elcc European Lung Cancer Congress 2023

Artificial intelligence in screening mammography

Prof. Andreas Charalambous
Cyprus University of Technology and
University of Turku (Finland)

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DECLARATION OF INTERESTS

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IASLC NAHP Committee - Member

What to (not) expect from this presentation…

-Challenges in medical decisions
-Opportunities opened up by artificial intelligence (AI) and machine learning (ML)
-The INCISIVE Project – Medical Imaging
-Critical Considerations
-Implementation Challenges

BACKGROUND

Challenges in medical decisions

Cancer offers a unique context for medical decisions, given not only due to its variegated forms with the evolution of the disease, but also regarding the need to consider the individual condition of patients, their ability to receive treatment, and their responses to Treatment – **Personalised Care**

Despite improved technologies, **challenges remain** in the accurate and early detection, tumor classification/characterization, the prediction of tumor evolution (either locally, recurrently, or metastatically), and the precise evaluation of treatment schemas and follow-up monitoring of cancer

The main advantages of **medical imaging techniques** include monitoring capability in real time, minimally invasive procedures, early detection (even for asymptomatic patients), accurate information on the tumor's precise location, as well as details on its size and morphology.

BACKGROUND

Opportunities opened up by artificial intelligence (AI) and machine learning (ML)

The increasing **volume and availability of collected data** (including cancer imaging) and the development of novel technological tools based on artificial intelligence (AI) and machine learning (ML) provide unprecedented opportunities for improved cancer detection and classification, tumor segmentation, image optimization, radiation reduction , and clinical workflow enhancement.

The current imaging methods may be enhanced by identifying findings, whether detectable or not by the human eye, moving from **a subjective perceptual skill to a more objective one**.

Although AI and machine learning techniques that can provide efficient cancer disease management pathways already exist, there is a **lack of publicly available AI-ready imaging data**, and there is **poor confidence in AI-based technology** among healthcare professionals for disease diagnosis, prediction, and follow-up

Project Profile

INCISIVE - https://incisive-project.eu/

A multimodal **AI-based toolbox** and an **interoperable health imaging repository** for the empowerment of imaging analysis related to the **diagnosis**, **prediction** and **follow-up** of **cancer.**

Duration: 42 months

From October 2020 to March 2024

Call: H2020-SC1-FA-DTS-2019

Topic: DT-TDS-05-2020 AI for Health Imaging

Funding: 9.995.727,50 €

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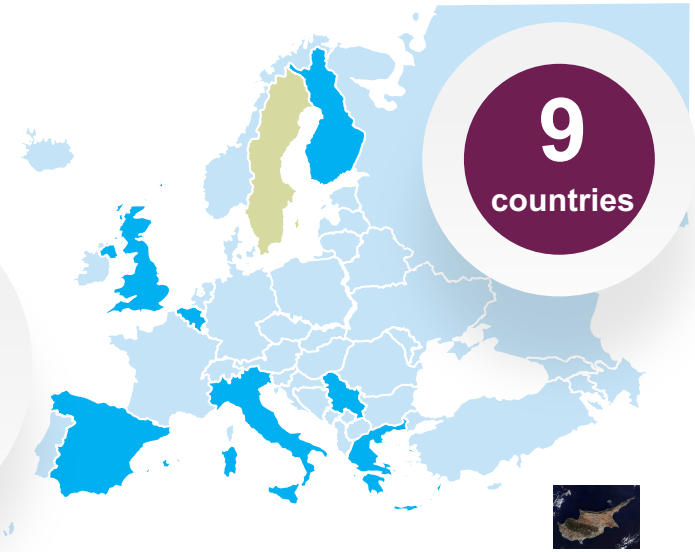
Consortium

INCISIVE

27
partners



- **9** Universities / Data providers
- **7** SMEs
- **6** Research / academic institutions
- **3** Large industries
- **2** Other

Areas of expertise

Consortium Partners

AI for health imaging & data analytics

Security

High Performance Computing

Complex ICT systems/integration

Areas of expertise

Consortium Partners

Cancer clinical research/practice & data sharing

German Oncology Center

Tor Vergata

IDIBAPS

ΕΛΛΗΝΙΚΗ ΑΝΤΙΚΑΡΚΙΝΙΚΗ ΕΤΑΙΡΕΙΑ
HELLENIC CANCER SOCIETY

VISARIS

Patient representation & evaluation

Cyprus University of Technology

PASYKAF

Kingston University London

Legal and ethical issues

TIMELEX

Innovation and business planning

WHITE RESEARCH

Medtronic
Further, Together

Main objectives

AI-based toolbox that enhances the accuracy, specificity, sensitivity, interpretability and cost-effectiveness of existing cancer imaging methods

Interoperable pan-European **federated repository** of medical images that enables secure donation and sharing of data in compliance with ethical, legal and privacy requirements

TARGETED IMPACT ON:

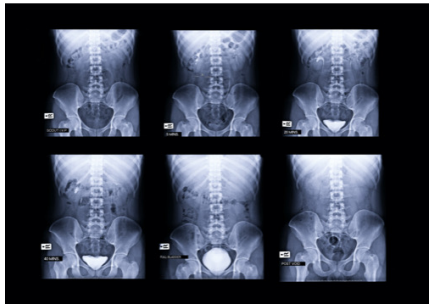
- Healthcare professionals involved in cancer care
- AI developers
  AI experts
- Researchers

Pilot studies

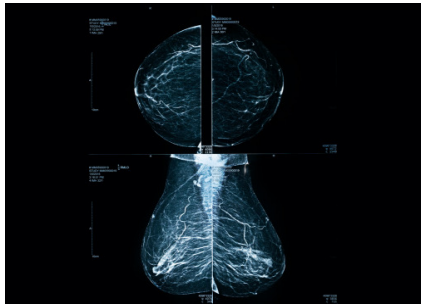
M25-M36 Observational Study

M36-M40 Interventional Study

LUNG CANCER (Cyprus, Greece, Italy)



PROSTATE CANCER (Cyprus, Greece, Spain)



BREAST CANCER (Cyprus, Greece, Italy, Serbia)

COLORECTAL CANCER (Cyprus, Greece, Italy)

2,000 patients will participate in 8 pilot studies in 5 countries for a period of 18-months.

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AI Toolbox

Overview of Breast Cancer AI Services – *Mammography*

From a pipeline perspective, the mammography is first passed through a **classifier** that determines whether the mammography is healthy or not.

If it is classified as **non-healthy**, a **second classifier** determines the type of abnormality (whether the mammography contains a lesion, calcifications, or both).

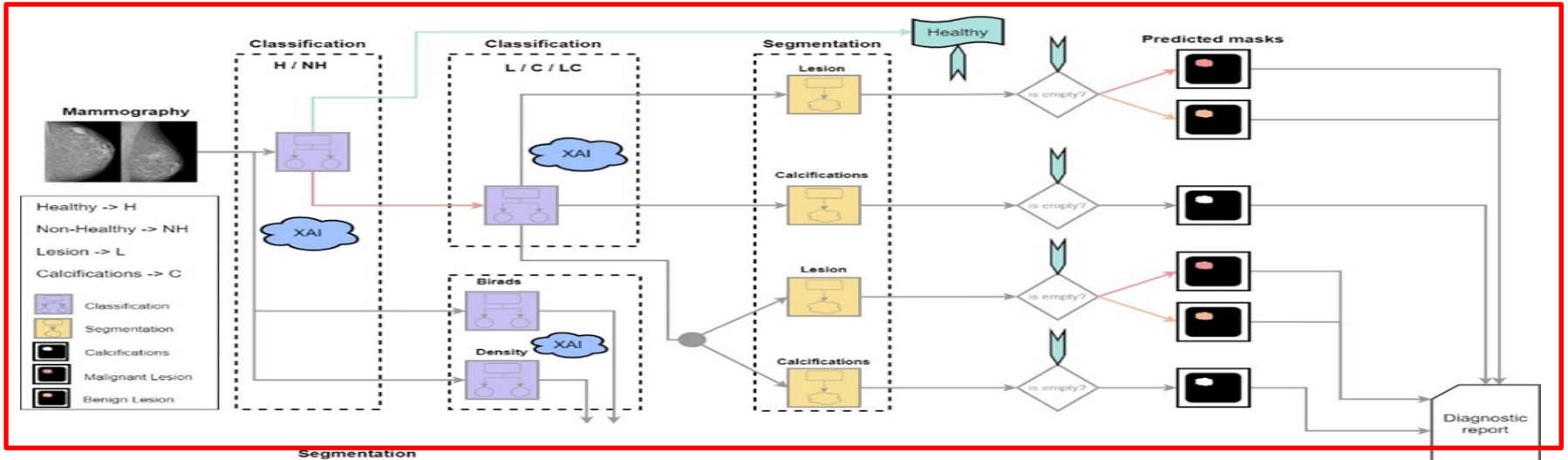
Depending on the outcome, different segmentation models look for the respective ROI and produce the output masks.

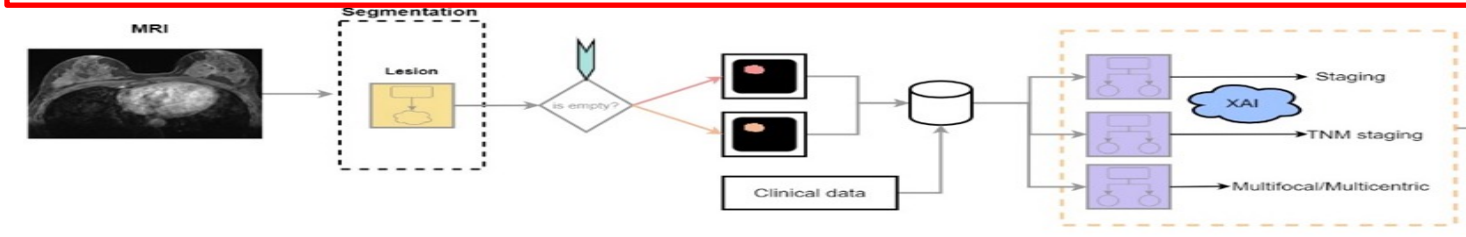
In addition to the classification/segmentation part of the pipeline, classification models determine the **BI-RADS score (Breast Imaging Reporting and Database System score)**, as well as the breast density, features that are of particular importance to the healthcare professionals to decide the **next treatment steps**.

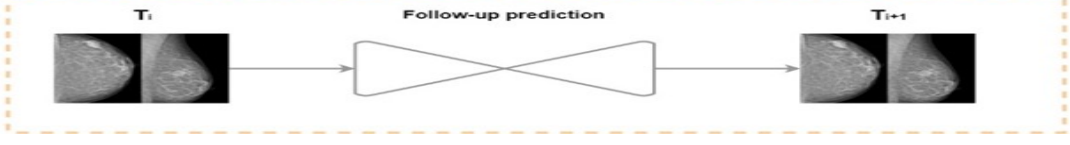
Additional pipeline applies for MRI (*see image*)

Final Assessment Categories			
Category		Management	Likelihood of cancer
0	Need additional imaging or prior examinations	Recall for additional imaging and/or await prior examinations	n/a
1	Negative	Routine screening	Essentially 0%
2	Benign	Routine screening	Essentially 0%
3	Probably Benign	Short interval-follow-up (6 month) or continued	>0 % but ≤ 2%
4	Suspicious	Tissue diagnosis	4a. low suspicion for malignancy (>2% to ≤ 10%) 4b. moderate suspicion for malignancy (>10% to ≤ 50%) 4c. high suspicion for malignancy (>50% to <95%)
5	Highly suggestive of malignancy	Tissue diagnosis	≥95%
6	Known biopsy-proven	Surgical excision when clinical appropriate	n/a

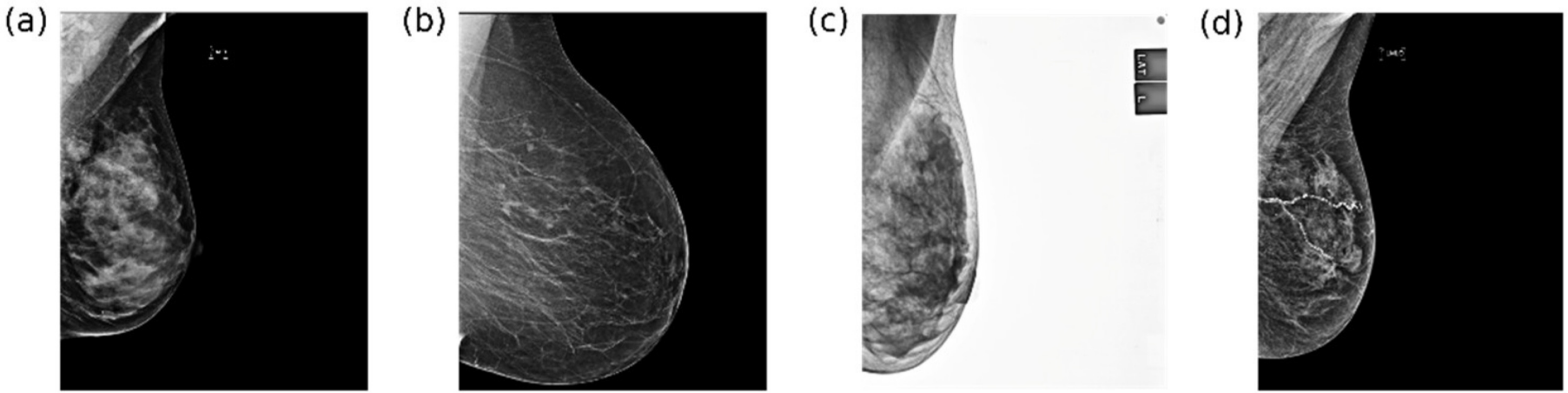
AI Toolbox


Classification
H / NH
Classification
L / C / LC
Segmentation
Healthy
Predicted masks
Mammography
Lesion
XAI
Calcifications
Healthy -> H
Non-Healthy -> NH
Lesion -> L
Calcifications -> C
Birads
Density
Classification
Segmentation
Calcifications
Malignant Lesion
Benign Lesion
is empty?
Diagnostic report


MRI
Segmentation
Lesion
is empty?
Clinical data
XAI
Staging
TNM staging
Multifocal/Multicentric

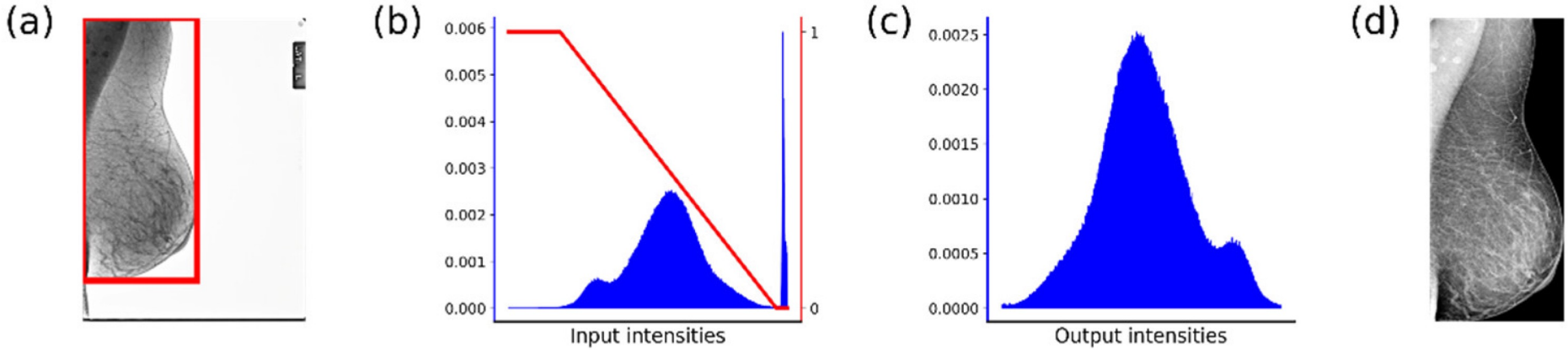

Tᵢ
Follow-up prediction
Tᵢ₊₁

MG images from the INCISIVE retrospective database in original size



An MG image in original size with an indicated region of interest (a)

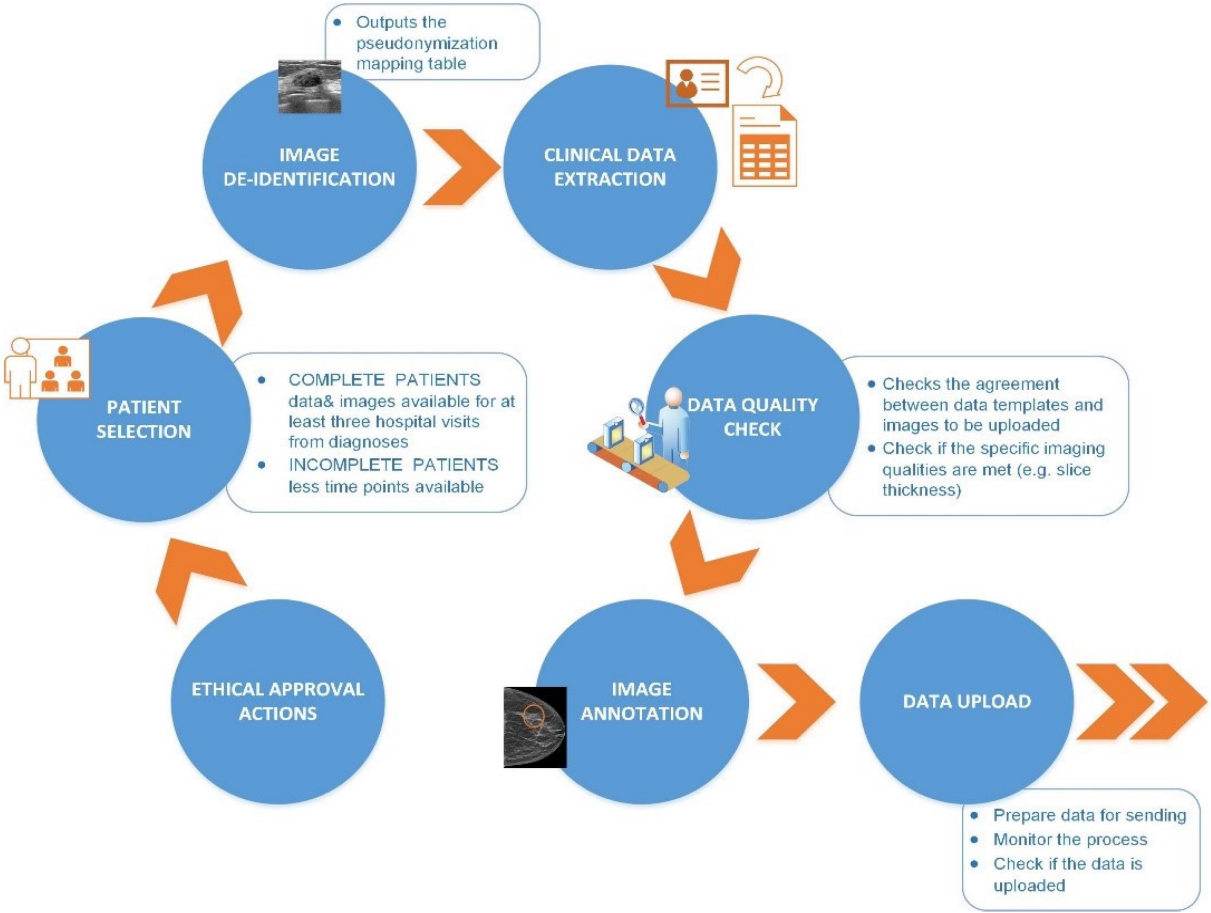
INCISIVE output example.



(b) a histogram of the original image (in blue) and intensity transformation applied for image enhancement (in red), (c) a histogram after pre-processing, and (d) a preprocessed image

Data Collection

Pathway



The care pathway in breast cancer

SUR – surgery
CHT – chemotherapy
RT – radiotherapy
HT – hormone therapy

MEDICAL REPORTS

Hospital Admission,
Radiology (US, MMG)
Histology

MDT – Oncologist, Radiologist, Surgeon
RT planning
CHT, RT delivery per visit
Laboratory, Rehabilitation,
Psychological support

Attending oncologist
Radiology (follow-up)
Laboratory
Rehabilitation,
Psychological support

Suspected case
- Self-examination
- Regular screening

Primary care
- Clinical examination

Hospital/Specialized centre
- MG/US
- Biopsy

Treatment
SUR CHT RT HT

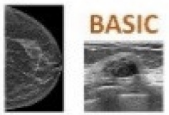
Post treatment monitoring
- MG/US

DIAGNOSES — TREATMENT — MONITORING

M0 — M1 — M2 — M6

MG – mamography
US – ultrasound
MRI – magnetic resonance imaging
CT – computerized tomography
PET – positron emission tomography

IMAGING


BASIC

IF APPROPRIATE


MRI

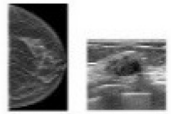

US liver


Abdomen CT/MRI

PET/CT



BONE SCAN



Artificial intelligence in Medical Imaging – Panacea?

Critical Considerations…

Outcome assessment in AI imaging studies is commonly defined by lesion detection while ignoring **the type and biological aggressiveness of a lesion**, which might create a skewed representation of AI's performance.

The use of **non-patient-focused radiographic and pathological endpoints** might enhance the estimated sensitivity at the expense of increasing false positives and possible overdiagnosis as a result of identifying minor changes that might reflect subclinical or indolent disease (*Oren et al 2020; Park et al 2019; Jiang et al 2018*).

Artificial intelligence in Medical Imaging

Implementation Challenges…

A critical challenged faced by developers (and clinicians) is the creation of a robust AI algorithm that is fair, trustable and transparent.

Another issue is on data governance, in which best practices in data sharing must be established to promote trust and protect the patients' privacy.

There is need to create trustworthy AI policies and regulatory frameworks for the introduction and sustainability of innovation in digital AI healthcare technology (*Shier and Kwan 2022*).

Machines often do not disclose the statistical rationale behind the elaboration of their tasks, which makes it complicated to apply in a medical setting - This means that it is impossible to understand the rationale behind the final output of a DL algorithm as to why a particular output is assigned (*Waller et al 2022*)

Take Home Message(s)

- The landscape of medical imaging has changed (…and continues to change).
- Continued developments are introduced in the field.
- Challenges (technological-clinical) remain in its efficient and effective implementation.
- The prospect of AI in medical imaging is unprecedented
- Developers and clinicians need to work together to further develop the technology taking into consideration the clinical “realities”
- Efficient ways to integrate in clinical pathways is critical.
- Investment in such technologies needs to continue
- Significant funding of translational research in the field should also continue.

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European Society for Medical Oncology (ESMO)
Via Ginevra 4, CH-6900 Lugano
T. +41 (0)91 973 19 00
esmo@esmo.org

esmo.org

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