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# Exploring the Role of Immunohistochemistry as a Complementary Diagnostic Tool in Burundi

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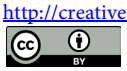



## Abstract

This study investigates the variability in cancer diagnosis across different tissues and organs, with a focus on the role of diagnostic methods such as Hematoxylin and Eosin (H&E) staining and immunohistochemistry (IHC). The predominance of female breast cancer (30%) aligns with global trends, underscoring the need for robust diagnostic protocols, particularly in developing regions. Other prevalent cancers, including skin, stomach, and cervix uteri, reflect a mix of environmental, genetic, and infectious factors. The underrepresentation of gallbladder and thyroid cancers (<1%) suggests potential underdiagnosis or lower prevalence. Age distribution data indicate peak cancer incidence in individuals aged 31 - 45 years, with gender-specific cancers like breast and cervical cancer predominantly affecting females (63.4%). The analysis also highlights significant diagnostic gaps, as 61.2% of cases did not undergo IHC testing due to resource constraints, leading to potential biases in cancer prevalence and diagnostic accuracy. The study emphasizes the complementary role of IHC in confirming ambiguous H&E findings, with strong alignment observed when both methods were used. However, the absence of IHC in many cases limits the robustness of conclusions, suggesting the need for increased access to IHC testing. The findings advocate for integrating IHC into routine diagnostics, expanding diagnostic capabilities, and improving sample sizes to ensure more reliable and comprehensive cancer data.

## Keywords

Cancer Diagnosis, Hematoxylin and Eosin (H&E) Staining, Immunohistochemistry (IHC), Diagnostic Protocols, Diagnostic Gaps, Routine Diagnostics, Cancer Prevalence

## 1. Introduction

In Burundi, there are significant challenges in cancer diagnosis despite the growing incidence of the disease. The only method used in the sole public laboratory is Hematoxylin and Eosin (H&E) staining. Immunohistochemistry (IHC) is a key supplementary procedure for pathologists that allows visualization of the distribution and number of certain molecules in tissue through specific antigen-antibody reactions [1].

IHC excels compared to other laboratory methods due to its ability to be performed without ruining the histologic architecture [1].

There are only two anatomic pathology laboratories in Burundi for a population of over 12 million: one public laboratory at Centre Hospitalo-Universitaire de Kamenge (CHUK) and one private laboratory at Bujumbura Pathology Centre (BUJAPATH) in the Kinindo quarter. The standard diagnostic method in these laboratories is H&E staining, with BUJAPATH occasionally performing IHC tests abroad due to limited local demand, despite recommendations from pathologists and oncologists.

H&E staining remains an invaluable tool in histopathology for routine diagnosis, tumor classification, and prognostic assessment. However, it does not provide detailed molecular information, complete cellular structure detection, or tumor type differentiation. The value of IHC for biomarker identification, morphologically similar tumor differentiation, and tumor subtyping and grading is undeniable [1].

The burden of cancer in Burundi continues to grow. Experts opine that addressing the challenges of late diagnosis, a poor understanding of the disease, and inadequate health infrastructure, including human resources, should be a key focus for the government [2] [3].

The diagnosis of cancer is a major problem in Burundi due to the lack of qualified workforce: pathologists, technologists, and equipment [2].

This study aims to evaluate the accuracy of the currently used H&E test and demonstrate the significance of using IHC as a complementary test for cancer diagnosis and prognosis. Specifically, we will assess its sensitivity and specificity in diagnosing cancers to provide an evidence-based recommendation for integrating this test into the cancer diagnosis protocol in Burundi.

By leveraging the strengths of both techniques, we aim to improve the accuracy and effectiveness of cancer diagnosis in Burundi, ultimately enhancing patient outcomes and optimizing healthcare delivery in the region.

## 2. Literature Review

Immunohistochemistry (IHC) is a crucial technique used to determine the localization of proteins within a cell or tissue sample using antibodies as probes [1]. This method has been in practice since the 1940s and remains a vital tool for pathologists and research scientists [1].

Despite its seemingly straightforward nature, IHC involves multiple steps

where issues can arise, potentially leading to false positive or negative results [1].

In recent years, the use of IHC has expanded significantly, particularly in the diagnosis and research of various cancers [4]. Medical practitioners traditionally used Haematoxylin and Eosin (H&E) stained slides for cancer diagnosis, but now IHC stained slides are often requested to confirm diagnoses and determine tumor subtypes when H&E slides are insufficient [4].

IHC has revolutionized diagnostic histopathology by enabling more accurate and precise diagnoses, theranostics, and prognostics in tumor management [4].

Despite its widespread use, IHC faces challenges related to standardization, which can result in intra- and interlaboratory variations [3]. Factors such as sample fixation, antibody selection (monoclonal or polyclonal), detection systems, use of controls, and blocking of endogenous proteins and enzymes all contribute to the complexity of the IHC process [3].

IHC is not only essential for routine diagnostic work but also for basic and clinical research, including the exploration of biomarkers. It allows for the confirmation of target molecule expressions within the context of the tissue microenvironment [5].

The technique's importance is underscored by its role in understanding the distribution and localization of biomarkers and differentially expressed proteins across various tissues [1].

In Burundi, the implementation and utilization of IHC face significant challenges due to limited resources and infrastructure. The lack of access to essential laboratory equipment and reagents hampers the ability to perform IHC effectively, which is crucial for accurate cancer diagnosis and research.

Additionally, there is a need for trained personnel who are proficient in IHC techniques to ensure reliable results. Establishing IHC practices in Burundi is essential to improve diagnostic accuracy and patient outcomes, particularly for cancer and other diseases requiring precise molecular diagnostics. Collaborative efforts and investments in healthcare infrastructure are necessary to make IHC more accessible and standardized in Burundi, thereby enhancing the overall quality of pathology services in the country.

Overall, IHC has become an indispensable component of histopathology. Continuous advancements in automation and standardization are necessary to optimize and accurately interpret IHC results. As the technique evolves, it remains a powerful tool for pathologists, enabling precise and comprehensive diagnostic capabilities [4] [6].

Efforts to establish and improve IHC practices in resource-constrained settings like Burundi are crucial to ensuring global diagnostic equity and enhancing the clinical utility of this vital technique [3] [7].

## 3. Research Hypothesis

The research hypothesis for the stated objectives could be:

Hypothesis: Immunohistochemistry (IHC) is a valuable complementary dia-

gnostic tool for cancer diagnosis and prognosis in Burundi, offering enhanced sensitivity, specificity, and predictive value compared to the standard Hematoxylin and Eosin (H&E) staining technique.

To break it down according to the specific objectives:

1) H&E staining is reliably accurate for cancer diagnosis at Bujumbura Pathology Centre.

2) IHC assays demonstrate higher sensitivity, specificity, and predictive value compared to H&E staining.

3) IHC provides additional molecular and morphological information for cancer diagnosis and prognosis, significantly enhancing the accuracy and precision of diagnostic assessments compared to H&E staining alone.

4) Integration of IHC into the cancer diagnosis protocol in Burundi is recommended, with guidelines proposed for optimizing test utilization, providing appropriate workforce training, and improving infrastructure to support IHC implementation effectively.

### 3.1. General Objective

To evaluate the effectiveness of Immunohistochemistry (IHC) as a complementary diagnostic tool for cancer diagnosis and prognosis in Burundi and provide evidence-based recommendations for its integration into the existing cancer diagnosis protocol.

### 3.2. Specific Objectives

1) Evaluate the accuracy and reliability of the standard Hematoxylin and Eosin (H&E) staining technique used for cancer diagnosis at Bujumbura Pathology Centre.

2) To assess the sensitivity, specificity, and predictive value of IHC assays compared to standard diagnostic methods of Haematoxylin and Eosin Staining.

3) Determine the significance of Immunohistochemistry (IHC) in providing additional molecular and morphological information for cancer diagnosis and prognosis compared to H&E staining alone.

4) Provide evidence-based recommendations for integrating Immunohistochemistry (IHC) into the cancer diagnosis protocol in Burundi, including guidelines for test utilization, workforce training, and infrastructure development.

## 4. Research Methodology

**Study design:** This study utilized a comparative cross-sectional design to evaluate the accuracy and significance of Immunohistochemistry (IHC) as a complementary diagnostic tool for cancer diagnosis and prognosis in Burundi.

**Sampling Strategies:** A purposive sampling approach was employed to select patients diagnosed with cancer at Bujumbura Pathology Centre (BUJAPATH). 1212 cases were selected based on availability of both Hematoxylin and Eosin (H&E) stained slides and Immunohistochemistry (IHC) stained slides.

**Data Collection:** Relevant clinical and pathological data was extracted from patient medical records, including demographic information, tumor characteristics, histopathological findings, and diagnostic methods employed.

H&E stained slides and IHC stained slides were reviewed by experienced pathologists blinded to the clinical information, and diagnostic interpretations were recorded.

**Data Analysis:** The study population were summarized demographically and clinically based on descriptive statistics.

The sensitivity, specificity, positive predictive value, and negative predictive value of Immunohistochemistry (IHC) compared to Hematoxylin and Eosin (H&E) staining were calculated.

Comparative analysis was conducted to assess the diagnostic capabilities of H&E staining versus IHC in identifying specific biomarkers, differentiating tumor types, and grading tumor differentiation.

***Ethical Consideration***: *This study adhered to ethical guidelines for human research, including obtaining informed consent from patients and ensuring confidentiality of patient data.*

**Limitations:** Limitations of the study may include potential selection bias due to the purposive sampling approach and the retrospective nature of data collection.

## 5. Results

### Descriptive Analysis

This bar chart highlights the most frequently affected tissues or organs in this study. The **female breast** stands out with the highest percentage, close to 30%, followed by **skin** as the second most affected tissue, accounting for approximately 22% of the cases. **Stomach** ranks third, contributing over 10% of the total cases.

The study also identifies moderately affected tissues or organs, such as the **cervix uteri** (8%), **colorectum** (7%), and **lymphoma** (6%). Lastly, the least frequently affected tissues or organs include the **gallbladder**, **multiple myeloma**, and **thyroid**, all accounting for under 1% of the cases.

Other tissues, such as the **kidney**, **nasopharynx**, and **brain/central nervous system**, also exhibit low representation, indicating their infrequent involvement in the study.

In this study, the largest age group is 31 - 45 years, accounting for 29.2% of the total population. The second-largest group is 46 - 60 years, representing 28.3% of the population. Individuals over 60 years comprise 25.8% of the total population, while the smallest group is those under 14 years, making up only 5.3%.

In this study, the cumulative percentages confirm that all participants (100%) are accounted for. Among the total of 1176 individuals, female patients are the majority, representing 63.4% of the population (746 individuals), while male patients account for 36.6% (430 individuals).

In this study, the majority of the samples tested positive using the H&E staining method, with a frequency exceeding 900. This confirms that positive results

constitute the largest category. In contrast, negative results are less frequent, with a count below 300, indicating a smaller proportion of the total.

The mean value of 1.23 suggests that the data is heavily skewed toward positive results. The standard deviation of 0.419 indicates some variation in the results, although it is relatively small given the binary nature of the categories. The total sample size (N) is 1176, consistent with previous data.

The "Not Done" results constitute the majority of tests, accounting for 61.2%, representing the largest proportion of the total. The "Positive" results make up a smaller portion, with 30.9% of the tests yielding positive outcomes. The "Negative" results form the smallest group, with only 7.9% of tests showing negative results. In total, the cumulative percentages confirm that 100% of the results are accounted for, with the majority of samples not undergoing immunohistochemistry testing, while the positive and negative results make up a smaller share of the total.

The Chi-Square tests analyzed the statistical significance of test result distributions across various tissues. Tissues such as **Female Breast, Skin, Cervix Uteri, and Colorectum** show highly significant results ($p < 0.05$), indicating meaningful differences in test result distributions. For example, in the case of **Female Breast**, both the Pearson Chi-Square and Likelihood Ratio tests are significant ($p = 0.000$), providing strong evidence of variability in test outcomes.

In contrast, tissues such as **Prostate, Stomach, and Bladder** do not show significant differences ($p > 0.05$), meaning the test result distributions for these tissues are not meaningfully different. These findings, however, may be influenced by limited sample sizes. For instance, **Prostate** has a Pearson Chi-Square p-value of 0.151, which is above the threshold for significance.

Lastly, some tissues, such as **Oesophagus, Kidney, and Gallbladder**, had too few valid cases or constant data, making statistical analysis either impossible or unreliable. This underscores the need for larger sample sizes to enable meaningful analysis in these cases.

The scale's results indicate a moderate level of variability in participant responses (as shown by the variance and standard deviation), with an overall average score of 6.81. However, the reliability of the scale is questionable due to the negative Cronbach's Alpha, suggesting that the three items do not measure a cohesive underlying construct. As a result, the scale may not provide valid or reliable insights into the intended concept, and caution should be exercised when interpreting these findings.

The crosstabulation shows a clear association between the **Results of Immunohistochemistry (IHC)** and the **Results of Haematoxylin and Eosin (H&E) Staining**. Positive results in one test are more likely to correspond to positive results in the other, indicating that these two diagnostic methods often align in their outcomes.

**1) Positive Results:**

- A high percentage (**38.9%**) of positive H&E cases also show positive IHC results, suggesting that IHC can reliably support positive findings from H&E staining.

**2) Negative Results:**

- Negative IHC results are more common in cases with negative H&E staining (**24.4%**) compared to positive H&E staining (**3.1%**). This indicates that negative results from both tests often coincide but also highlights some discrepancies.

**3) Absence of IHC Testing:**

- The majority of cases (**61.2%**) had no IHC performed. This large proportion suggests a need for expanded IHC testing to improve diagnostic coverage and reliability.

**4) Diagnostic Consistency:**

- The results confirm that H&E staining and IHC are generally consistent, making them valuable complementary diagnostic tools. However, the absence of IHC in many cases could limit the ability to confirm or refine diagnoses based solely on H&E results.

While there is a strong alignment between the two diagnostic methods, the reliance on H&E without IHC in a significant number of cases raises concerns about the completeness of diagnostic evaluations. Addressing this testing gap could enhance the accuracy and reliability of diagnoses.

## 6. Discussion

The analysis reveals significant variation in the frequency of affected tissues or organs. The predominance of the female breast (30%) aligns with global cancer incidence trends, which highlight breast cancer as a leading concern, particularly in developing regions [8]. The skin, stomach, and cervix uteri follow, representing a mix of cancers associated with environmental, genetic, and infectious factors [9].

The low representation of tissues like the gallbladder and thyroid (<1%) may indicate either low prevalence or under diagnosis in the study population. These disparities suggest a need for targeted public health interventions and diagnostic advancements (See **Figure 1**).

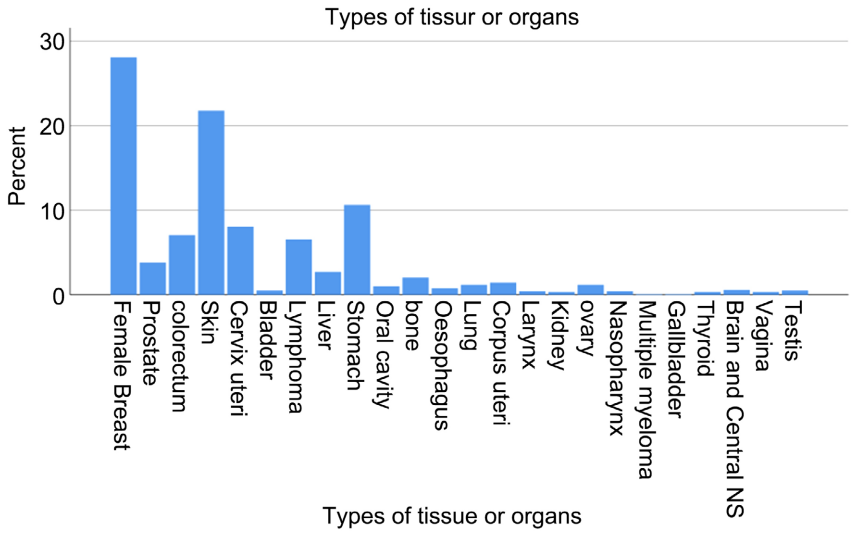


**Figure 1.** Breakdown of patients by type of tissue and organ.

The age distribution indicates a peak incidence of affected individuals between 31 - 45 years (29.2%), followed by 46 - 60 years (28.3%). This trend reflects the typical age-related cancer incidence patterns, where reproductive and occupational factors contribute to increased cancer risk [10]. The low frequency in individuals under 14 (5.3%) suggests limited pediatric cancer cases, which aligns with global patterns but warrants further pediatric-specific research (See **Table 1**).

**Table 1.** Frequency distribution of age groups.

| Age group | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Under 14 | 62 | 5.3 | 5.3 | 5.3 |
| | 15 - 30 | 135 | 11.5 | 11.5 | 16.8 |
| | 31 - 45 | 343 | 29.2 | 29.2 | 45.9 |
| | 46 - 60 | 333 | 28.3 | 28.3 | 74.2 |
| | Over 60 | 303 | 25.8 | 25.8 | 100.0 |
| | Total | 1176 | 100.0 | 100.0 | |

The study population is predominantly female (63.4%), which could reflect gender-specific cancers like breast and cervical cancer. The male representation (36.6%) highlights potential underreporting or gender disparities in healthcare access. Gender-focused health strategies are essential to bridge these gaps and improve outcomes for male patients (See **Table 2**).

**Table 2.** Patient gender distribution.

| Patient gender | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Male | 430 | 36.6 | 36.6 | 36.6 |
| | Female | 746 | 63.4 | 63.4 | 100.0 |
| | Total | 1176 | 100.0 | 100.0 | |

The predominance of positive H&E results (>900 cases) reinforces its role as a reliable diagnostic method. The skewed mean (1.23) and low standard deviation (0.419) suggest consistent findings, but the high proportion of positive cases raises concerns about the potential over-reliance on this method without corroborative testing. Expanding confirmatory methods like immunohistochemistry could address this limitation [11] (See **Figure 2**).

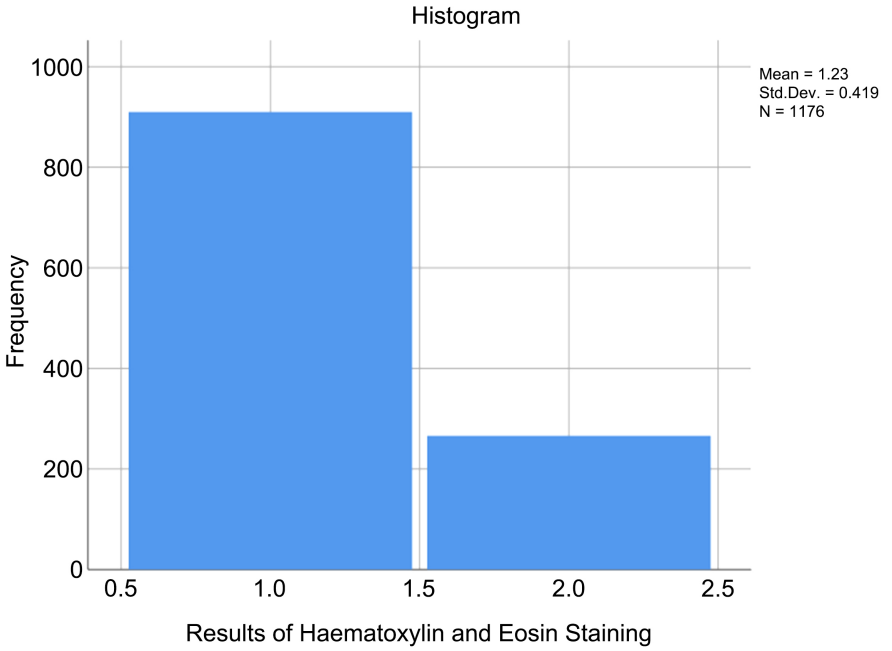


**Figure 2.** Frequency distribution of results from Haematoxylin and Eosin (H&E).

The high percentage of "Not Done" cases (61.2%) underscores a significant diagnostic gap. Despite this, the positive alignment with H&E results (30.9%) validates its complementary role. Increasing the use of immunohistochemistry is critical for refining diagnostic accuracy and reducing false positives or negatives in complex cases [11] (See **Table 3**).

**Table 3.** Frequency distribution of the Results of Immunohistochemistry.

| Results of Immunohistochemistry | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Not Done | 720 | 61.2 | 61.2 | 61.2 |
| | Positive | 363 | 30.9 | 30.9 | 92.1 |
| | Negative | 93 | 7.9 | 7.9 | 100.0 |
| | Total | 1176 | 100.0 | 100.0 | |

The chi-square tests highlight significant variability in diagnostic outcomes across tissues, with p-values $< 0.05$ for key tissues like the female breast, cervix uteri, and colorectum. These findings emphasize the heterogeneous nature of cancer presentation and the importance of tailored diagnostic and treatment approaches [12] (See **Table 4**).

**Table 4.** Chi square test.

| Chi-Square Tests | | | | | | |
|---|---|---|---|---|---|---|
| Types of tissue or organs | | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
| Female Breast | Pearson Chi-Square | 53.604[b] | 2 | 0.000 | | |
| | Likelihood Ratio | 35.241 | 2 | 0.000 | | |
| | Linear-by-Linear Association | 0.538 | 1 | 0.463 | | |
| | N of Valid Cases | 330 | | | | |
| Prostate | Pearson Chi-Square | 3.780[c] | 2 | 0.151 | | |
| | Likelihood Ratio | 4.042 | 2 | 0.133 | | |
| | Linear-by-Linear Association | 1.260 | 1 | 0.262 | | |
| | N of Valid Cases | 45 | | | | |
| Colorectum | Pearson Chi-Square | 6.584[d] | 2 | 0.037 | | |
| | Likelihood Ratio | 9.914 | 2 | 0.007 | | |
| | Linear-by-Linear Association | 0.160 | 1 | 0.689 | | |
| | N of Valid Cases | 83 | | | | |
| Skin | Pearson Chi-Square | 41.799[e] | 2 | 0.000 | | |
| | Likelihood Ratio | 46.917 | 2 | 0.000 | | |
| | Linear-by-Linear Association | 0.533 | 1 | 0.465 | | |
| | N of Valid Cases | 256 | | | | |
| Cervix uteri | Pearson Chi-Square | 95.000[f] | 2 | 0.000 | | |
| | Likelihood Ratio | 26.636 | 2 | 0.000 | | |
| | Linear-by-Linear Association | 0.467 | 1 | 0.494 | | |
| | N of Valid Cases | 95 | | | | |
| Bladder | Pearson Chi-Square | 0.600[g] | 2 | 0.741 | | |
| | Likelihood Ratio | 0.908 | 2 | 0.635 | | |
| | Linear-by-Linear Association | 0.429 | 1 | 0.513 | | |
| | N of Valid Cases | 6 | | | | |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Lymphoma | Pearson Chi-Square | .[h] | | | | |
| | N of Valid Cases | 77 | | | | |
| Liver | Pearson Chi-Square | 7.176[i] | 2 | 0.028 | | |
| | Likelihood Ratio | 4.054 | 2 | 0.132 | | |
| | Linear-by-Linear Association | 2.246 | 1 | 0.134 | | |
| | N of Valid Cases | 32 | | | | |
| Stomach | Pearson Chi-Square | 0.727[j] | 2 | 0.695 | | |
| | Likelihood Ratio | 0.614 | 2 | 0.735 | | |
| | Linear-by-Linear Association | 0.721 | 1 | 0.396 | | |
| | N of Valid Cases | 125 | | | | |
| Oral cavity | Pearson Chi-Square | 0.429[k] | 2 | 0.807 | | |
| | Likelihood Ratio | 0.573 | 2 | 0.751 | | |
| | Linear-by-Linear Association | 0.000 | 1 | 1.000 | | |
| | N of Valid Cases | 12 | | | | |
| Bone | Pearson Chi-Square | 1.043[l] | 1 | 0.307 | | |
| | Continuity Correction[m] | 0.000 | 1 | 1.000 | | |
| | Likelihood Ratio | 1.430 | 1 | 0.232 | | |
| | Fisher's Exact Test | | | | 1.000 | 0.500 |
| | Linear-by-Linear Association | 1.000 | 1 | 0.317 | | |
| | N of Valid Cases | 24 | | | | |
| Oesophagus | Pearson Chi-Square | .[n] | | | | |
| | N of Valid Cases | 9 | | | | |
| Lung | Pearson Chi-Square | 1.077[l] | 1 | 0.299 | | |
| | Continuity Correction[m] | 0.000 | 1 | 1.000 | | |
| | Likelihood Ratio | 1.463 | 1 | 0.226 | | |
| | Fisher's Exact Test | | | | 1.000 | 0.500 |
| | Linear-by-Linear Association | 1.000 | 1 | 0.317 | | |
| | N of Valid Cases | 14 | | | | |
| Corpus uteri | Pearson Chi-Square | 3.569[o] | 2 | 0.168 | | |
| | Likelihood Ratio | 3.238 | 2 | 0.198 | | |
| | Linear-by-Linear Association | 0.333 | 1 | 0.564 | | |
| | N of Valid Cases | 17 | | | | |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Larynx | Pearson Chi-Square | .[n] | | | | |
| | N of Valid Cases | 5 | | | | |
| Kidney | Pearson Chi-Square | .[h] | | | | |
| | N of Valid Cases | 4 | | | | |
| Ovary | Pearson Chi-Square | 2.240[p] | 1 | 0.134 | | |
| | Continuity Correction[m] | 0.709 | 1 | 0.400 | | |
| | Likelihood Ratio | 3.291 | 1 | 0.070 | | |
| | Fisher's Exact Test | | | | 0.251 | 0.210 |
| | Linear-by-Linear Association | 2.080 | 1 | 0.149 | | |
| | N of Valid Cases | 14 | | | | |
| Nasopharynx | Pearson Chi-Square | .[h] | | | | |
| | N of Valid Cases | 5 | | | | |
| Multiple myeloma | Pearson Chi-Square | .[q] | | | | |
| | N of Valid Cases | 1 | | | | |
| Gallbladder | Pearson Chi-Square | .[q] | | | | |
| | N of Valid Cases | 1 | | | | |
| Thyroid | Pearson Chi-Square | 4.000[r] | 2 | 0.135 | | |
| | Likelihood Ratio | 4.499 | 2 | 0.105 | | |
| | Linear-by-Linear Association | 2.273 | 1 | 0.132 | | |
| | N of Valid Cases | 4 | | | | |
| Brain and Central NS | Pearson Chi-Square | 0.467[s] | 1 | 0.495 | | |
| | Continuity Correction[m] | 0.000 | 1 | 1.000 | | |
| | Likelihood Ratio | 0.738 | 1 | 0.390 | | |
| | Fisher's Exact Test | | | | 1.000 | 0.714 |
| | Linear-by-Linear Association | 0.400 | 1 | 0.527 | | |
| | N of Valid Cases | 7 | | | | |
| Vagina | Pearson Chi-Square | .[h] | | | | |
| | N of Valid Cases | 4 | | | | |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Testis | Pearson Chi-Square | 0.600[t] | 1 | 0.439 | | |
| | Continuity Correction[m] | 0.000 | 1 | 1.000 | | |
| | Likelihood Ratio | 0.908 | 1 | 0.341 | | |
| | Fisher's Exact Test | | | | 1.000 | 0.667 |
| | Linear-by-Linear Association | 0.500 | 1 | 0.480 | | |
| | N of Valid Cases | 6 | | | | |
| Total | Pearson Chi-Square | 209.604[a] | 2 | 0.000 | | |
| | Likelihood Ratio | 224.263 | 2 | 0.000 | | |
| | Linear-by-Linear Association | 2.620 | 1 | 0.106 | | |
| | N of Valid Cases | 1176 | | | | |

[a]0 cells (0.0%) have expected count less than 5. The minimum expected count is 21.04; [b]1 cells (16.7%) have expected count less than 5. The minimum expected count is 0.93; [c]4 cells (66.7%) have expected count less than 5. The minimum expected count is 2.93. [d]2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.69; [e]0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.63; [f]4 cells (66.7%) have expected count less than 5. The minimum expected count is 0.09. [g]6 cells (100.0%) have expected count less than 5. The minimum expected count is 0.17; [h]No statistics are computed because Results of Haematoxylin and Eosin Staining is a constant; [i]4 cells (66.7%) have expected count less than 5. The minimum expected count is 0.13; [j]2 cells (33.3%) have expected count less than 5. The minimum expected count is 0.51; [k]5 cells (83.3%) have expected count less than 5. The minimum expected count is 0.17; [l]2 cells (50.0%) have expected count less than 5. The minimum expected count is 0.50. [m]Computed only for a 2 × 2 table; [n]No statistics are computed because Results of Immunohistochemistry is a constant; [o]5 cells (83.3%) have expected count less than 5. The minimum expected count is 0.24; [p]3 cells (75.0%) have expected count less than 5. The minimum expected count is 1.14; [q]No statistics are computed because Results of Haematoxylin and Eosin Staining and Results of Immunohistochemistry are constants; [r]6 cells (100.0%) have expected count less than 5. The minimum expected count is 0.25; [s]4 cells (100.0%) have expected count less than 5. The minimum expected count is 0.29; [t]4 cells (100.0%) have expected count less than 5. The minimum expected count is 0.33.

Tissues with non-significant results, such as the prostate and stomach, often had small sample sizes, limiting statistical power. Increasing sample sizes in future studies will improve the reliability of these findings.

The negative Cronbach's Alpha indicates poor internal consistency among the three items measured. This suggests the need to reassess the scale's design and ensure it measures a coherent construct. Reliable scales are essential for generating meaningful and actionable data in clinical studies [13] (See **Table 5**).

**Table 5.** Scale statistics.

| Scale Statistics | | | |
|---|---|---|---|
| Mean | Variance | Std. Deviation | N of Items |
| 6.8087 | 19.879 | 4.45860 | 3 |

The cross-tabulation between H&E and immunohistochemistry results highlights strong diagnostic alignment, with positive results in one method often

corresponding to the other. However, the absence of immunohistochemistry in 61.2% of cases limits the robustness of the diagnostic process. Implementing both methods systematically could enhance diagnostic precision, especially for complex or ambiguous cases [14] (See **Table 6**).

**Table 6.** Sensitivity and specificity test.

| Results of Immunohistochemistry * Results of Haematoxylin and Eosin Staining Crosstabulation | | | | | |
|---|---|---|---|---|---|
| | | | Results of Haematoxylin and Eosin Staining | | Total |
| | | | Positive | Negative | |
| Results of Immunohistochemistry | Not Done | Count | 528 | 192 | 720 |
| | | % within Results of Haematoxylin and Eosin Staining | 58.0% | 72.2% | 61.2% |
| | Positive | Count | 354 | 9 | 363 |
| | | % within Results of Haematoxylin and Eosin Staining | 38.9% | 3.4% | 30.9% |
| | Negative | Count | 28 | 65 | 93 |
| | | % within Results of Haematoxylin and Eosin Staining | 3.1% | 24.4% | 7.9% |
| Total | | Count | 910 | 266 | 1176 |
| | | % within Results of Haematoxylin and Eosin Staining | 100.0% | 100.0% | 100.0% |

## 7. Conclusions

This study provides critical insights into cancer diagnosis patterns, highlighting the pivotal role of immunohistochemistry (IHC) testing in enhancing diagnostic accuracy and addressing gaps in cancer care. The predominance of female breast cancer (30%) mirrors global trends, underscoring the urgency of establishing robust and accessible diagnostic protocols, particularly in resource-constrained settings. The notable frequency of cancers such as skin, stomach, and cervix uteri reflects the complex interplay of environmental, genetic, and infectious factors, while the underrepresentation of tissues like the gallbladder and thyroid may indicate underdiagnosis or a genuinely lower prevalence within the study population.

The study emphasizes the limitations of relying heavily on Hematoxylin and Eosin (H&E) staining, which, despite its utility, cannot reliably confirm ambiguous findings when used in isolation. The significant diagnostic gap caused by the absence of IHC testing in 61.2% of cases highlights resource constraints, including insufficient infrastructure, reagents, and trained personnel. This gap not only

undermines the ability to validate H&E results but also introduces potential biases, limiting the robustness of conclusions regarding cancer prevalence and diagnostic accuracy.

Where both H&E and IHC testing were performed, the strong alignment between the two methods reinforces the critical role of IHC as a complementary diagnostic tool. Addressing the resource-driven underutilization of IHC is essential to improving cancer diagnosis, particularly for complex or high-burden cases.

## 8. Recommendations

**Expand Access to IHC Testing:**

Invest in infrastructure, reagents, and training programs to enable consistent and widespread application of IHC testing.

**Integrate IHC into Routine Diagnostics:**

Develop and implement protocols to systematically incorporate IHC alongside H&E, ensuring more accurate diagnosis, especially in ambiguous or complex cases.

**Bridge Resource Gaps:**

Collaborate with policymakers and healthcare stakeholders to secure funding, foster partnerships, and prioritize the expansion of diagnostic capabilities in underserved areas.

**Prioritize High-Burden Cancers:**

Focus diagnostic efforts on prevalent cancers such as breast and cervical cancer, prioritizing IHC testing to enhance staging accuracy and guide treatment planning.

**Expand Geographic Coverage:**

Broaden the scope of future studies to include underserved regions, ensuring representative data and reducing bias due to under-sampling.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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