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Pathology foundation model for multi-stain virtual staining

Submission date
07/07/2026

Recruitment status
Recruiting

Registration date
08/07/2026

Overall study status
Ongoing

Last Edited
08/07/2026

Condition category
Cancer

[ ] Prospectively registered
[ ] Protocol
[ ] Statistical analysis plan
[ ] Results
[ ] Individual participant data
[X] Record updated in last year

Plain English summary of protocol

Background and study aims
Pathologists usually stain tissue slides with chemicals (such as H&E or special stains for proteins) to see cell details and make diagnoses. However, staining takes time, costs money, and each stain often requires a separate piece of tissue. This study aims to develop a computer-based method that uses artificial intelligence to create digital images from unstained tissue slides – images that look just like the real stained ones. Our goal is to generate several different stain types from a single unstained slide while keeping the original tissue structure and cell details intact. We hope this virtual staining approach can work as well as, or even better than, conventional staining.

Who can participate?
Patients aged 18 years and over who have been diagnosed with one of the following cancers: nasopharyngeal, liver, breast, or colorectal cancer. Participants must have well-preserved tissue samples available for analysis.

What does the study involve?
If you agree to take part, we will use your existing tissue samples (already collected as part of your routine care) to test our AI model. No extra biopsies or procedures are required. The study involves taking unstained sections from your samples, scanning them with a digital scanner, and then running our deep learning algorithm to produce virtual stained images. We will compare these virtual images with the actual stained slides from your samples to see how closely they match. We will also ask clinicians to score the image quality and measure the diagnostic accuracy against the gold standard (real staining). The whole process is done on computer images – your tissue samples are handled according to standard laboratory safety protocols.

What are the possible benefits and risks of participating?
There is no direct clinical benefit to you personally from taking part. However, your participation will help us develop a new technique that could, in the future, save time, reduce costs, and preserve precious tissue for additional tests, potentially leading to faster and more accurate diagnoses for patients.

Since we only use leftover tissue from your routine care and do not perform any extra medical procedures, the risk to you is minimal. Your personal health information will be kept confidential and anonymised. There is no physical risk from the computer analysis itself.

Where is the study run from?
First Affiliated Hospital of Jinan University (China)

When is the study starting and how long is it expected to run for?
March 2026 to December 2026

Who is funding the study?
This research is funded by the National Key Research and Development Program of China (2023YFF1204600). The funder has no role in the study design, data collection, or interpretation of results.

Who is the main contact?
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Study information

Scientific Title
Pathology foundation model guided unified framework for multi-stain virtual staining

Acronym
PFM-VS

Study objectives

This study maps an unstained formalinfixed paraffinembedded (FFPE) section to H&E and multiple immunohistochemical (IHC) or special stain appearances, while preserving the structural and pathological integrity of the tissue.

Ethics approval required
Ethics approval required

Ethics approval(s)
Approved 25/03/2026, Ethics Committee of Jinan University (No. 601, Huangpu Avenue West, Tianhe District, Guangzhou, 510627, China; +86 (0)85220250; oykyc@jnu.edu.can), ref: JNUECKY-20260325-006

Primary study design
Observational

Secondary study design
Cohort study

Study type(s)

Health condition(s) or problem(s) studied
Nasopharyngeal carcinoma, hepatocellular carcinoma, breast cancer, colorectal cancer, or other malignant tumors

Interventions
Existing virtual staining methods are typically formulated as independent imagetoimage translation tasks, in which a separate model is trained for each target stain. Although such approaches can perform specific conversions - for instance, generating H&E images from unstained sections, or producing a particular immunohistochemical stain from unstained ones - they inherently treat different staining tasks as isolated problems. This modelling strategy neglects the shared foundational pathological information that underlies both histological and immunohistochemical staining. In clinical histopathological diagnosis, H&E and multiple IHC stains represent different visualisations of the same tissue state, collectively reflecting pathological features such as tissue architecture, cellular composition, nuclear morphology, and the local microenvironment.

In this work, we formulate multistain virtual staining as a unified conditional generation problem and propose a pathologyfoundationmodelbased unified framework that generates multiple target stains from a single unstained tissue image within a single conditional generative model. The core design principle of our framework is to decouple stainagnostic shared pathological information from stainspecific visual appearances. The model first extracts a shared pathological representation from the unstained image, which captures tissue architecture, cell morphology, and spatial microenvironmental cues that are common to different stains. Then, the target stain condition modulates this shared representation, allowing the generative model to selectively produce the visual features and biological patterns characteristic of the desired stain. In this way, the model can learn a common pathological basis across diverse staining tasks while preserving the distinct appearance and expression profiles of each stain.

Intervention Type
Other

Primary outcome(s)
1. Diagnostic accuracy measured using receiver operator characteristic curve at a single timepoint

2. Image quality measured using clinician assessment at a single timepoint

3. Virtual staining consistency measured using structural similarity index measure (SSIM), peak signal to noise ratio (PSNR), learned perceptual image patch similarity (LPIPS) and Dice coefficient at a single timepoint

Key secondary outcome(s)

Completion date
31/12/2026

Eligibility

Key inclusion criteria
1. Age ≥ 18 years
2. Patients diagnosed with nasopharyngeal carcinoma, hepatocellular carcinoma, breast cancer, colorectal cancer, or other malignant tumors
3. Well-preserved formalinfixed paraffinembedded (FFPE) tissue samples

Healthy volunteers allowed
No

Age group
Mixed

Lower age limit
18 Years

Upper age limit
100 Years

Sex
All

Total final enrolment
400

Key exclusion criteria
1. Age <18 years
2. Not diagnosed with malignant tumors, or diagnosis is unclear
3. Insufficient FFPE tissue samples, or samples with poor quality that do not meet testing requirements
4. H&E and IHC staining are unsatisfactory (e.g., poor section quality, artifacts, or insufficient cellularity)

Date of first enrolment

26/03/2026

Date of final enrolment
30/09/2026

Locations

Countries of recruitment
China

Sponsor information

Organisation
First Affiliated Hospital of Jinan University

ROR
https://ror.org/05d5vvz89

Funder(s)

Funder type

Funder Name
National Key Research and Development Program of China

Alternative Name(s)
, National Basic Research Program of China (973 Program), Special Fund for the National Key Research and Development Plan, China National Key Research and Development Plan Project, National Key Research and Development of China, National Key Research and Development Program, National Key R&D Program of China, National Key R&D Programmes of China, China's National Key R&D Programmes, National Basic Research Program of China, 973 Program, National Program on Key Basic Research Project (973 Program), National Plan on Key Basic Research and Development, National Basic Research Program, NKRDPC, NKPs

Funding Body Type
Government organisation

Funding Body Subtype
National government

Location
China

Results and Publications

Individual participant data (IPD) sharing plan

IPD sharing plan summary
Not expected to be made available