader	135 (93.1)	10 (6.9)		
Artisan	46 (90.2)	5 (9.8)		
Religion				
Christianity	258 (90.8)	26 (9.2)	1.842	0.398
Islam	53 (85.5)	9 (14.5)		
Traditional	2 (100.0)	0 (0.0)		

*Significant at $p<0.05$

Table 7. HIV disclosure, ART and viral load status associated with SS among PLWHIV

	High SS n (%)	Poor SS n (%)	X^2	P-value
Living with family				
Yes	251 (90.3)	27 (9.7)	0.182	0.670
No	62 (88.6)	8 (11.4)		
HIV status disclosure				
Yes	253 (92.3)	21 (7.7)	8.159	0.004*
No	60 (81.1)	14 (18.9)		
Length of ART				
1 year	21 (91.3)	2 (8.7)	2.359	0.307
2 years	34 (97.1)	1 (2.9)		
3 years	258 (89.0)	32 (11.0)		
Ever experienced an unsuppressed viral load				
Yes	124 (86.7)	19 (13.3)	2.798	0.094
No	189 (92.2)	16 (7.8)		
Ever been placed on EAC				
Yes	75 (85.2)	13 (14.8)	2.895	0.089
No	238 (91.5)	22 (8.5)		
Have TB with HIV				
Yes	29 (87.9)	4 (12.1)	0.172	0.679
No	284 (90.2)	31 (9.8)		

Table 8. T-test showing the association of SS of PLWHIV with EAC enrolment

Social support factors	Ever been enrolled in EAC (N±SD)			
	Yes n = 88	No n = 260	T-test	P-value
Belonging	3.80 ± 0.87	4.04 ± 0.755	2.524	0.012*
Esteem	3.75 ± 0.82	4.00 ± 0.80	2.133	0.020*
Self-development	3.58 ± 0.75	3.80 ± 0.75	2.387	0.018*
Overall SS	3.67 ± 0.64	3.89 ± 0.65	2.764	0.006*

*Significant at $p<0.05$

ART, have previously been placed on EAC, and have tuberculosis. The possible reason for this could be that disclosing one's HIV status to family members can have several benefits. It can help the individual form a support system, reduce feelings of isolation and stigma, and improve overall mental and emotional well-being.[34] Disclosure within a family environment is important to facilitate communication about HIV between family members.[35] Additionally, if the individual requires assistance with managing their condition, being open about their status can lead to better cooperation and understanding from their loved ones.

Also, a lengthy stay on ART can positively impact individuals living with HIV. One of the most significant benefits is that ART can help suppress the virus and prevent disease progression. This can improve the immune system and reduce the risk of HIV-related illnesses and complications, improving overall health.[36] Another important impact is that a lengthy stay on ART can also prevent virus transmission to others. However, despite all this, most of the HIV clients in this study did not experience viral load suppression. This could be due to poor ART adherence. Poor adherence to antiretrovirals therapy increases plasma viral load, which has been proven to be a significant risk factor for the formation of drug-resistant HIV strains, increasing the infectivity rate.[37,38] The findings of this study were consistent with a study by Anne et al.[39]. Therefore, it is recommended that HIV patients adhere to ART as prescribed by a healthcare provider. Also, there is need for HIV patient to regularly attend follow-up appointments with a healthcare provider to monitor viral load and assess the effectiveness of ART. Avoid missing doses of ART or interrupting treatment, as this can lead to the development of drug resistance and a higher viral load.

Based on the result of this study, a significant proportion of the participants (87.2%) were enrolled in EAC due to their poor adherence to ART. This was supported by a study carried out by Diress et al. [40] Poor adherence to antiretroviral therapy is the most common cause of high viral load, and the WHO advises EAC to address this issue.[7] Based on several literature findings, the possible cause of poor adherence to ART among HIV patients could be due to some socio-economic variables such as unemployment, poverty, food insecurity and transport costs.[41,42] Also, adherence to ART is negatively impacted by a number of social factors, including but not limited to stigma and prejudice, disclosure, and a lack of social support.[21,43] It is believed that a lack of human resources in developing countries like Nigeran causes congestion and long waiting periods in ART centres, which discourages many people who use ART from receiving treatment.[44] Poor healthcare provider practices, including inadequate counselling sessions, abuse of patient confidentiality, lack of adherence follow-ups and drug stock-outs, have been demonstrated as major health systems barriers to adherence.[45,46] Another well-known reason for poor adherence is the complicated nature of ART regimens with their heavy dosage of tablets and tight dietary and hydration requirements. It is widely known that patient-related issues such as forgetfulness, side effects, feeling better, distrust, and misunderstandings surrounding ARV therapy prohibit many patients from following

treatment. This is especially true for those patients who have HIV.[47-49]

Furthermore, based on the findings of this study, the contributing factor analysis to determine the reliability of social support among PLWHA were belonging, esteem, and self-development. The findings show that participants who perceived that they could freely express their opinion to their partner or group of friends and those who stated that if something is for their own good, their family will support them in items 3 and 10, respectively, contributed 60.6% to the social support belonging factor. Self-belonging, or a person's sense of self-worth and acceptance, can influence the level of social support they receive as someone living with HIV. If a person has a strong sense of self-belonging, they may be more likely to reach out for support and be more open about their HIV status, potentially leading to stronger relationships and a greater support network. On the other hand, if a person lacks self-belonging, they may face stigma and discrimination, causing them to isolate themselves and potentially receive less social support.

Also, the findings of this study showed that participants who perceived that they could count on their closest friends or partner when they needed to be listened to in item 2 contributed 67.2% of the total variance for esteem. Self-esteem can affect social support for people living with HIV by influencing their ability to reach out for help and engage with support networks. High self-esteem may lead to greater confidence in seeking out and accepting support, while low self-esteem may cause feelings of shame or stigma, making it harder to reach out. The quality of support received can also impact self-esteem, with positive experiences leading to increased self-worth and negative experiences potentially decreasing self-esteem.

Additionally, the findings of this study show that participants who think that their friends gave them the possibilities for growth in item 6 contributed 67.8% of the total self-development variance. Self-development can influence social support for people living with HIV by affecting one's ability to cope with the condition's physical, emotional, and social impacts. Self-development can lead to increased resilience, better communication skills, and a positive outlook, all of which can facilitate the formation and maintenance of supportive relationships. On the other hand, a lack of self-development can lead to negative coping mechanisms, poor communication, and decreased ability to form meaningful connections, all of which can undermine the potential for social support. Overall, self-development plays a crucial role in enhancing the quality and availability of social support for individuals living with HIV.

The study findings show that the overall internal consistency of social support for PLWHA was 0.862. "Self-development had the highest internal consistency while the sub-scale "Belonging" had a low internal consistency. The findings show that the overall scale and sub-scale had good internal consistency. Self-development, which happens to have the highest internal consistency for social support in this study, could influence the internal consistency of social support for PLWHA by building their confidence and self-esteem, improving their communication skills, expanding their social network of support, increasing resilience, and enhance an individual's ability to manage their HIV status.

Additionally, this study findings showed that all three factors sub-scale were positively correlated. Those that have high sense of belonging also have high esteem and self-development. Overall, social support enhances sense of belonging, self-esteem and self-development of the patients in this study. This is an important finding, as these factors can play a crucial role in a client's overall well-being and ability to adhere to their treatment plan which could help suppress their viral load.

This study's finding also showed that the level of social support was higher among male respondents than female respondents. Social support for PLWHIV was not significantly associated with marital status, occupation,

and religion (P>0.05). The findings of this result align with the study carried out by Berhe et al. [50], Oppong et al.[51], and Deichert et al.[52]. A plausible explanation may be due to less stigmatization among men than women, particularly in the family and society. Also, another reason could be that low self-esteem may have played a role in the extent to which women were able to perceive and receive support efforts from friends and families. Self-esteem has been shown to influence interpersonal relationships because individuals' feelings of self-worth have a bearing on both their beliefs and social behaviours.[53] This means that low self-esteem may damage interpersonal relationships because it promotes a self-protective interpersonal relationship. In other words, PLWHAs feel socially isolated and have negative perceptions of their social relationships. This process may be fueled by internalized HIV-related stigma and discrimination, among PLWHA.[54] Social support is instrumental in determining the psychological well-being of men and women living with HIV. This should be a wake-up call to critical stakeholders to enhance the uptake of EAC among HIV patients. As the counselling session will help patients build up patient self-esteem and also their perception to social support. This reflects that we should pay more attention to females living with HIV/AIDS and encourage them to participate in various forms of activities and share their inner thoughts and feelings with others. However the findings of this study result was contrary to the findings of studies by Xiao et al. [55] and Li et al. [56], who found that females received more social support than males. In their study, they believed that it could be because females are more inclined to share their unpleasant experiences with their relatives, friends or colleagues to reduce psychological pressure. Men are more likely to choose to endure setbacks or face difficulties, hoping to overcome and reduce their psychological burden through their own efforts.[56]

Based on the findings of this study, living with family, HIV status disclosure, client length on ART, ever experienced unsuppressed viral load, ever being placed on EAC, and having TB with HIV were all factors associated with social support among PLWHA. However, only HIV status disclosure was statistically associated with social support among PLWHA. This showed that the majority of participants whose HIV status were disclosed had high social support. These findings were supported by a study carried out by Cama et al.[57] A possible explanation for this could be that revealing one's HIV status may help other people to provide some emotional, informational and psychological support to HIV patients. Patient disclosure of HIV status will enable the social circle to know the problem and act as a support system to the patient, which in turn helps to improve ART adherence. HIV status disclosure, or the decision to reveal one's HIV-positive status to others, can greatly impact the level of social support a person living with HIV receives. If people are open about their status, they may receive support from loved ones, friends, and healthcare providers. However, if they fear stigma and discrimination, they may choose to keep their status private, potentially limiting their support network. Additionally, not disclosing their status may lead to isolation and decreased access to healthcare resources. Ultimately, the decision to disclose one's HIV status is a personal one and can have signifycant implications for a person's social support and well-being. However, these findings contrast with the outcome of studies conducted in Addis Ababa in, Ethiopia, by Dessalegn et al. [58], and Tehran University in Iran by Shushtari et al. [59] and in Southern Ethiopia by Berhe et al. [50]

The result of this study shows that those with lower sense of belonging, esteem and self-development were more included in EAC. This indicate that clients included in EAC had poor SS. Also, these findings shows that those with social support are less likely to be enrolled in EAC, meaning that social support may help adherence or treatment and hence those with social support are less likely to have high viral load than those without social support.

Conclusion

Based on the finding of this study, a significant proportion of the HIV client disclosed their HIV status to their family members, have spent three years receiving ART, have previously been placed on EAC, and have tuberculosis. However, the majority did not achieve viral load suppression. This shows that their adherence level to ART is poor. Also, this study found that the majority of participants enrolled for EAC due to poor adherence. The study findings also found that all three factor analyses contributed to social support and had a good internal consistency. Social support in this study enhances sense of belonging, self-esteem and self- development of the patients. Furthermore, in this study, males received higher social support than female, likewise, those that disclosed their HIV status and those with social support were less likely to be enrolled in EAC.

Overall, this study found that that PLWHIV without adequate social supports are more likely to experience high viral load, and hence be should be included in EAC

Therefore, it is recommended that efforts should be made to increase the level of social support for HIV clients, especially among females. Also, support programmes and interventions aimed at improving adherence to ART should be designed and implemented. This may include medication reminders, counselling, and peer support groups. Additionally, regular monitoring of clients' adherence to ART should be implemented to identify any issues and provide early intervention. This can help to ensure that clients remain on treatment and achieve viral load suppression.

References

1. Awolude OA, Olaniyi O, Moradeyo M, Abiolu J. Virologic Outcomes Following Enhanced Adherence Counselling among Treatment Experienced HIV Positive Patients at University College Hospital , Ibadan , Nigeria. 2021;10(1):53–65.
2. BvochoraID T, 1* SS, 2, Kudakwashe C. Takarinda2, 3 HB, Prosper Chonzi1, Brian Komtenza3, Clemence Duri1 TA. Enhanced Adherence Counseling (EAC) for Adults Learning Objectives. 2019;
3. Taylor SE. Social Support. In H.S. Friedman & R.C Silver (Eds.), Foundations of Health Psychology (pp. 145-171). Oxford ; New York Oxford Univ Press. 2007;
4. Khamarko K, Myers JJ. The Influence of Social Support on the Lives of HIV-Infected Individuals in Low- and Middle-Income Countries. World Heal Organ. 2013;1–40.
5. WHO. WHO 2016 HIV guidelines. 1–259 [Internet]. 2016; Available from: http://apps.who.int/iris/bitstream/10665/208825/1/9789241549684_eng.pdf
6. UNAIDS. UNAIDS Goal 90-90-90: An ambitious treatment target to help end the AIDS epidemic. Http://WwwUnaidsOrg/Sites/Default/Files/Media_Asset/90-90-90_En_0Pdf [Internet]. 2014;40. Available from: http://www.unaids.org/sites/default/files/media_asset/90-90-90_en.pdf
7. Fox MP, Cutsem G Van, Giddy J, Maskew M, Keiser O, Prozesky H, et al. Rates and predictors of failure of first-line antiretroviral therapy and switch to second-line ART in South Africa. J Acquir Immune Defic Syndr. 2012;60(4):428–37.
8. Jobanputra K, Parker LA, Azih C, Okello V, Maphalala G, Kershberger B, et al. Factors associated with virological failure and suppression after enhanced adherence counselling, in children, adolescents and adults on antiretroviral therapy for HIV in Swaziland. PLoS One [Internet]. 2015;10(2). Available from: http://dx.plos.org/10.1371/journal.%0Apone.0116144. https://doi.org/10.1371/journal.pone.0116144
9. Bonner K, Mezochow A, Roberts T, Ford N, Cohn J. Viral load monitoring as a tool to reinforce adherence: A systematic review. J Acquir Immune Defic Syndr [Internet]. 2013;64(1):74–8. Available from: http://hdl.handle.net/10144/336376

10. Talent Bvochora Id, Id SS, Takarinda KC, Bara H. Enhanced adherence counselling and viral load suppression in HIV seropositive patients with an initial high viral load in Harare , Zimbabwe : Operational issues. 2019;444:1–13.
11. WHO. Consolidated Guidelines on the Use of Antiretroviral Drugs for Treating and Preventing HIV Infection. Recommendations for a Public Health Approach. 2016;(2nd ed):1–429.
12. Brooks K, Diero L, DeLong A, Balamane M, Reitsma M, Kemboi E, et al. Treatment failure and drug resistance in hiv-positive patients on tenofovir-based first-line antiretroviral therapy in western Kenya. J Int AIDS Soc. 2016;19(1).
13. Haile D, Takele A, Gashaw K, Demelash H, Nigatu D. Predictors of treatment failure among adult antiretroviral treatment (ART) clients in Bale Zone Hospitals, South Eastern Ethiopia. PLoS One. 2016;11(10).
14. Telele NF, Kalu AW, Marrone G, Gebre-Selassie S, Fekade D, Tegbaru B, et al. Baseline predictors of antiretroviral treatment failure and lost to follow up in a multicenter countrywide HIV-1 cohort study in Ethiopia. PLoS One. 2018;13(7).
15. Skhosana NL, Struthers H, Gray GE, McIntyre JA. HIV disclosure and other factors that impact on adherence to antiretroviral therapy: The case of Soweto, South Africa. African J AIDS Res. 2006;5(1):17–26.
16. Kagee A, Le Roux M, Dick J. Treatment adherence among primary care patients in a historically disadvantaged community in South Africa: A qualitative study. J Health Psychol. 2007;12(3):444–60.
17. Nachega JB, Hislop M, Dowdy DW, Lo M, Omer SB, Regensberg L, et al. Adherence to highly active antiretroviral therapy assessed by pharmacy claims predicts survival in HIV-infected South African adults. J Acquir Immune Defic Syndr. 2006;43(1):78–84.
18. Timmons JC and LF. The impact, meaning, and challenges of work: Perspect Individ with HIV/AIDS Heal Soc Work. 2004;29(2):137.
19. Kelly JD, Hartman C, Graham J, Kallen MA, Giordano TP. Social support as a predictor of early diagnosis, linkage, retention, and adherence to HIV care: Results from the steps study. J Assoc Nurses AIDS Care. 2014;25(5):405–13.
20. Muñoz M, Bayona J, Sanchez E, Arevalo J, Sebastian JL, Arteaga F, et al. Matching social support to individual needs: A community-based intervention to improve HIV treatment adherence in a resource-poor setting. AIDS Behav. 2011;15(7):1454–64.
21. Ncama BP, McInerney PA, Bhengu BR, Corless IB, Wantland DJ, Nicholas PK, et al. Social support and medication adherence in HIV disease in KwaZulu-Natal, South Africa. Int J Nurs Stud. 2008;45(12):1757–63.
22. Simoni JM, Frick PA, Huang B. A longitudinal evaluation of a social support model of medication adherence among HIV-positive men and women on antiretroviral therapy. Heal Psychol. 2006;25(1):74–81.
23. Edwards L V. Perceived social support and HIV/AIDS medication adherence among African American women. Qual Health Res. 2006;16(5):679–91.
24. FMoH. National AIDS and STI's Control Programme, Federal Ministry of Health: 2016 National Guidelines for HIV Prevention Treatment and Care. 2016;1–123.
25. Britannica. The Editors of Encyclopaedia. "evaporation". Encyclopedia Britannica . Encyclopedia [Internet]. 2023; Available from: https://www.britannica.com/place/Abuja-federal-capital-territory-Nigeria
26. Villa africa reality. Abuja - FCT | All About Nigeria's Federal Capital City. 2021;1–1. Available from: https://www.villaafrika.com/fct-abuja-city-profile/
27. World Population Review. Abuja Population 2022. World Popul Rev [Internet]. 2022; Available from: https://worldpopulationreview.com/world-cities/abuja-population

28. Boumphery S. World's Fastest Growing Cities are in Asia and Africa - Euromonitor International Blog. Euromonitor [Internet]. 2010;34. Available from: http://blog.euromonitor.com/2010/03/special-report-worlds-fastest-growing-cities-are-in-asia-and-africa.html
29. Oxford Business Group. Rapid Urbanisation in Abuja Nigeria Drives Infrastructure and Real Estate Investments. 2020; Available from: https://oxfordbusinessgroup.com/overview/keys-city-rapid-urbanisation-one-continent's-most-prosperous-cities-drives-investment-infrastructure
30. NAIIS. NIGERIA PREVALENCE RATE - NACA Nigeria [Internet]. 2019 [cited 2021 Oct 18]. p. 1–1. Available from: https://naca.gov.ng/nigeria-prevalence-rate/
31. Abah IO, Ncube NBQ, Bradley HA, AgbaJi OO, Kanki P. Antiretroviral Therapy-associated Adverse Drug Reactions and their Effects on Virologic Failure- A Retrospective Cohort Study in Nigeria. Curr HIV Res. 2019;16(6):436–46.
32. Cortes A, Hunt N, McHale S. Development of the Scale of Perceived Social Support in HIV (PSS-HIV). AIDS Behav. 2014;18(12):2274–84.
33. Cortes A, Hunt N, McHale S. Development of the Scale of Perceived Social Support in HIV (PSS-HIV). AIDS Behav. 2014;18(12):2274–84.
34. Chaudhury S, Kirk CM, Ingabire C, Mukunzi S, Nyirandagijimana B, Godfrey K, et al. HIV Status Disclosure through Family-Based Intervention Supports Parenting and Child Mental Health in Rwanda. Front Public Heal. 2016;4(June):1–9.
35. Kennedy DP, Cowgill BO, Bogart LM, Corona R, Ryan GW, Murphy DA, et al. Parents' disclosure of their HIV infection to their children in the context of the family. AIDS Behav. 2010;14(5):1095–105.
36. Rowell-Cunsolo TL, Liu J, Shen Y, Britton A, Larson E. The impact of HIV diagnosis on length of hospital stay in New York City, NY, USA. AIDS Care - Psychol Socio-Medical Asp AIDS/HIV. 2018;30(5):591–5.
37. Martin F, Lee J, Thomson E, Tarrant N, Hale A, Lacey CJ. Two cases of possible transmitted drug-resistant HIV: likely HIV superinfection and unmasking of pre-existing resistance. Int J STD AIDS. 2016;27(1):66–9.
38. Rayment M. Prevention of HIV-1 infection with early antiretroviral therapy. J Fam Plan Reprod Heal Care. 2012;38(3):193.
39. Anne L, Jobanputra K, Parker LA, Azih C, Okello V, Maphalala G. Factors Associated with Virological Failure and Suppression after Enhanced Adherence Counselling , in Children , Adolescents and Adults on Antiretroviral Therapy for HIV in Swaziland Authors Factors Associated with Virological Failure and Suppression afte. 2021;
40. Diress G, Dagne S, Alemnew B, Adane S, Addisu A. Viral Load Suppression after Enhanced Adherence Counseling and Its Predictors among High Viral Load HIV Seropositive People in North Wollo Zone Public Hospitals , Northeast Ethiopia , 2019 : Retrospective Cohort Study. 2020;2020.
41. Weiser SD, Tuller DM, Frongillo EA, Senkungu J, Mukiibi N, Bangsberg DR. Food insecurity as a barrier to sustained antiretroviral therapy adherence in Uganda. PLoS One. 2010;5(4).
42. Tuller DM, Bangsberg DR, Senkungu J, Ware NC, Emenyonu N, Weiser SD. Transportation costs impede sustained adherence and access to HAART in a clinic population in Southwestern Uganda: A qualitative study. AIDS Behav. 2010;14(4):778–84.
43. Gilbert L, Walker L. "My biggest fear was that people would reject me once they knew my status...": Stigma as experienced by patients in an HIV/AIDS clinic in Johannesburg, South Africa. Heal Soc Care Community. 2010;18(2):139–46.
44. Hardon AP, Akurut D, Comoro C, Ekezie C, Irunde HF, Gerrits T, et al. Hunger, waiting time and transport costs: Time to confront challenges to ART adherence in

Africa. AIDS Care - Psychol Socio-Medical Asp AIDS/HIV. 2007;19(5):658–65.
45. Ahsan Ullah AKM. HIV/AIDS-related stigma and discrimination: A study of health care providers in Bangladesh. J Int Assoc Physicians AIDS Care. 2011;10(2):97–104.
46. Merten S, Kenter E, McKenzie O, Musheke M, Ntalasha H, Martin-Hilber A. Patient-reported barriers and drivers of adherence to antiretrovirals in sub-Saharan Africa: A meta-ethnography. Trop Med Int Heal. 2010;15(SUPPL. 1):16–33.
47. Sanjobo N, Frich JC, Fretheim A. Barriers and facilitators to patients' adherence to antiretroviral treatment in Zambia: A qualitative study. Sahara J [Internet]. 2008;5(3):136–43. Available from: http://dx.doi.org/10.1080/17290376.2008.9724912
48. Bhat VG, Ramburuth M, Singh M, Titi O, Antony AP, Chiya L, et al. Factors associated with poor adherence to anti-retroviral therapy in patients attending a rural health centre in South Africa. Eur J Clin Microbiol Infect Dis [Internet]. 2010;29(8):947–53. Available from: http://dx.doi.org/10.1007/%0As10096-010-0949-4
49. Joglekar N, Paranjape R, Jain R, Rahane G, Potdar R, Reddy KS, et al. Barriers to ART adherence & follow ups among patients attending ART centres in Maharashtra, India. Indian J Med Res. 2011;134(12):954–9.
50. Berhe H, Godana W, Sidamo NB, Birgoda GT, Gebresillasie L, Hussen S, et al. Perceived Social Support and Associated Factors Among Adults Living with HIV/AIDS Attending ART Clinic at Public Hospitals in Gamo Zone, Southern Ethiopia 2021. HIV/AIDS - Res Palliat Care. 2022;14(March):103–17.
51. Oppong Asante K. Social support and the psychological wellbeing of people living with HIV/AIDS in Ghana. African J Psychiatry (South Africa). 2012;15(5):340–5.
52. Deichert NT, Fekete EM, Boarts JM, Druley JA, Delahanty DL. Emotional support and affect: Associations with health behaviors and active coping efforts in men living with HIV. AIDS Behav. 2008;12(1):139–45.
53. Stinson DA, Logel C, Zanna MP, Holmes JG, Cameron JJ, Wood J V., et al. The Cost of Lower Self-Esteem: Testing a Self- and Social-Bonds Model of Health. J Pers Soc Psychol. 2008;94(3):412–28.
54. Steward WT, Herek GM, Ramakrishna J, Bharat S, Chandy S, Wrubel J, et al. HIV-related stigma: Adapting a theoretical framework for use in India. Soc Sci Med. 2008;67(8):1225–35.
55. Xiao Z, Li X, Qiao S, Zhou Y, Shen Z. Coping, social support, stigma, and gender difference among people living with HIV in Guangxi, China. Psychol Heal Med. 2018;23(1):18–29.
56. Li Y, Zhang XW, Liao B, Liang J, He WJ, Liu J, et al. Social support status and associated factors among people living with HIV/AIDS in Kunming city, China. BMC Public Health. 2021;21(1):1–11.
57. Cama E, Brener L, Slavin S, de Wit J. The relationship between negative responses to HIV status disclosure and psychosocial outcomes among people living with HIV. J Health Psychol. 2020;25(4):538–44.
58. Dessalegn NG, Hailemichael RG, Shewa-amare A, Sawleshwarkar S, Lodebo B, Amberbir A, et al. HIV disclosure: HIV-positive status disclosure to sexual partners among individuals receiving HIV care in Addis Ababa, Ethiopia. PLoS One. 2019;14(2).
59. Shushtari ZJ, Sajjadi H, Forouzan AS, Salimi Y, Dejman M. Disclosure of HIV status and social support among people living with HIV. Iran Red Crescent Med J. 2014;16(8).

Review article

Creating Psychological Safety in the Medical Laboratory Science Profession: From Workplace Culture to Education

Heather Hilgart[1,2*], Patricia Tille[1], and Beth Warning[1]

Medical Laboratory Sciences Program, College of Allied Health Sciences. University of Cincinnati, Cincinnati, Ohio, USA[1]. Department of Laboratory Medicine and Pathology, Mayo Clinic, Rochester, Minnesota, USA[2]

Psychological safety (PS) is needed in medical laboratory science (MLS). All roles in MLS must have an environment where it is safe to make and admit to mistakes. There are evident characteristics of environments with low and high levels of PS. Creating PS for medical laboratory professionals and learners can be accomplished with simple strategies. The strategies can be used for in-person and virtual environments, and by all MLS roles. Assessments can be used to measure if the implementation of PS strategies are successful. The General Health Questionnaire (GHQ-12) is a resource to model survey questions for assessment. There are several positive outcomes after implementing PS strategies in MLS involving workplace culture, teamwork, professional identity, and education. PS creates a practice zone for all roles in MLS.

Keywords: psychological safety, medical laboratory science, workplace culture

---

Accepted: February 10, 2024
*Corresponding author: Heather Hilgart. E-mail: Hilgart.heather@mayo.edu

Introduction

Medical laboratory professionals, educators, and learners can create psychological safety in the work and learning environments. Psychological safety (PS) is an individual's perception of an environment to take interpersonal risks.[1] Psychological safety is not trust or trauma from harassment. Knowing the difference between high and low characteristics of PS is important to evaluate an environment and make changes if needed. The different environments to evaluate in medical laboratory science (MLS) include in-person environments such as the medical laboratory workplace, professional development sessions, training, and the MLS education classroom. All the in-person environments could also be virtual; therefore, it is also pertinent to evaluate virtual settings.

Extremely limited, if any, literature exists on the impact of PS in the medical laboratory and MLS education programs. To evaluate the impact of PS more accurately in a medical laboratory, PS must first be created. PS is critical to a work environment as complex and equivocal as MLS.[2]

Creating PS is the responsibility of all individuals independent of their role in the medical laboratory and MLS education. Medical laboratory professionals crave improvements in workplace culture. Educators and learners are entitled to a learning environment where mistakes are accepted. Creating psychological safety for medical laboratory professionals and learners can be accomplished with simple strategies and improve workplace culture.

Background

Psychological safety has many definitions. In general, PS is a perception of feeling safe to engage in interpersonal risk taking.[3,4] An individual's perception evaluates the consequences of admitting mistakes in an environment and believing there will be no rejection in being oneself.[4,5] PS should not be considered a mechanism to remove discomfort and make an environment enjoyable. PS is not workplace violence, harassment, or bullying. Trust and PS are not the same. Trust occurs between two people or entities, and how one views the other.[2,5] PS is between an environment and individuals.[5] Trust is an individual giving another the benefit of the doubt, and PS is the perception of whether others will give the individual the benefit of the doubt.

Psychological safety is important in MLS for professionals and learners. In education, PS is necessary for educational alliance.[6] The educational alliance is a bond between teacher and learner or trainer and trainee to work together on a common goal. An MLS learner must perceive the educational environment as a safe place to make and learn from mistakes. The professional medical laboratory should have the same safe environment. PS creates a space where mistakes are allowed which results in a positive working and learning environment.

There are notable characteristics of an MLS environment that provides a high level of PS. Not surprisingly, open communication is a top indicator of PS.[4,5,7] Table 1 outlines characteristics of an environment with PS. A work environment with PS has four domains: Leader commitment to stress prevention, safety prioritized over productivity, listening, and active participation at all levels.[8] Medical laboratories and MLS education, whether in person or virtual, have similar domains.

Medical laboratory professionals and educators must recognize characteristics of an environment with low levels of PS (Table 1). Negative environments where PS is hidden away may create harmful cultures. Medical laboratory professionals become silent, are disengaged, and may have negative emotions erupt.[7,9] An environment lacking PS will inhibit learning and communication.[6] Individuals taking interpersonal risks in a low PS environment may develop a feeling of incompetence.[9] If signs of low PS are not recognized and changed, a negative working and learning environment may continue.

Many barriers exist prohibiting PS in MLS. Some behavioral characteristics blocking PS include rudeness, aggressiveness, isolation, bullying, and harassment.[2,4,10] Many of these barriers are typical characteristics of toxic

Table 1. Characteristics of Environments with High and Low Levels of Psychological Safety

Environments with High Levels of PS*	Environments with Low (or No) Levels of PS*
Open communication	Silence
Mistakes tolerated	Adverse events
Commitment to growth	Low job satisfaction
Encouragement	Lack of contributions
Motivation	Avoidance
Seek feedback	Defensiveness
Judgement free	Feeling of incompetence
Empathy	Apathy
Autonomy	Dependency
Increased learning	Issues with learning
Engagement	Absenteeism
Awareness	Low or no feedback
Stewardship	-
Self-development	-
Accessibility	-
Forgiveness	-
High retention	-
Reduced anxiety	-
Compassion	-
Healing	-

** Psychological Safety (PS)*

Data compiled from: Torralba KD, Jose D, Byrne J. Psychological safety, the hidden curriculum, and ambiguity in medicine [Internet]. Clinical rheumatology. 2020 Mar [cited 2023 Jan 17];39(3):667-71. Available from: https://link.springer.com/article/10.1007/s10067-019-04889-4. Daniels AL, Morse C, Breman R. Psychological safety in simulation-based prelicensure nursing education: a narrative review [Internet]. Nurse Educ. 2021 [cited 2023 Aug 25];46(5):E99-E102. doi:10.1097/NNE.0000000000001057. Available from: https://journals.lww.com/nurseeducatoronline/Fulltext/2021/09000/Psychological_Safety_in_Simulation_Based.32.aspx?casa_token=ICCVifxlXH4AAAAA:apDRsoRMsLCjY9yQSTMxHRAlYeGCSXfiP9vn7M1M-xwASiqygju3S_WayG5BxhiqlgX3mY2cItmyPP4Xl9K34RE0Ng. Ma Y, Faraz NA, Ahmed F, et al. Curbing nurses' burnout during COVID-19: The roles of servant leadership and psychological safety [Internet]. J Nurs Manag. 2021 [cited 2023 Aug 25];29:2383-2391. Available from: https://doi.org/10.1111/jonm.13414. Newman A, Donohue R, Eva N. Psychological safety: A systematic review of the literature [Internet]. Human resource management review. 2017 Sep 1 [cited 2022 Oct 8];27(3):521-35. Available from: https://www.sciencedirect.com/science/article/pii/S1053482217300013. Johnson CE, Keating JL, Molloy EK. Psychological safety in feedback: What does it look like and how can educators work with learners to foster it? [Internet]. Med Educ. 2020 [cited 2023 Sept 3];54:559-570. Available from: https://doi.org/10.1111/medu.14154. Chou E, Grawey T, Paige JB. Psychological Safety as an Educational Value in Interprofessional Health Education [Internet]. AMA J Ethics. 2023 May 1 [cited 2023 Aug 26];25(5):E338-343. doi: 10.1001/amajethics.2023.338. PMID: 37132619. Available from: https://journalofethics.ama-assn.org/article/psychological-safety-educational-value-interprofessional-health-education/2023-05. Pfeifer LE, Vessey JA. Psychological safety on the healthcare team [Internet]. Nursing Management. 2019 Aug 1 [cited 2022 Oct 22];50(8):32-8. Available from: https://journals.lww.com/nursingmanagement/FullText/2019/08000/Psychological_safety_on_the_healthcare_team.7.aspx?casa_token=xJrreDIB6RkAAAAA:PwRTWs2bNBW9tqp0hX8wDbXF192nLpsERlSSKlffSZrPm7bE39LOY9nf1VN3ucqT6I_JUrK8Thx37bT8JAc45zYelA. Turner S, Harder N, Martin D, Gillman L. Psychological safety in simulation: Perspectives of nursing students and faculty [Internet]. Nurse Educ Today. 2023 Mar [cited 2023 Sep 4];122:105712. doi: 10.1016/j.nedt.2023.105712. Epub 2023 Jan 13. PMID: 36669303. Available from: https://www.sciencedirect.com/science/article/pii/S0260691723000060. Inoue A, Eguchi H, Kachi Y, Tsutsumi A. Perceived psychosocial safety climate, psychological distress, and work engagement in Japanese employees: A cross-sectional mediation analysis of job demands and job resources [Internet]. J Occup Health. 2023 [cited 2023 Aug 26];65:e12405. doi:10.1002/1348-9585.12405. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/1348-9585.12405.

people. However, toxic people may have a feeling of worthlessness resulting in such characteristics. This explains the need to manipulate and control the environment and others because they do not want to feel abandonment.[10]

Absence of employee recognition and role clarity are also obstacles to PS.[10] In MLS, role clarity may be an obstacle for PS because of a lack of common professional nomenclature. The profession uses MLS to describe the individuals and clinical laboratory science (CLS) in some cases which may be confusing to define roles. There is a continued lack of understanding and agreement throughout the profession on the proper use of these terms. In addition, an individual's own shame and fear can be a barrier to PS and fear can lead to disconnection.[10] For example, an MLS who has made multiple attempts at providing ideas to improve a workflow process and consistently the ideas are turned down by the team without explanation. This repeated rejection may cause the technologist to disconnect from the team.

Psychological safety can look and feel different depending on the level of interaction an individual has in the environment. The different environment levels include organizational, team, and the individual. At the organizational level PS is about providing job clarity, executive leader participation, and attention to employee wellness.[4,8,9] Executives, or c-suite leaders, participate by listening to contributions and finding ways to prevent stress.[8] Executive leaders may provide work unit level laboratory leaders with proper job descriptions for staff and provide resources that are readily accessible for MLS professionals and learners on mental health wellness.

Overall, the PS encountered by MLS professionals and learners is at the team and individual levels. PS at the team level is a valuable resource because it is more meaningful.[5] PS creates connections between team members leading to increased learning, innovation, and growth.[9] Team PS typically evolves from a direct supervisor or another laboratory leader through inclusive participation in decision-making and professional development.[4]

At the individual level medical laboratory professionals and learners may demonstrate common characteristics if experiencing high or low levels of PS. Individual characteristics of low or no PS include anxiety, defensiveness, discomfort, and silence.[2,3,9] Anxiety may develop when an individual is concerned about being embarrassed or afraid to make a mistake. The individual cannot view mistakes as opportunities.[3] Silence comes from the motivation to protect self and be risk avoidant which suppresses efforts.[2] An example of a low level of PS in MLS is when a learner in a microbiology laboratory rotation accidently punctures a glove or comes across a biohazardous spill. Rather than report the accident to the educator or trainer, if the learner is experiencing a low level of PS, fear may cause anxiety and silence which leads to the learner not reporting the accident. Conversely, individual characteristics of high PS include increased self-esteem and connections, proactive personality, and emotional stability.[9,11] Individuals may also experience increased autonomy, mutual respect, communication, and a stronger educational alliance.[6,8] The learner in a microbiology laboratory rotation may be more inclined to report an accident or spill.

There are many ways that individuals cope with a lack of PS in the environment. Individuals experiencing low, or no PS, may exhibit a conservation of resources. The conservation of resources (COR) theory is when a threat is detected, whether with resource loss or conflict, and the natural response is to acquire resources.[4,5,7] Resources of PS are social bonding and support, rewards and recognition, autonomy, and job security.[4,5] MLS professionals may experience COR when a conflict is detected, and an individual may communicate with others in the laboratory work unit establishing support for one side of the conflict. If PS is missing in a medical laboratory, survival mode for an individual may kick in possibly leading to acquiring social bonding resources, which could create assumptions, gossip, and cliques. The escalation of these behaviors often manifests in a toxic work environment.

Strategies for creating psychological safety

Creating PS in a medical laboratory can be accomplished as a leader, laboratory supervisor, technologist, educator, or learner. All roles can contribute to an environment of high PS with empathy, recognition, and proper communication.[3,9,10] Good communication includes feedback, another resource of a psychologically safe environment.[12] A medical laboratory should have a plan ready to create PS in the professional or educational environment. Create a plan based on whether the environment will be in-person, virtual, synchronous, or asynchronous. Also consider if the audience are employees learning a new skill, professional development, or if the audience are learners in an MLS program. Many of the same strategies to create PS can be used in any environment.

A laboratory leader or supervisor sets the stage for PS. Enforcing openness, transparency, and using supportive language invites participation.[3,9] A leader or supervisor initiates interpersonal risk-taking by encouraging staff to ask questions and give input.[2-4] For example, during a laboratory huddle a supervisor will ask for input on purchasing a new incubator, document suggestions, and take each suggestion seriously.

It is important to note that as a leader, it is not enough to invite participation, it is important that the leader internalize the input or ideas and actively listen to others. A leader can role-model interpersonal risk-taking with hum-

ility, asking genuine questions that do not already have answers, admitting mistakes, and reporting errors.[2] For instance, a technical specialist with oversight of programming instrument assays discovers a calculation error resulting in revised results. Rather than hiding the mistake, the technical specialist documents the investigation and shares the experience with others. This is a normal process, and in a PS environment the individual is comfortable correcting the error without fear of retaliation or punishment.

It is also important for laboratory leaders to utilize employee recognition as a means to create PS.[9] Recognition does not have to be an honor, award, or celebration. Recognition can be given to staff through empathy, respect, and valuing different perspectives.[3,10] An example is a laboratory supervisor who keeps a list of employees, and each workday the supervisor connects with a different employee with intention. The supervisor recognizes staff on a personal level.

Recognition from a supervisor is important, however, recognition from peers not in a leadership or supervisory role may be more impactful in creating PS. Being a medical laboratory professional can sometimes be isolating work creating a barrier for peer-to-peer recognition. Technical work can consume employees and may prevent staff from using soft skills such as emotional intelligence. One way to promote peer-to-peer recognition beyond technical abilities and build soft skills is to rotate willing employees through a 'chief happiness/joy officer' role in the medical laboratory. Placing staff in a leadership-like role with the intent of recognizing joy is a safe environment to practice interpersonal risk-taking. If this effort creates too much anxiety at the individual role, instead form a joy team. Bringing a team together to brainstorm ways to recognize one another and promote dialogue by conveying that recognition creates a psychologically safe environment.[9]

Promoting dialogue through recognition is a good start for individuals in any MLS role toward creating PS to obtain feedback or participate in difficult conversations. Before offering feedback, especially in difficult situations, the initiator should propose a communication plan upfront and ask for input on the plan from the recipient.[6] The communication plan should include a date, time, and place to meet. Also include what the feedback or conversation will be about and allow the recipient to make changes to the plan. Proposing and following the communication plan helps to create PS for the recipient.

Feedback is considered a resource and therefore should never be withheld.[12] To create PS when there is a power gap between the initiator and recipient engaged in the feedback or conversation, the leader should approach the conversation differently. The leader, whether the initiator or recipient, should bring humility, empathy, and encourage dialogue through open-ended questions and allow time for responses.[6] The leader can show humility by admitting to their own mistakes or knowledge gap. For PS to be sustainable in feedback or difficult conversations, mistakes should be expected of both initiator and recipient, and allow an environment to practice communication.[6] Psychological safety is present when MLS professionals can practice communication, make mistakes, and try again.

Similar to creating PS in feedback, an MLS learning event should have a plan. Learning events such as simulations or professional development sessions taking place in-person can use the Work Team Learning (WTL) model. The WTL model helps to plan learning events to include concepts that create PS.[3] First is preparation which includes orienting to environment, acknowledging emotions, and nonverbal communication.[3] As in feedback, clarify date, time, environment, and topic. Different from feedback, include expectations of participants and objectives of the learning event. In MLS education courses, prepare learners with more than expectations, a syllabus, and contact information. Emphasize the common goals between educator and learner.[7] The educator can communicate to the learners how they hope to learn something new during

the time together or admit to the learners a knowledge gap in the topic and hopes of learning more by engaging with the learners.

Second in the WTL model is confidence in the team. Creating confidence and trust in an in-person team includes the preparation of a non-threatening environment and allowing space for team members to receive clarity.[3] Step two may sound like preparation, but the first step takes place prior to the learning event. Creating confidence and trust in the team occurs at the beginning and during the learning event and is facilitated by the leader. The leader can make sure all questions and concerns are addressed throughout the learning event. For MLS education, create confidence in the team by inviting participation and encourage the freedom of learner discussion and for the learners to draw own conclusions.[7] Freedom of discussion among learners may be easier for the learners if the educator previously emphasized the common goals and admitted to knowledge gaps. By doing so, the educator has created PS and exhibited interpersonal risk-taking.

Next in the WTL model is explicit and implicit actions. Actions or conduct of team members creates PS through transparency, confidentiality, respect, and nonverbal communication such as eye contact.[3] During the second step, confidence in a team, the leader can establish confidentiality and respect as an expectation by explicit verbal communication. Then all participants of the learning event must follow through to maintain the psychologically safe environment. Participants can accomplish this by not interrupting other participants, being aware of facial expressions, and not repeating any sensitive information shared during the learning event. MLS educators must acknowledge emotions coming through nonverbal communication during the learning event.[3,7] When uncomfortable emotions are expressed, respond with respect, and continue to encourage communication and participation.[7] For example, during an in-person MLS professional development session, a participant displays shaking of the head, eye rolls, and sighs. Without interrupting another participant, the educator asks this participant to share their thoughts. The educator's nonverbal expressions remain neutral, and the tone of voice is inviting.

Finally, the WTL model evaluates the outcomes. The outcomes can be products, consequences, or effects and include anxiety, confidence, and engagement levels of team members.[3] To evaluate the outcomes of a learning event, a survey can be given to the participants. The survey should include assessment of the participant's anxiety or stress level before and during the event, and confidence of knowledge before and after the topic(s) discussed.

The leader of the learning event can evaluate the engagement level of the participants by active dialogue during the event and survey responses. An MLS educator should evaluate whether the participants performed as a team, and whether the event was learning-centered. Keeping the team learning-centered encourages PS and growth.[7] Learner growth occurs because the environment is deemed safe by the learners, allowing more inter-personal risk-taking. The educator should also provide positive feedback to the learners and reward growth over performance.[7] The positive feedback from the educator to the learners is reward or recognition of the learners' growth.

The most important WTL model concept used in creating PS in virtual MLS education is preparation.[3,7,11] Virtual MLS education environments, either synchronous or asynchronous, must create PS. Building positive and trusting relationships with learners can be more challenging in a virtual environment where live communication is used sparingly, if at all. An educator can build transparency and reduce anxiety by preparing learners for virtual interactions and communications. An example of preparing for a virtual educational experience is to hold a virtual orientation before a course, simulation, or event for learners to interact with the learning management system,

work out technical difficulties, and ask additional questions. An opportunity for a virtual and live interaction with the educator during the orientation should be offered. If the education event duration is short or only offered asynchronously, the first few minutes should include instruction to help the learner engage in the educational process.

Additional changes to a synchronous virtual MLS learning environment can be made so learners come to expect a non-intimidating experience.[3] The strategies are simple and may have a large impact for the learners. Do not require cameras to be on and allow communication through a chat feature.[13] Limit participant size to ten learners or less and do not record the event when possible.[13] If recording is necessary, inform learners recording will take place. If possible, allow learners to self-schedule or have flexibility in scheduling a learning event. These strategies give the learners autonomy to choose how to create a psychological safe space best for individual learning in a virtual and synchronous environment.

Another strategy to create PS for new MLS professionals or students is through near-peer mentoring. Near-peer mentoring for new professionals is when mentoring is more relatable between mentor and mentee.[14] For example, an experienced MLS professional may be the best individual to train a new professional, however, they may not have much in common with each other. Pairing the new professional up with another employee who is more relatable may benefit the mentee-mentor relationship. The closer or more relatable a mentor and mentee, PS is higher for the mentee.[14] Near-peer mentoring is not designed to limit who the educator or trainer is but to help to create an inviting environment for the new learner.

How will the MLS leader, professional, educator, or learner know PS has been created and successful in the environment? Most assessment tools for evaluating PS in an environment are subjective.[15] Subjective assessments include changes in behaviors. Whether explicit or implicit actions, both can be measured before versus after an in-person or virtual education or professional event. Subjective assessments can also be used for laboratory meetings in the professional work unit. An example of explicit behaviors would include more participants speaking up in a group, and examples of implicit behaviors are appropriate non-verbal communications such as eye contact and active listening. For example, before, during, and after a work unit medical laboratory meeting, have an individual assess the implicit and explicit actions observed to compare before and after implementation of PS strategies (Table 2).

Table 2. Explicit and Implicit Strategies Contributing to Psychological Safety

Strategy	Before MLS* Meeting	During MLS* Meeting	After MLS* Meeting
Implicit Actions or Behaviors	Private Environment	Behavioral Integrity	Behavioral Integrity
	Arrive Early	Empathy	Positive Affect
	Circular Seating	Pause to Listen	Positive Regard
	Co-facilitator Positioning	Positive Affect	Confidentiality
	Mindful of timing	Positive Regard	-
	-	Eye Contact	-
Explicit Actions of Behaviors	Clarify Expectations	Authenticity	Express Appreciation
	Confidentiality	Inclusivity	Invite Feedback
	Transparency	Validation & Paraphrasing	Offer Support
	Inclusive Language	Curiosity & Appreciation	-
	Commit to Respect	Normalization	-
	Attend to Logistics	Vulnerability	-

**Medical Laboratory Science*

Modified from: Kolbe M, Eppich W, Rudolph J, Meguerdichian M, Catena H, Cripps A, et al. Managing psychological safety in debriefings: a dynamic balancing act [Internet]. BMJ simulation & technology enhanced learning. 2020 [cited 2023 Oct 21];6(3):164. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8936758/.

Surveys are another way to assess the level of PS in the environment. After an MLS educational event whether in-person or virtual, such as professional development or training, the educator or facilitator can send out a survey to participants. By making the survey anonymous PS is maintained. Questions on the survey to

assess PS for participants can be taken from the General Health Questionnaire (GHQ-12) which is a tool that has been validated to measure PS.[12] The GHQ-12 survey is typically used for quantitative analysis of mental health and was developed in 1988 by Goldberg and Williams.[12,16] Examples of questions on the GHQ-12 survey are how the participant felt during the event and what, if any, resources were unavailable to help the participant succeed. Using exact questions from the GHQ-12 survey may not be necessary in a medical laboratory assessment of PS. However, the GHQ-12 survey may serve as a model to determine the correct questions to ask and evaluate if PS strategies are successful.

Discussion

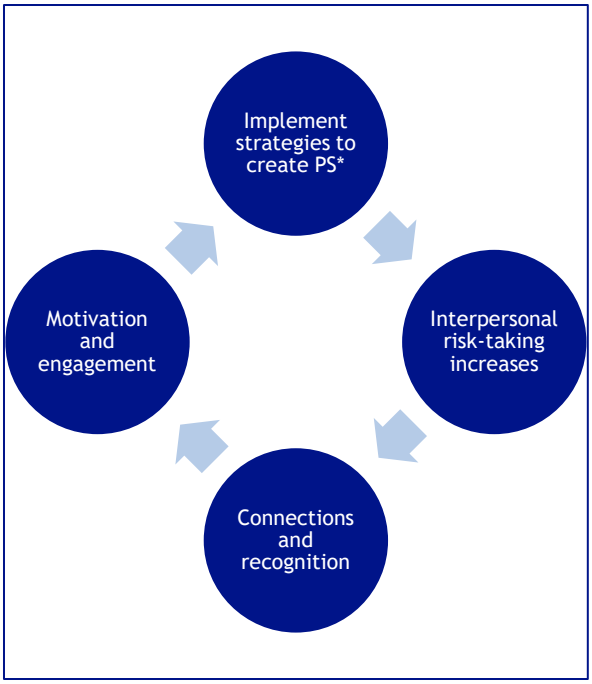
The purpose of creating PS in an MLS professional or educational in-person and virtual setting is to improve workplace culture. Studies have shown PS will create a more open environment for interpersonal risk-taking.[1,2,4,6] Additionally, interpersonal risk-taking may lead to increased collaboration among teams, and individuals may have a better sense of professional identity. Furthermore, adding simple PS strategies to virtual MLS education impacts learner agility.

Psychological safety creates a positive workplace culture. The positive culture is attributed to decreases in turnover, absenteeism, and adverse events, all of which correlate to high levels of PS.[4,9] Consequently, increases are seen in retention and engagement of staff working in an environment with PS.[3,4,7,9] MLS professionals that experience staff satisfaction in the workplace environment may be more likely to stay in the profession and participate in internal and external activities such as volunteering for process improvements and for activities in professional organizations. There is also increased stewardship and a general feeling of compassion and kindness.[4] An MLS environment may start to feel like a family where encouragement and compassion are readily given not only for professional conduct, but also for personal events.

The characteristics of an environment with high levels of PS foster teamwork. Psychological safety within a team creates better connections among team members leading to increased learning.[9] Consider an MLS learning event such as a one-hour professional development session on crucial conversations, and the participants and facilitator of the learning event are considered the team. With PS communication is better, and collaboration and innovation thrive.[9,14] The MLS professional development session with PS strategies included may provide more ideas by and for the learners than the facilitator anticipated. With PS at the team level, mistakes are tolerated, and encouragement, compassion, and forgiveness are present among team members.[4] Teams with characteristics of high levels of PS build trust. Team members with that trust lead to better performance.[9] An MLS learning event may be more successful using PS strategies. The educational alliance between educator/learner or trainer/trainee increases.[14]

Individuals in the MLS profession may develop professional identity because of PS. Professional identity is associated with self-confidence and a sense of purpose which increases, and anxiety decreases when PS is present.[2,3,9,11,17] Even with PS present an MLS professional, and learner may feel vulnerable. However, PS allows inter-personal risk-taking despite feeling vulnerable, and individuals can increase connections.[9,10]

These inter-personal connections between MLS professionals, educators, and learners can lead to recognition. A sense of being heard through recognition leads to validation and individuals exhibiting characteristics of high PS.[10] High levels of PS keep people motivated and individuals start to notice the value in other perspectives.[2-4] Based on research of PS, a lifecycle for MLS on creating PS is described in Figure 1. The outcome of implementing PS may not only be in motivation of job performance and learning agility but also motivation to support on-going PS.



**Psychological Safety (PS)*

Figure 1. Psychological Safety Creation Lifecycle in Medical Laboratory Science

Implementation of strategies to create psychological safety in MLS lead to interpersonal risk-taking. Increased interpersonal risk-taking leads to connections and recognition among MLS professionals and learners. MLS professionals and learners become more motivated and engaged, and creating psychological safety in MLS is sustainable.

Similar outcomes are expected where PS has been incorporated for MLS virtual education. Psychological safety increases the usefulness of virtual learning.[18] Without PS in the virtual learning environment, interpersonal risk-taking may be reduced and connections lost. Psychological safety increases the wellbeing of educators and learners creating connections in a virtual education setting.[19] Without connections, motivation, and engagement, the virtual learning environment may lose its usefulness, and the educational alliance may be weakened.

Despite the clear advantages of PS, opposing views suggest PS does not directly correlate to outcomes. PS is viewed only as a mediator for team learning.[17] When PS is viewed as a mediator, other resources are needed in combination to achieve desired outcomes such as a positive workplace culture. One of the resources suggested is felt accountability.[17] Felt accountability is the "expectation that one's decisions and behaviors will be evaluated by a salient audience and receive reward or sanctions."[20] If this were true for MLS, the idea of felt accountability, or the constant feeling of being evaluated, may not help with PS in a medical laboratory environment. Felt accountability could be a barrier to PS.

Although there are clear advantages to improving PS, the overall concept may fall victim to the Too-Much-of-a-Good-Thing (TMGT) effect. Too much PS could lead to unethical behavior such as choosing what is beneficial over what is right.[5] Too much PS may also decrease individual team members effort and motivation which decreases interpersonal risk-taking.[17] Unethical interpersonal risk-taking can lead to a bad reputation.[5] In MLS, PS is TMGT when the medical laboratory environment has such a high a level of PS that certain employees communicate in an unethical manner. For example, a medical laboratory technologist feels safe enough at work to use intimidating and repressive verbal and non-verbal communication when questioned by a coworker on following a procedure. The coworker attempts to inquire about the expiration date after preparation of a reagent, and the expiration date on the reagent label differs from what is written in the standard operating procedure. The medical laboratory technologist responds with "this is how it has always been" with arms crossed. Situations such as this are where felt accountability may be valuable.

Other limitations to consider regarding a virtual environment either in education or a workplace meeting are the challenges of communication and emotions. Remote interactions may cause adverse effects such as feelings of loneliness, discomfort, and detachment.[18,21] Communication in virtual environments tends to be informal and spontaneous and not all necessary stakeholders are always included.[21] The combination of both isolation and miscommunication makes for a damaging

combination in the virtual environment for MLS education and professionals. Distress is the outcome of such an environment and individuals are not successful.[22] Instead use PS to mitigate distress, especially during times of uncertainty.[17] Creating PS in a virtual environment may ease the challenges of communication and emotions.

Conclusion

Creating PS in a medical laboratory provides more benefits than adverse outcomes. When all roles in a medical laboratory commit to creating PS, the entire team will perform better. A few simple changes to a virtual environment will increase engagement and participation. To study these outcomes more accurately in MLS professionals and learners, PS must first be created. More research is also needed to determine if felt accountability is an asset or a barrier of PS. Suggested next steps are for MLS professionals, educators, and learners to evaluate PS in the environment whether virtual or in-person. Then implement strategies to create PS. Once strategies have been implemented, take a pulse on the environment and be open to feedback on the strategies.

A misconception is PS makes learning more engaging by being enjoyable.[23] PS is not about creating a comfort or complaining zone.[17] MLS professionals, educators, and learners can work through the discomfort in open and encouraging communication. Medical laboratory professionals can create positive work and learning environments using simple PS strategies.

References

1. Edmondson AC. The fearless organization: Creating psychological safety in the workplace for learning, innovation, and growth. John Wiley & Sons; 2018 Nov 20.
2. Torralba KD, Jose D, Byrne J. Psychological safety, the hidden curriculum, and ambiguity in medicine [Internet]. Clinical rheumatology. 2020 Mar [cited 2023 Jan 17];39(3):667-71. Available from: https://link.springer.com/article/10.1007/s10067-019-04889-4.
3. Daniels AL, Morse C, Breman R. Psychological safety in simulation-based prelicensure nursing education: a narrative review [Internet]. Nurse Educ. 2021 [cited 2023 Aug 25];46(5):E99-E102. doi:10.1097/NNE.0000000000001057. Available from: https://journals.lww.com/nurseeducatoronline/Fulltext/2021/09000/Psychological_Safety_in_Simulation_Based.32.aspx?casa_token=ICCVifxlXH4AAAAA:apDRsoRMsLCjY9yQSTMxHRAlYeGCSXfiP9vn7M1M-xwASiqygju3S_WayG5BxhiqlgX3mY2cItmyPP4Xl9K34RE0Ng.
4. Ma Y, Faraz NA, Ahmed F, et al. Curbing nurses' burnout during COVID-19: The roles of servant leadership and psychological safety [Internet]. J Nurs Manag. 2021 [cited 2023 Aug 25];29:2383-2391. Available from: https://doi.org/10.1111/jonm.13414.
5. Newman A, Donohue R, Eva N. Psychological safety: A systematic review of the literature [Internet]. Human resource management review. 2017 Sep 1 [cited 2022 Oct 8];27(3):521-35. Available from: https://www.sciencedirect.com/science/article/pii/S1053482217300013.
6. Johnson CE, Keating JL, Molloy EK. Psychological safety in feedback: What does it look like and how can educators work with learners to foster it? [Internet]. Med Educ. 2020 [cited 2023 Sept 3];54:559-570. Available from: https://doi.org/10.1111/medu.14154.
7. Chou E, Grawey T, Paige JB. Psychological Safety as an Educational Value in Interprofessional Health Education [Internet]. AMA J Ethics. 2023 May 1 [cited 2023 Aug 26];25(5):E338-343. doi: 10.1001/amajethics.2023.338. PMID: 37132619. Available from: https://journalofethics.ama-assn.org/article/psychological-safety-educational-value-interprofessional-health-education/2023-05.
8. Inoue A, Eguchi H, Kachi Y, Tsutsumi A. Perceived psychosocial safety climate,

psychological distress, and work engagement in Japanese employees: A cross-sectional mediation analysis of job demands and job resources [Internet]. J Occup Health. 2023 [cited 2023 Aug 26];65:e12405. doi:10.1002/1348-9585.12405. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/1348-9585.12405.
9. Pfeifer LE, Vessey JA. Psychological safety on the healthcare team [Internet]. Nursing Management. 2019 Aug 1 [cited 2022 Oct 22];50(8):32-8. Available from: https://journals.lww.com/nursingmanagement/FullText/2019/08000/Psychological_safety_on_the_healthcare_team.7.aspx?casa_token=xJrreDIB6RkAAAAA:PwRTWs2bNBW9tqp0hX8wDbXF192nLpsERlSSKlffSZrPm7bE39LOY9nf1VN3ucqT6I_JUrK8Thx37bT8JAc45zYeIA.
10. Howard K. How to Heal a Workplace: Tackle Trauma, Foster Psychological Safety and Boost Happiness at Work. 1st ed. Australia: John Wiley & Sons; 2023 Feb 17.
11. Turner S, Harder N, Martin D, Gillman L. Psychological safety in simulation: Perspectives of nursing students and faculty [Internet]. Nurse Educ Today. 2023 Mar [cited 2023 Sep 4];122:105712. doi: 10.1016/j.nedt.2023.105712. Epub 2023 Jan 13. PMID: 36669303. Available from: https://www.sciencedirect.com/science/article/pii/S0260691723000060.
12. Obrenovic B, Jianguo D, Khudaykulov A, Khan MA. Work-family conflict impact on psychological safety and psychological well-being: A job performance model [Internet]. Frontiers in psychology. 2020 Mar 31 [cited 2023 Aug 25];11:475. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.00475/full.
13. Goldsworthy S, Verkuyl M. Facilitated virtual synchronous debriefing: A practical approach. Clinical Simulation in Nursing [Internet]. 2021 Oct 1 [cited 2023 Aug 26];59:81-4. Available from: https://doi.org/10.1016/j.ecns.2021.06.002.
14. Dokal K, Rampes S, Mukhammadaminov A, Divecha YA, Yousefi S. Reducing the perceived power gap: A practical way to achieve psychological safety in undergraduate education [Internet]. Med. Educ. 2020 Oct 1 [cited 2023 Sept 3];54:963. Available from: https://www.researchgate.net /profile/Sanketh-Rampes-2/publication/341250081_Reducing_the_perceived_power_gap_A_practical_way_to_achieve_psychological_safety_in_undergraduate_education/links/5ed9fc10299bf1c67d41b074/Reducing-the-perceived-power-gap-A-practical-way-to-achieve-psychological-safety-in-undergraduate-education.pdf.
15. O'Donovan R, McAuliffe E. A systematic review exploring the content and outcomes of interventions to improve psychological safety, speaking up and voice behaviour [Internet]. BMC health services research. 2020 Dec [cited 2023 Oct 21];20(1):1-1. Available from: https://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-020-4931-2.
16. Griffith GJ, Jones K. Understanding the population structure of the GHQ-12: Methodological considerations in dimensionally complex measurement outcomes [Internet]. Social Science & Medicine. 2019 Dec 1 [cited 2023 Oct 21];243:112638. Available from: https://www.sciencedirect.com/science/article/pii/S0277953619306331?casa_token=ImmuTz86OFIAAAAA:lp4VwfImH65uW0-ba9RWmaRCWQXb78TSNAMb3sBFtpSdmpwJlpZGYYD7-uwuO4VxSvMfNaJDENv6.
17. Higgins MC, Dobrow SR, Weiner JM, Liu H. When is psychological safety helpful in organizations? A longitudinal study [Internet]. Academy of Management Discoveries. 2022 Mar [cited 2023 Sept 1];8(1):77-102. Available from: https://journals.aom.org/doi/abs/10.5465/amd.2018.0242
18. Korneeva E, Strielkowski W, Krayneva R, Sherstobitova A. Social Health and Psychological Safety of Students Involved in Online Education during the COVID-19 Pandemic [Internet]. International Journal of Environmental Research and Public Health. 2022 Oct 26 [cited 2023 Aug 26];19(21):13928.

Available from: https://doi.org/10.3390/ijerph192113928.
19. Sjöblom K, Juutinen S, Mäkikangas A. The importance of self-leadership strategies and psychological safety for well-being in the context of enforced remote work [Internet]. Challenges. 2022 Apr 4 [cited 2023 Sept 3];13(1):14. Available from: https://www.mdpi.com/2078-1547/13/1/14.
20. Schillemans T, Overman S, Fawcett P, Flinders M, Fredriksson M, Laegreid P, et al. Understanding Felt Accountability: The institutional antecedents of the felt accountability of agency-CEO's to central government [Internet]. Governance. 2021 Jul [cited 2023 Oct 21] ;34(3):893-916. Available from: https://onlinelibrary.wiley.com/doi/full/ 10.1111/gove.12547.
21. Lechner A, Tobias Mortlock JM. How to create psychological safety in virtual teams [Internet]. Organizational dynamics. 2022 Apr 1 [cited 2023 Aug 31];51(2). Available from: https://openaccess.city.ac.uk/id/eprint/25878/1/.
22. Henricksen JW, Altenburg C, Reeder RW. Operationalizing healthcare simulation psychological safety: a descriptive analysis of an intervention [Internet]. Simulation in healthcare. 2017 Oct 1 [cited 2023 Oct 21] ;12(5):289-97. Available from: https://journals.lww.com/simulationinhealthcare/FullText/2017/10000/Operationalizing_Healthcare_Simulation.3.aspx?casa_token=JnVfqdXUN48AAAAA:pgSTqnztkBtzm-eMTHddTQnBeoyspOQsDi4VeWb3KYLqlpLzXuHGCwq_5NVpWrQlVUmESxEcX5sJ_UnrpCY7HxESCg.
23. Pottle J. Virtual reality and the transformation of medical education [Internet]. Future healthcare journal. 2019 Oct [cited 2023 Oct 21];6(3):181. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6798020/.

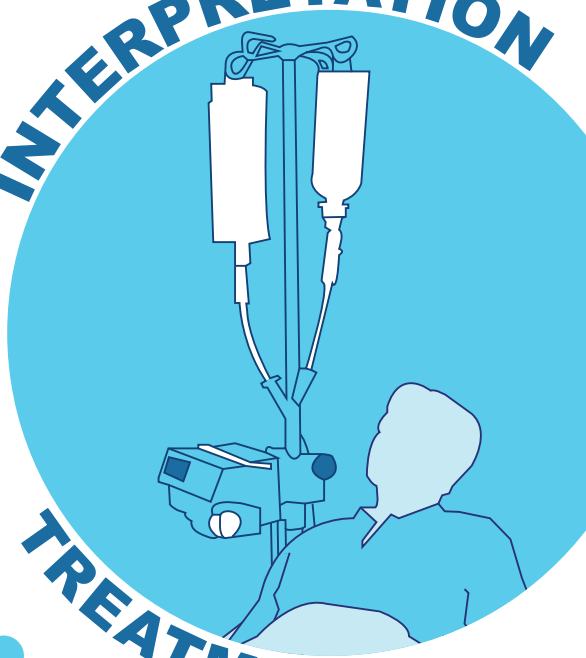
PATIENT

METHOD

RESULT

QUALITY ASSURANCE

INTERPRETATION



TREATMENT

GUARDIANS OF QUALITY AND PATIENT SAFETY: BIOMEDICAL LABORATORY SCIENTISTS

INTERNATIONAL BIOMEDICAL LABORATORY SCIENCE DAY - APRIL 15TH 2024

IFBLS

International Federation of Biomedical Laboratory Science

IFBLS.org