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Mining Healthcare Systems to Personalize Patient Care & Improve Clinical Decisions

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Knowledge Solutions

Siemens Medical Solutions Inc.

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Outline

- Healthcare Challenges
- Knowledge-Based Medicine
- KBM in practice
  - Quality
  - Targeted decision support
  - Knowledge discovery
- Conclusion

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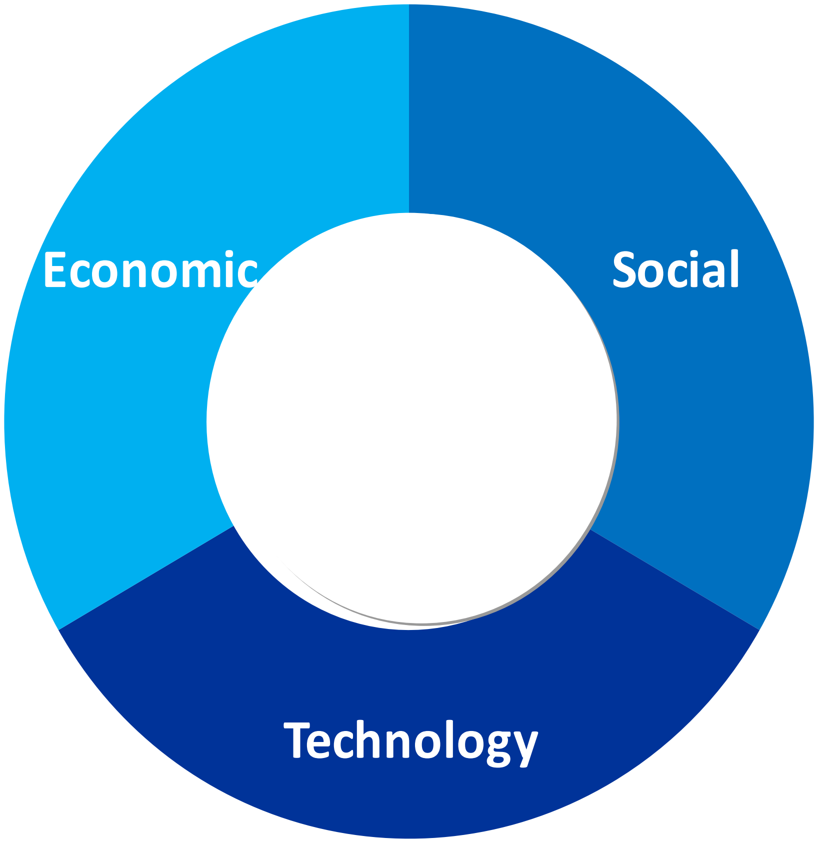
Global Healthcare Market Trends

- Increasing Healthcare Costs (73% over the next 9 years)[1]
- Increased consumerism & consumer awareness
- Knowledge explosion
    - Increased creation and dissemination of evidence based guidelines
- Data overload
    - Increased digitization of data
- New Technology
- Personalized Medicine



1:"National Health Expenditures…Calendar Years 2009—2018" - Centers for Medicare & Medicaid Services, Office of the Actuary

Clinical decisions are more complex

Clinicians need support to manage these challenges.
Data mining and personalization of care can help.

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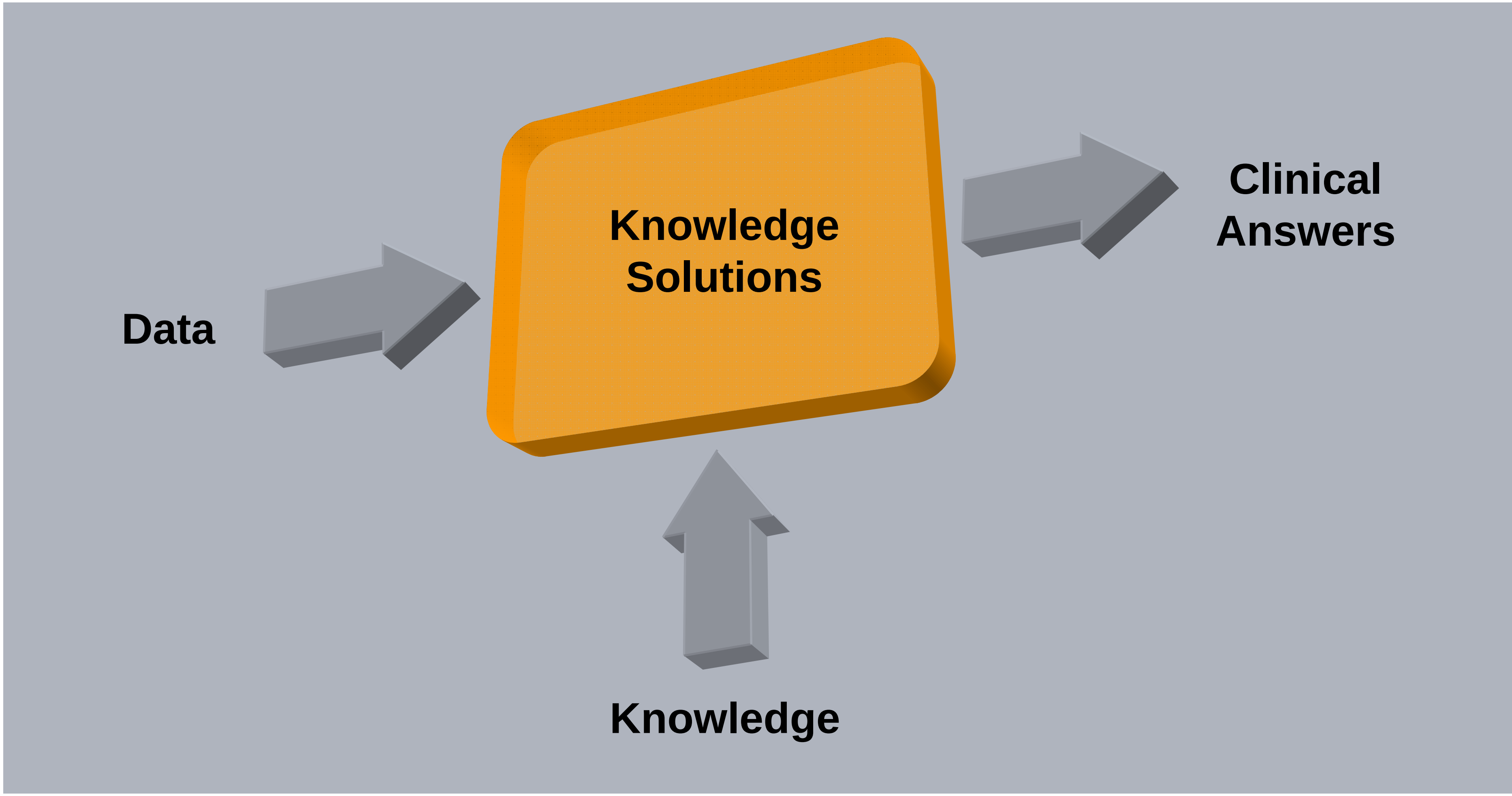
Integrate patient data with medical knowledge to improve health outcomes.

- Access existing patient data from disparate sources
- Manage and integrate knowledge for decision support
- Impact workflow & outcomes

Impacting Clinical Workflow



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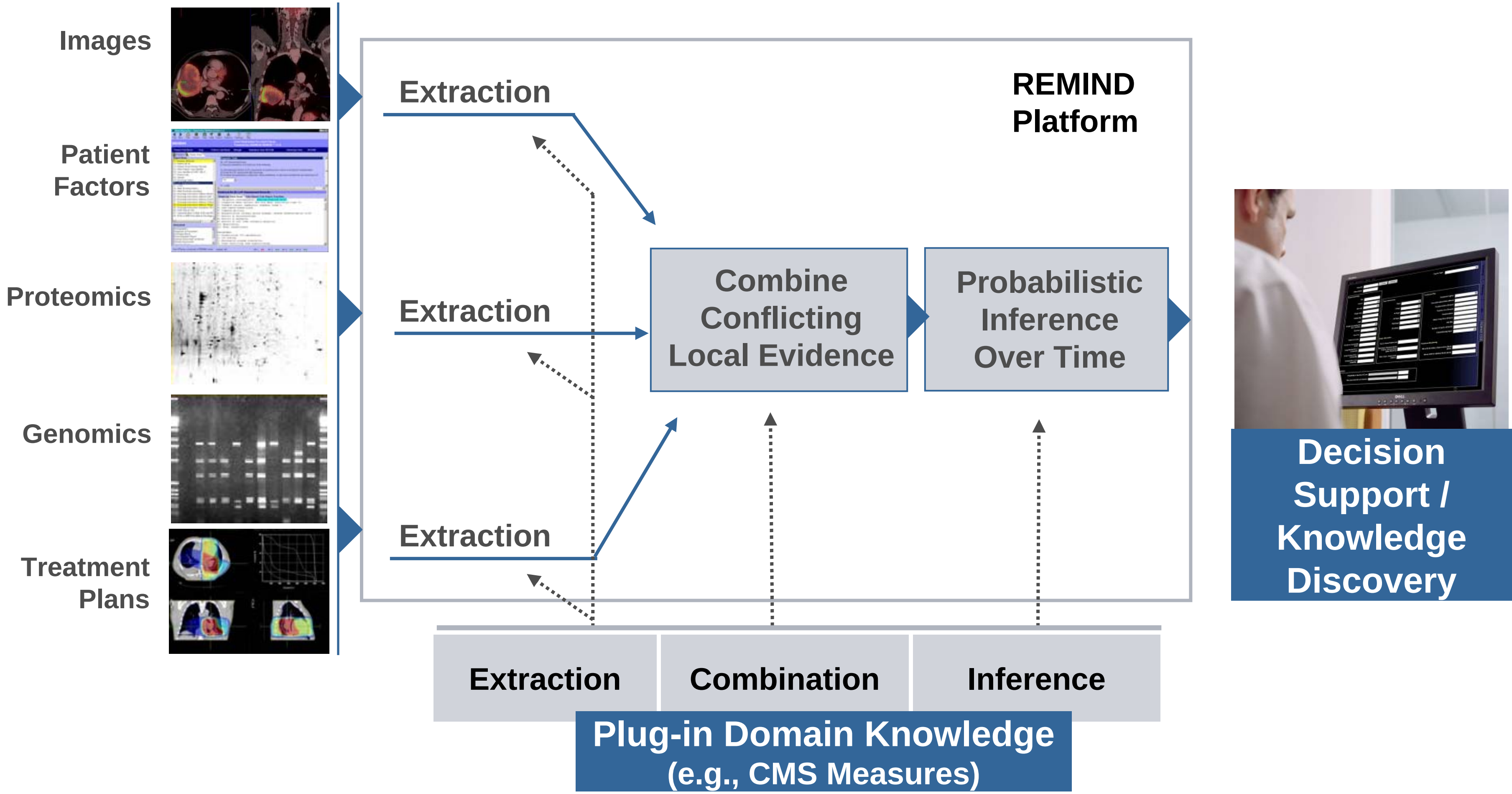
Two aspects of Knowledge Based Medicine

- Knowledge Utilization
  - Knowledge-driven decision support
  - Data aggregation from disparate sources – **using existing data**
  - Inject knowledge (e.g., guidelines) via Probabilistic inference
  - Present conclusive findings
- Knowledge Discovery
  - Combine imaging, clinical, IVD and genetic information
  - Discover combined diagnostic signatures
  - ... from multi-institution data
  - Enable increasing personalization of care

*Not considered a Medical device.

REMIND Knowledge Platform*: Architecture

Reliable Extraction & Meaningful Inference from Nonstructured Data



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Automated Quality Abstraction & Reporting

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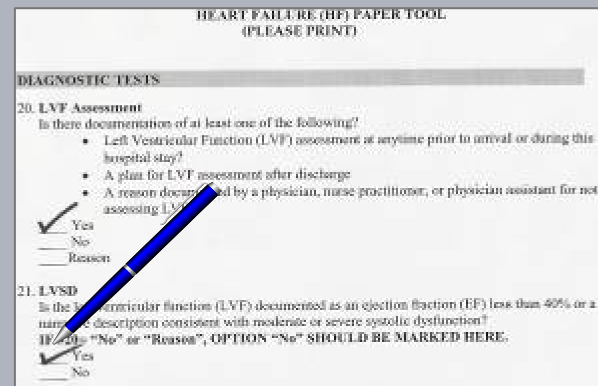


HEART FAILURE (HF) PAPER TOOL
(PLEASE PRINT)

DIAGNOSTIC TESTS

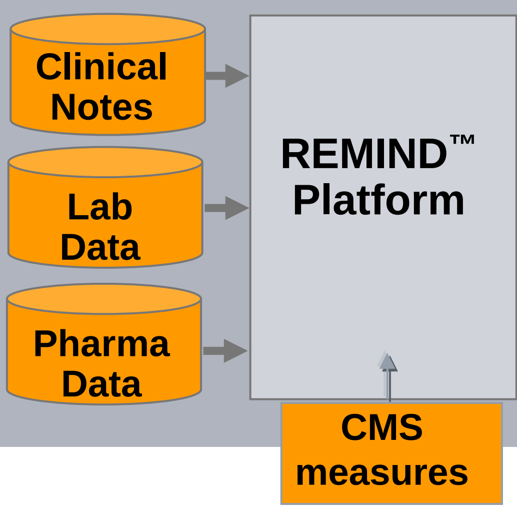
20. LVF Assessment
Is there documentation of at least one of the following?
- Left Ventricular Function (LVF) assessment at anytime prior to arrival or during this hospital stay?
- A plan for LVF assessment after discharge
- A reason docum[illegible]d by a physician, nurse practitioner, or physician assistant for not assessing LV[illegible]

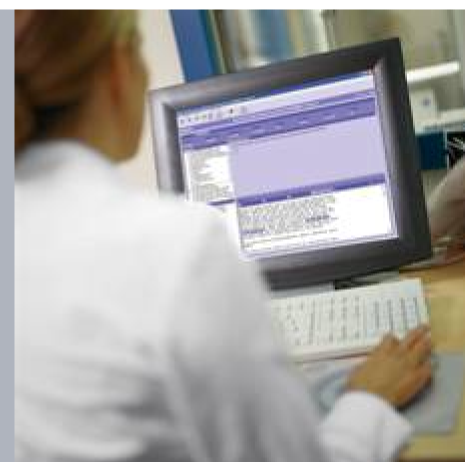
✓ Yes
___ No
___ Reason

21. LVSD
Is the l[illegible]ventricular function (LVF) documented as an ejection fraction (EF) less than 40% or a narr[illegible]e description consistent with moderate or severe systolic dysfunction?
IF [illegible]20= "No" or "Reason", OPTION "No" SHOULD BE MARKED HERE.

✓ Yes
___ No

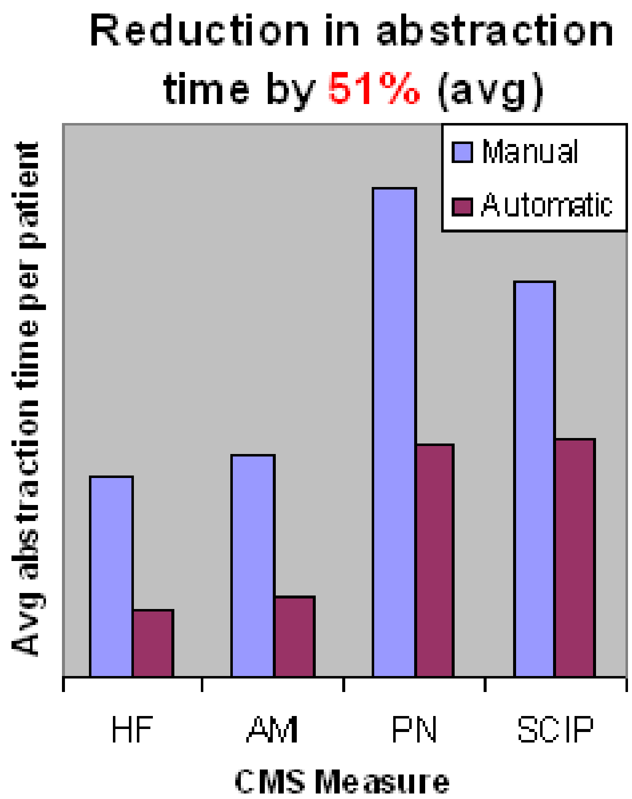
Manual Chart Abstraction





Quality Measures enabled by the REMIND Platform

Quality Measurement & Improvement
Quality Measures



“Soarian Quality Measures is an essential, time-saving solution that automates the abstraction of critical patient data from both structured and unstructured free text from clinical narratives. It enables our teams to focus on providing the best quality of care possible.”

Janene Yeater, Vice President of Quality and Planning MedCentral Health System - July 2009

N. Chopra, F. Farooq, B. Krishnapuram, J. Yeater, “Automatic Abstraction for CMS Quality Measures,” IHI 2009

Quality Measurement & Improvement

Data

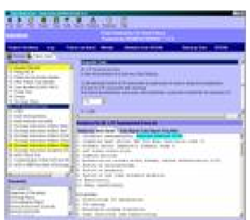
REMIND Platform

Clinical Answers

Automated Quality Measurement & Improvement

Labs

Demo-graphics



Free text Pt. Factors

Medication

Knowledge

Existing guidelines - CMS & Joint Commission guidelines

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Personalized dose recommendation

Non Small-Cell Lung Cancer

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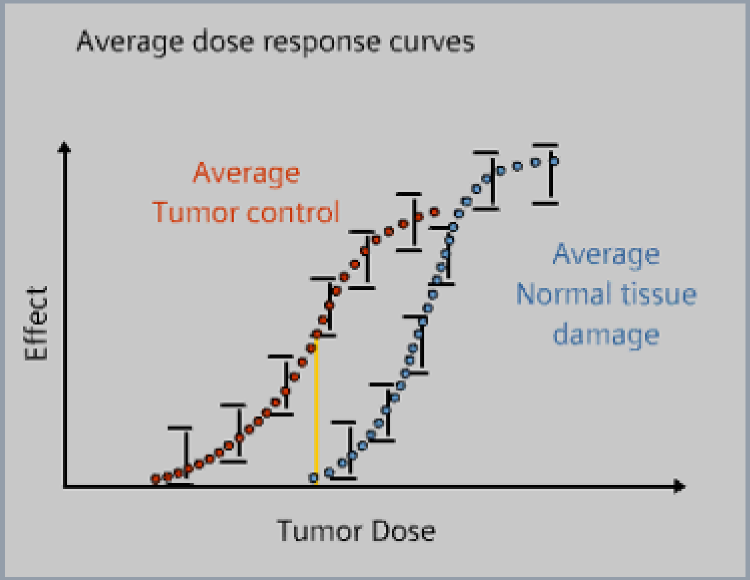
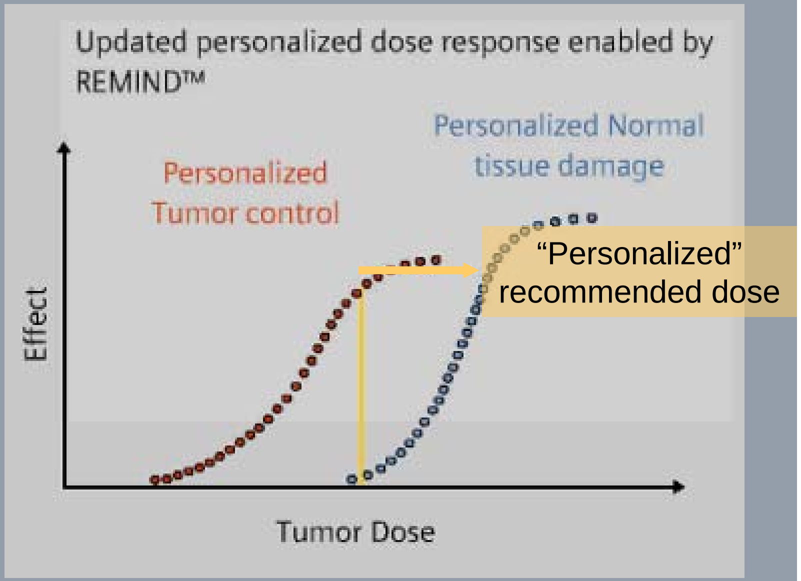


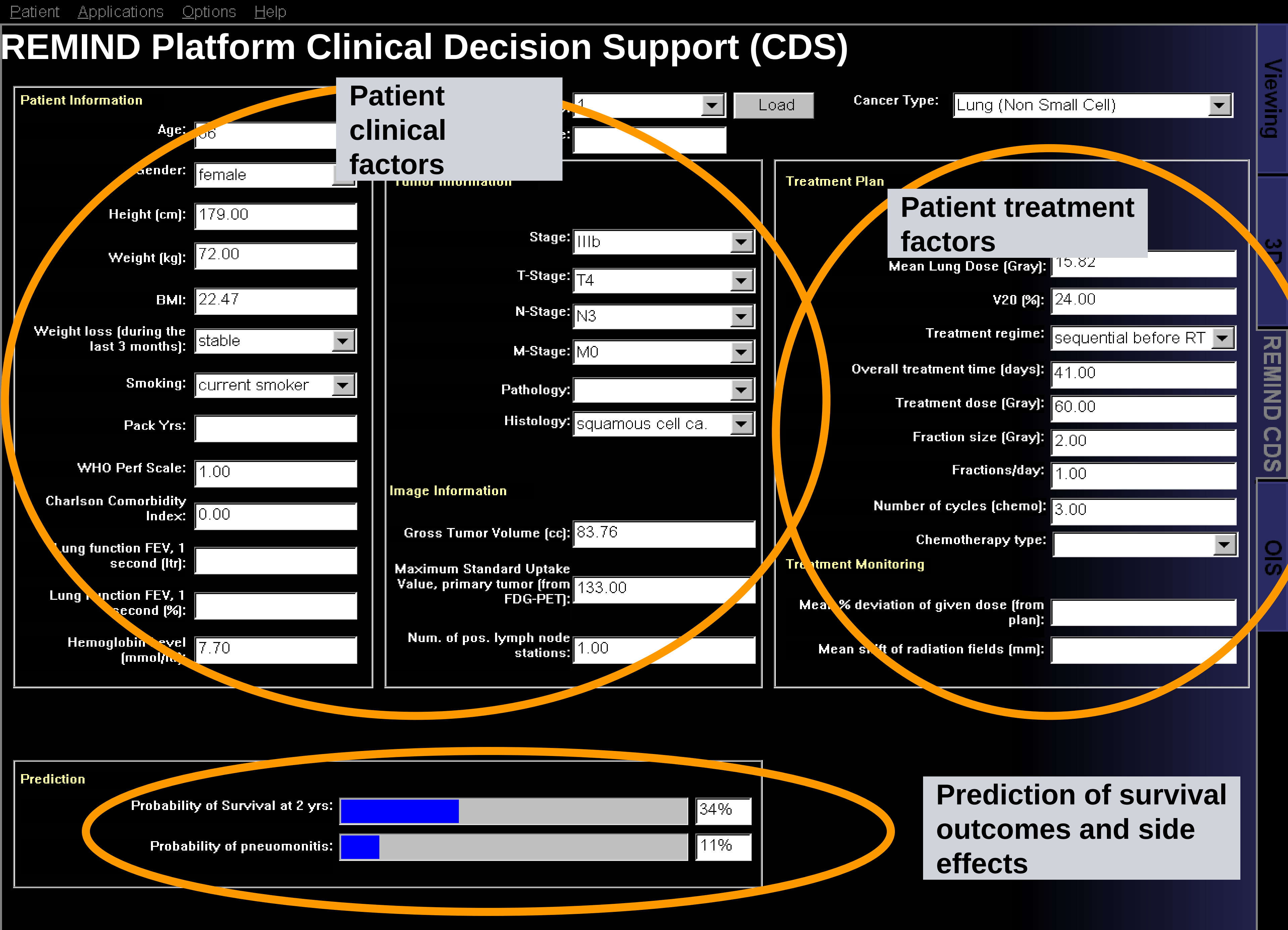
Current plans based on "average dose response curves" appropriate for a population

REMIND Platform: Prediction models for lung cancer patients: www.predictcancer.org



Create personalized dose response rate for individual patients for models created by mining large database of patient data and external medical knowledge

*This information about this product is preliminary. The product is under development and not commercially available for sale in the U.S. and its future availability cannot be ensured.



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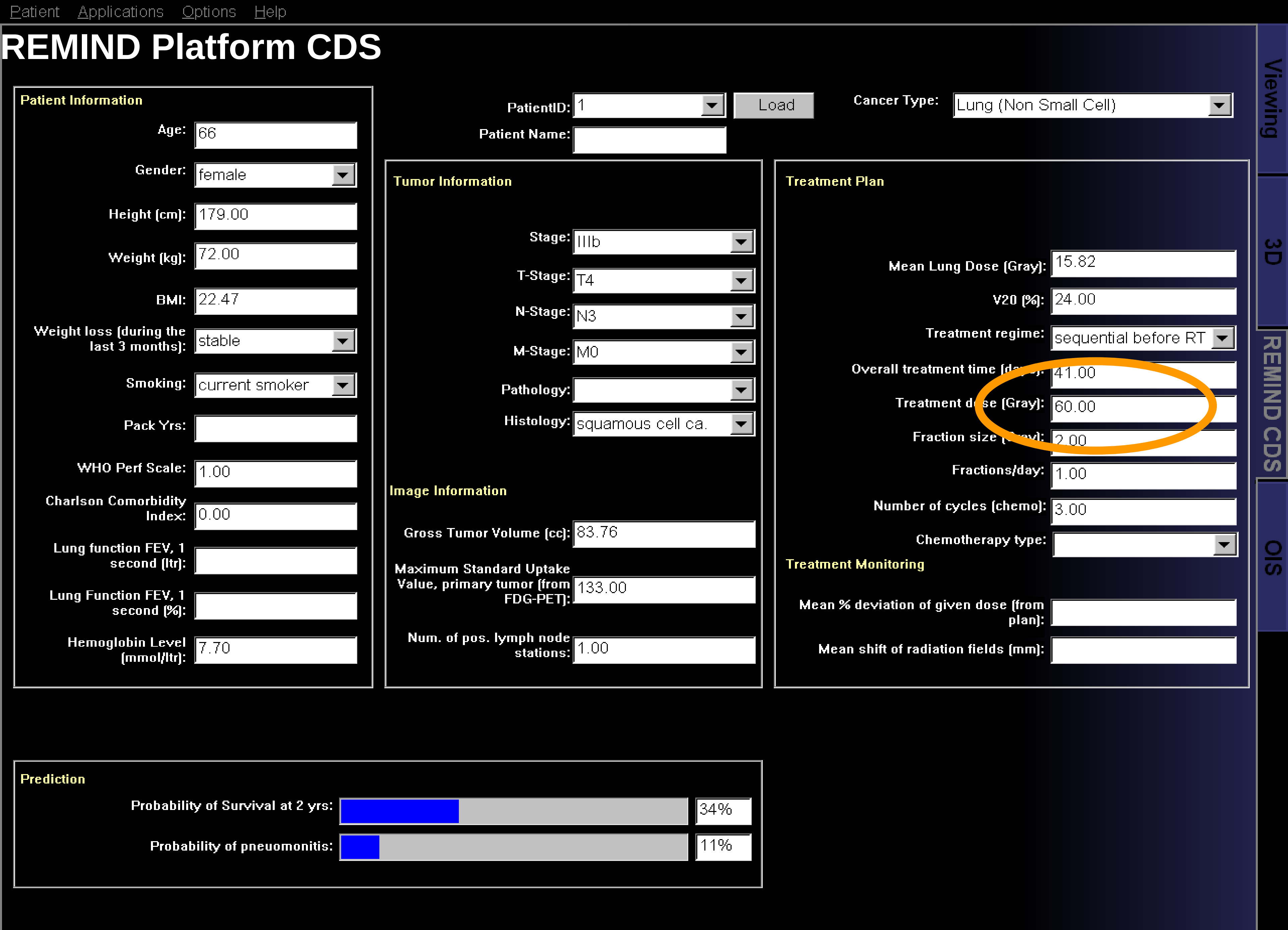

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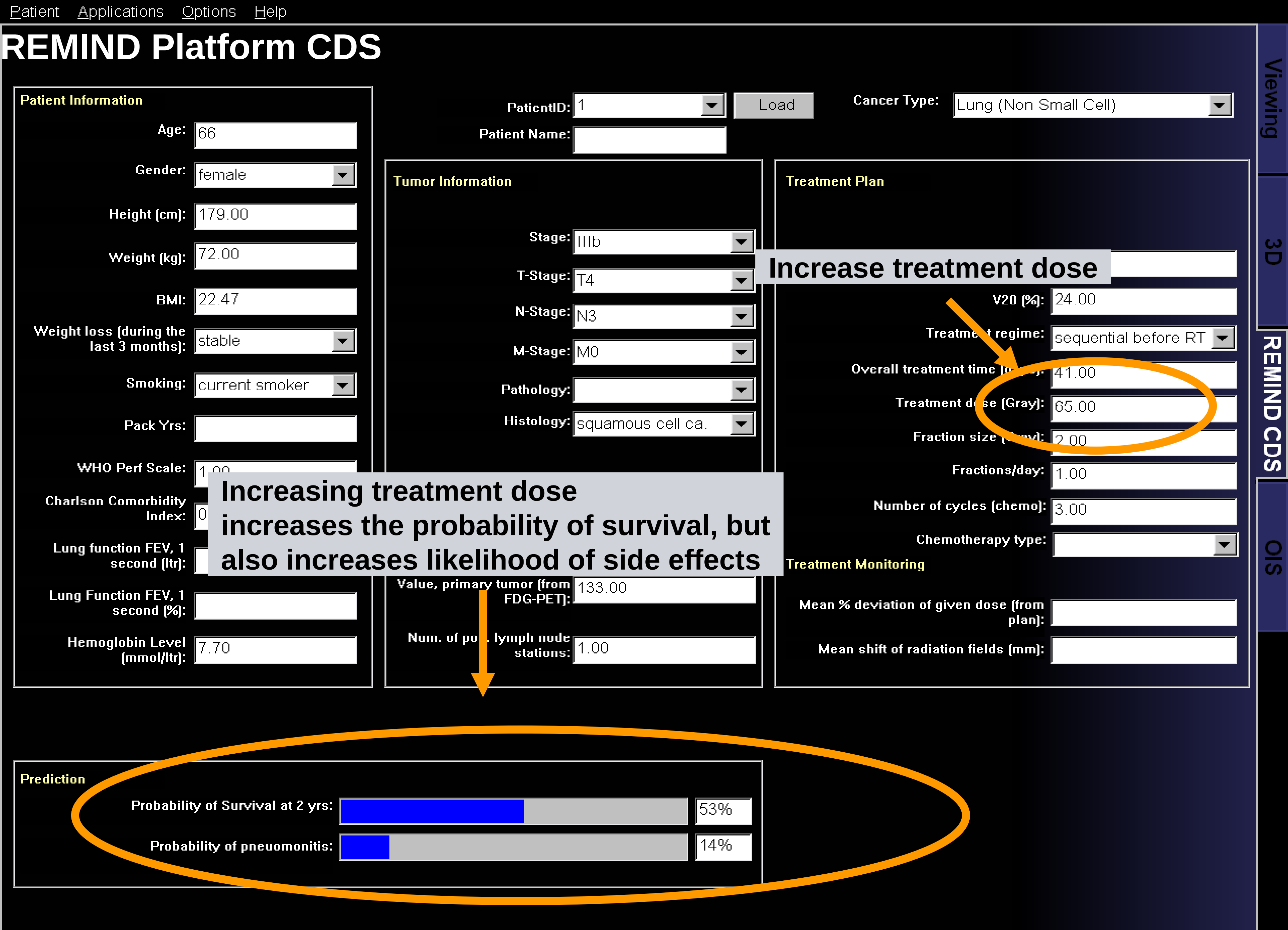

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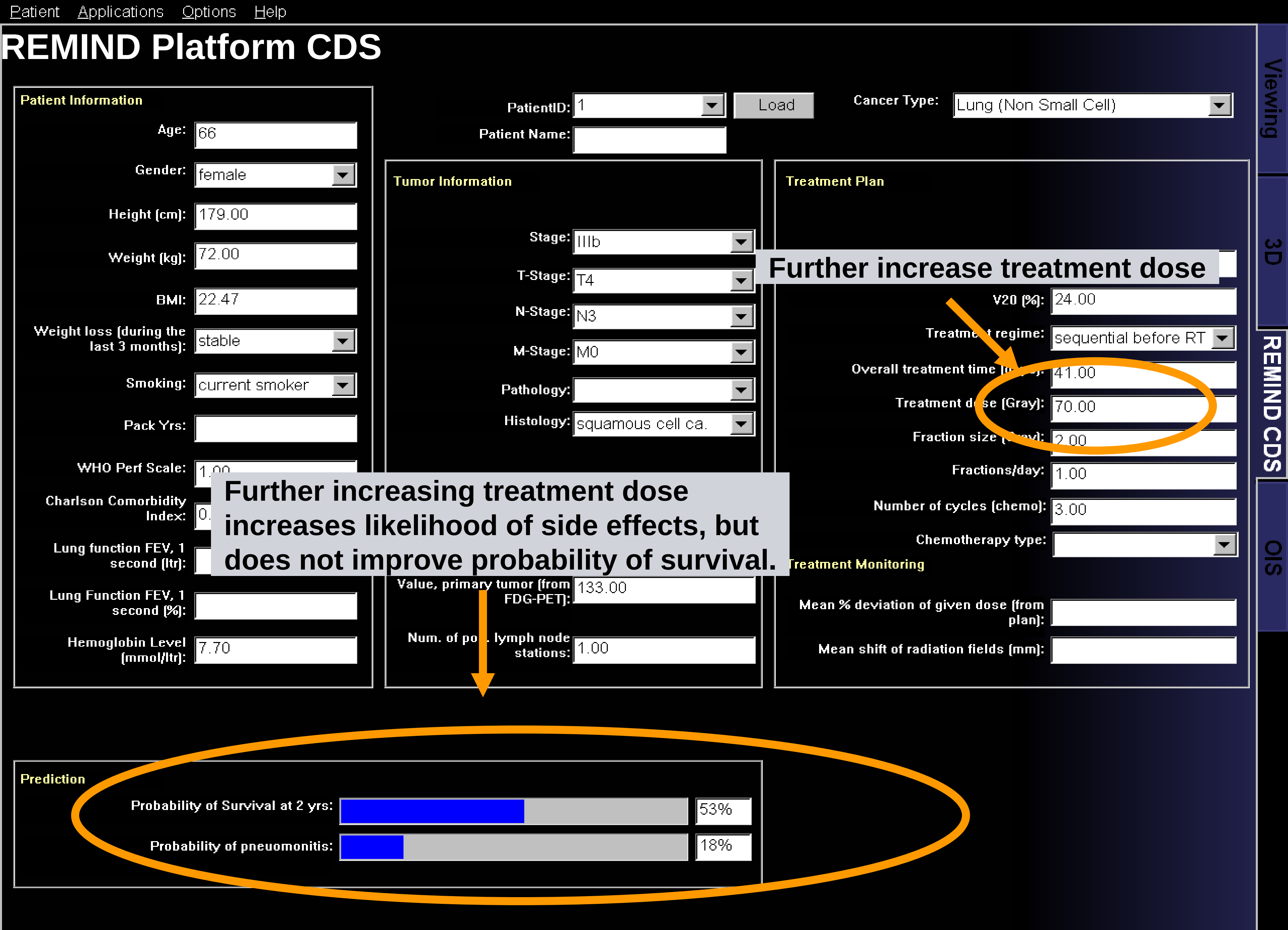

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Targeted Decision Support at Point of Care

Personalized therapy selection for Lung cancer

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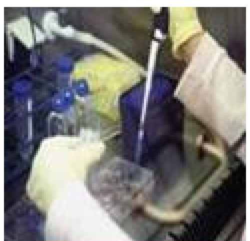
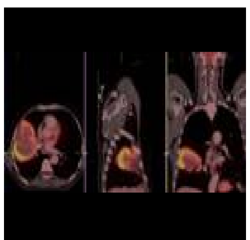
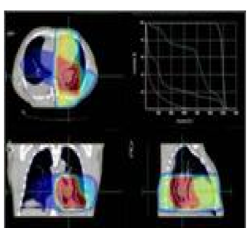
Data

REMIND Platform

Clinical Answers


Labs


Images


Treatment Plans

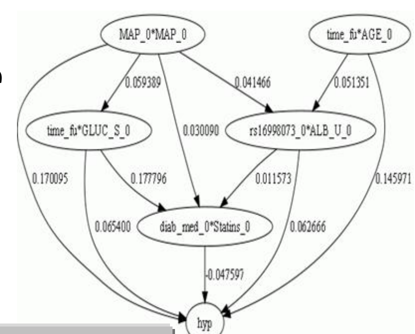

Genomics

Knowledge

Existing guidelines

Learned knowledge
- Predictive models discovered from patient data)

Treatment impact
- Adjust dose based on outcomes & side effects



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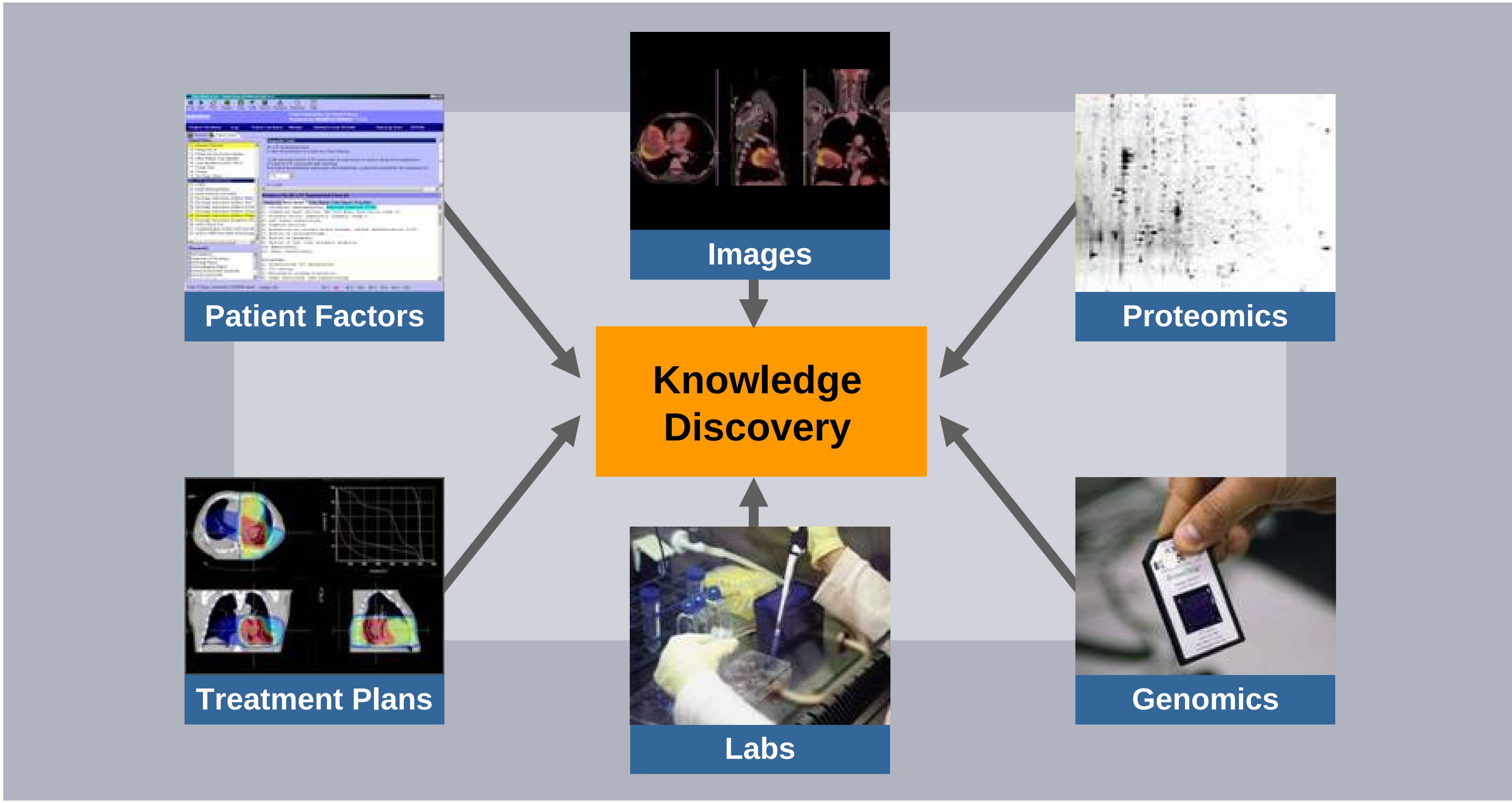
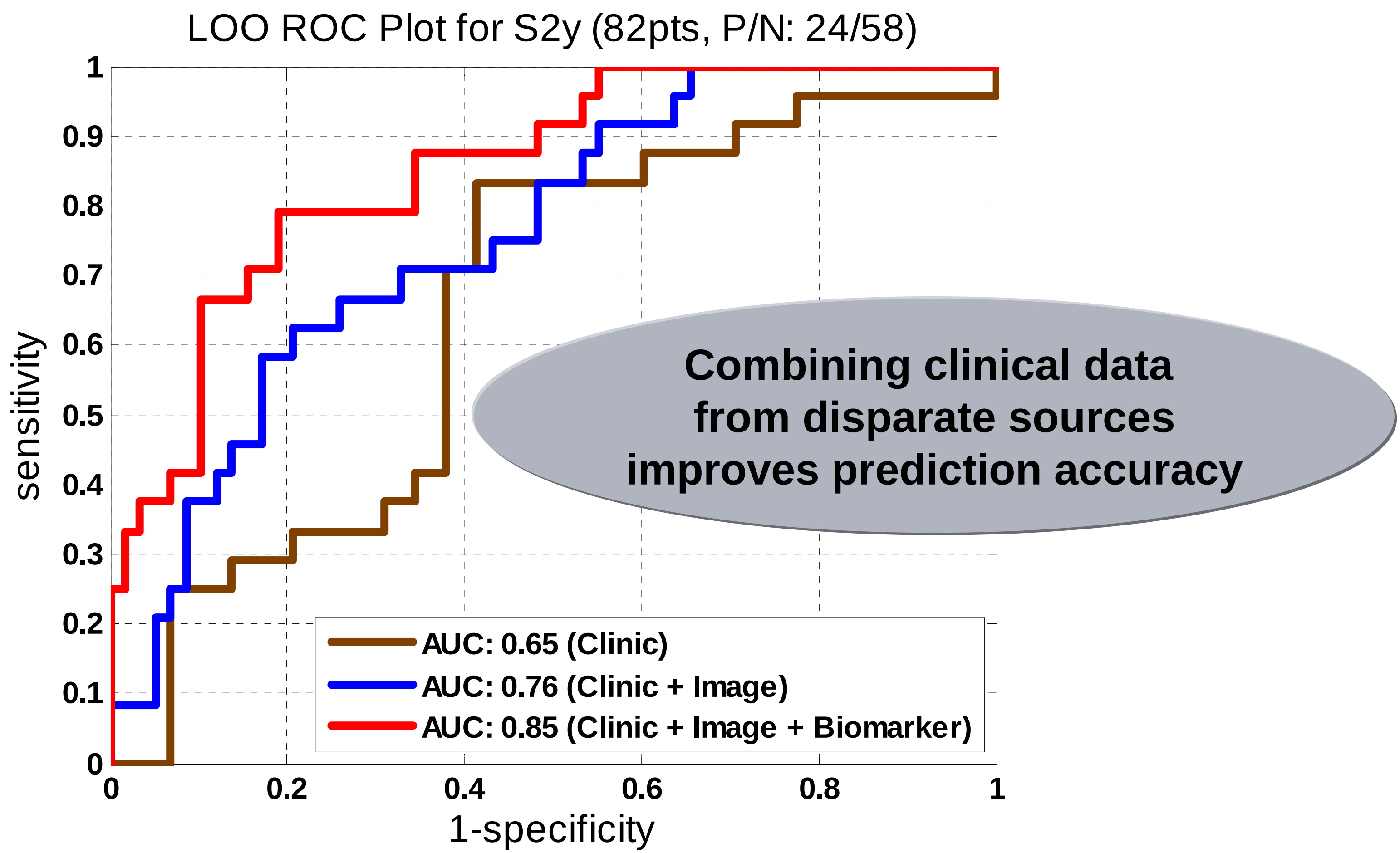
Discover Combined Diagnostics

Models that span Imaging, IVD, Genomic, Molecular & Clinical Biomarkers



Knowledge Discovery: Learning Combined Diagnostics

Does incorporating more data help? (Collaboration with MAASTRO)



S. Yu, C. Dehing-Oberije, D. De Ruysscher, K. van Beek, Y. Lievens, J. Van Meerbeeck, W. De Neve, G. Fung, B. Rao, P. Lambin, "Development, External Validation and further Improvement of a Prediction Model for Survival of Non-Small Cell Lung Cancer Patients treated with (Chemo) Radiotherapy,", ASTRO 2008

What about data from multiple institutions?

Predicting 2 year Lung Cancer Survival

- 455 inoperable NSCLC patients, stage I-IIIB, referred to the MAASTRO clinic (Netherlands) to be treated with (chemo)radiotherapy
- 112 patients from Gent hospital (Belgium)
- 40 patients from Leuven hospital (Belgium)

How do we use data from different institutions while preserving patient privacy?

Example: Cox Regression for Survival Analysis

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- Cox regression, or the Cox propositional-hazards model, is one of the most popular algorithms for survival analysis
  - Defines a semi-parametric model to directly relate the predictive variables with the real outcome (i.e. the survival time)
  - Assumes a linear model for the log-hazard:

$$\lambda(t|\mathbf{x}_i) = \lambda_0(t)\exp[\mathbf{w}^\top \mathbf{x}_i]$$

- We propose privacy-preserving Cox regression (PPCox) which is based on random projection
  - Provides accurate classification
  - Does not reveal private information

$$\lambda_{\mathrm{HPPCox}}(t|\mathbf{x}_i) = \lambda_0(t)\exp[\mathbf{w}^\top \mathbf{B}^\top \mathbf{x}_i]$$

Developing Privacy Preserving Models for Survival

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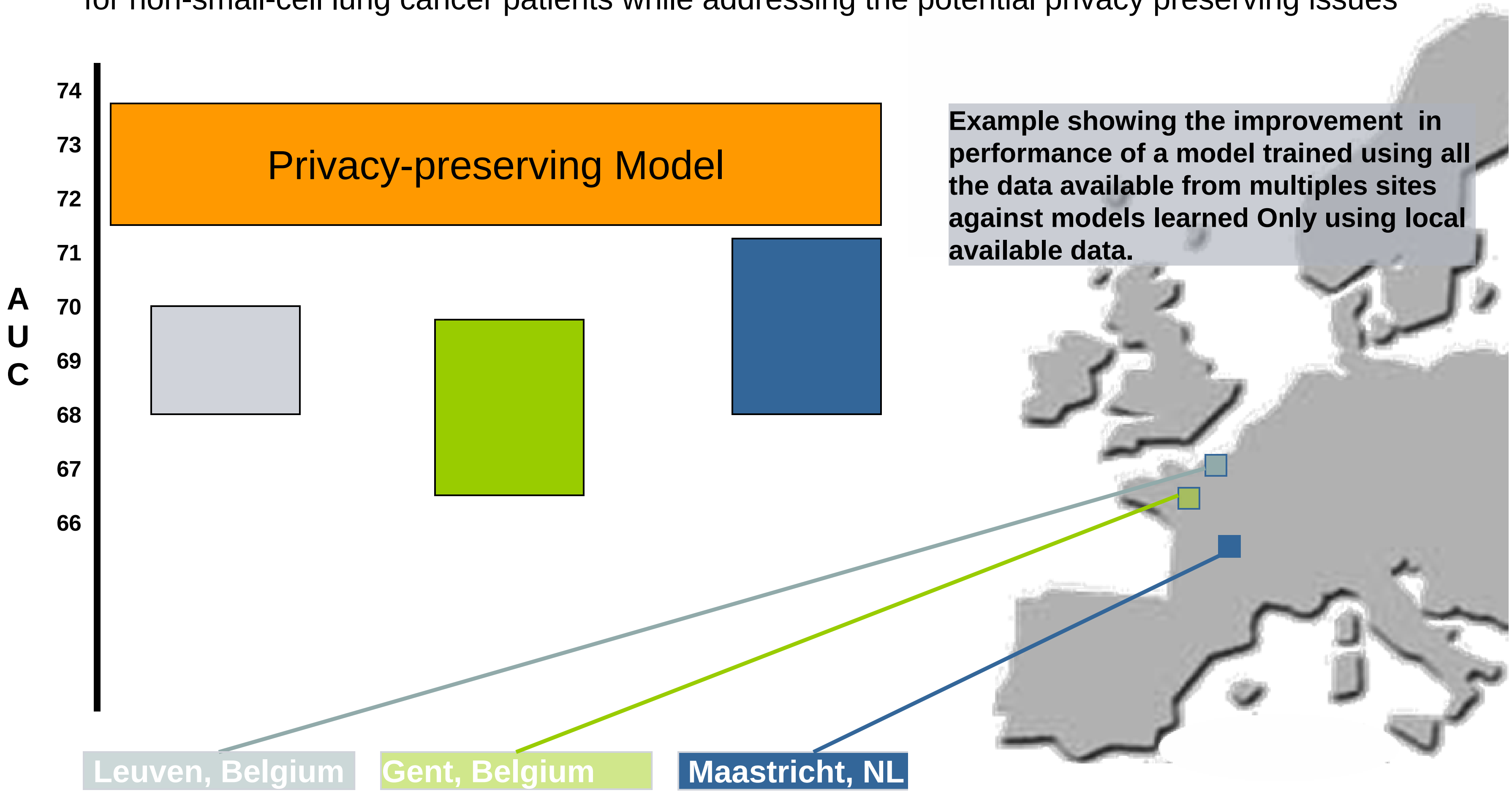
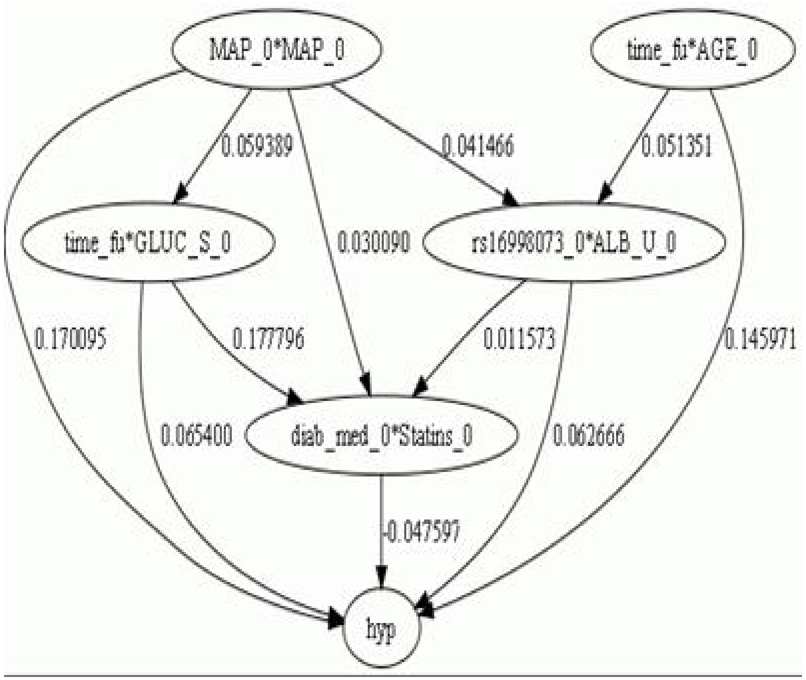
- We are using real data from several institutions across Europe to build models for survival prediction for non-small-cell lung cancer patients while addressing the potential privacy preserving issues



Which asymptomatic patients will develop hypertension within 5 years?

Collaboration with Univ of Greifswald



- Based on data from large study, >4000 patients over 10 years
  - Genetic (SNPs), clinical, lab, imaging, …
- Analyzed 100s of potential predictive variables to identify the most informative subset
- Learned a Bayesian Network
  - predicts patients who are at high risk to become hypertensive (AUC >0.85).

G. Fung, S. Yu, T. Itterman, M. Nauck, R. Rettig, S. B. Felix, H. K. Kroemer, H. Volzke. "A combined diagnostics model for the prediction of hypertension development," AMIA

Creating Medical Knowledge

Mining large patient databases from multiple institutions

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Data

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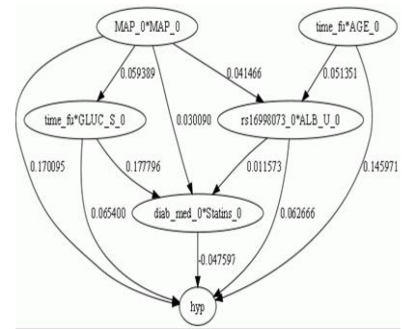
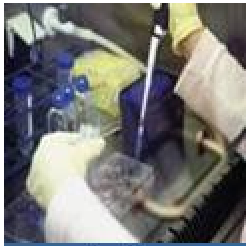
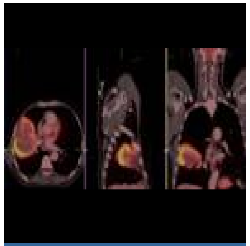
Predictive Models



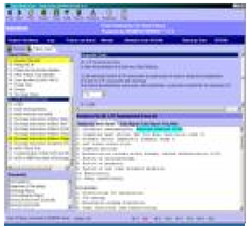


Labs



Images

Medication



Patient Factors

Genomics

Knowledge

Existing guidelines
for cancer therapy

Learned knowledge
- Predictive models discovered from patient data

Automated Identification of Patients for Clinical Trials**

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Knowledge Discovery can accelerate and improve the selection process of appropriate patients for clinical studies**

5 million patients in hospital database → 85 found by REMIND SmartTrials → 44 eligible (52% eligible) → 3 patients enrolled

Greatly Reducing Research Nurse Time

Manual (current methodology)	Using REMIND SmartTrials
1 eligible patient found per **3 hours** of nurse time	1 eligible patient found per **12 minutes** of nurse time
1 patient enrolled per **75 hours** of nurse time	1 patient enrolled per **3 hours** of nurse time

Greatly Reducing Elapsed Time

Manual (current methodology)	Using REMIND SmartTrials
7 patients enrolled in 9 months	**3 patients enrolled in 1 week**

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The Road to Personalized Medicine

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Future

Knowledge-Driven Workflow

Clinical decisions using all available electronic data & medical knowledge for Personalized Medicine, Quality Improvements, and Workflow Management.

Key Enablers

Application of Knowledge
Integration of Data

Current

Focused Tasks

"Does this patient have a history of smoking?"
"Find a lung nodule in a chest CT"

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Integrate existing patient data with medical knowledge to improve health outcomes.

- Key components
  - Access existing patient data from disparate sources
  - Manage and integrate knowledge for decision support
  - Impact workflow & outcomes
- Healthcare Impact
  - Improve quality of care
  - Support personalization of care via targeted decision support
  - Continuous improvement by learning new medical knowledge

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Thank You

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Knowledge Solutions
Siemens Healthcare

Patient Identification for Clinical Trials enabled by the REMIND Platform

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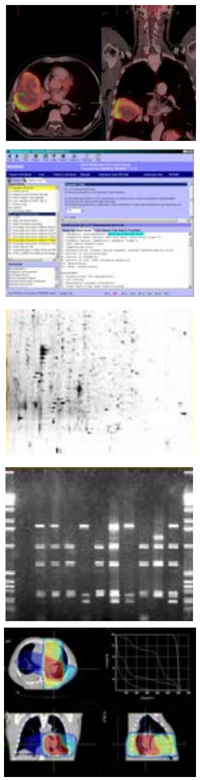
Images

Patient Factors

Proteomics

Genomics

Treatment Plans



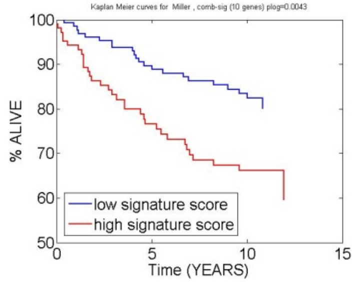
Computerized Patient Data

REMIND Platform

Clinical Decision Support

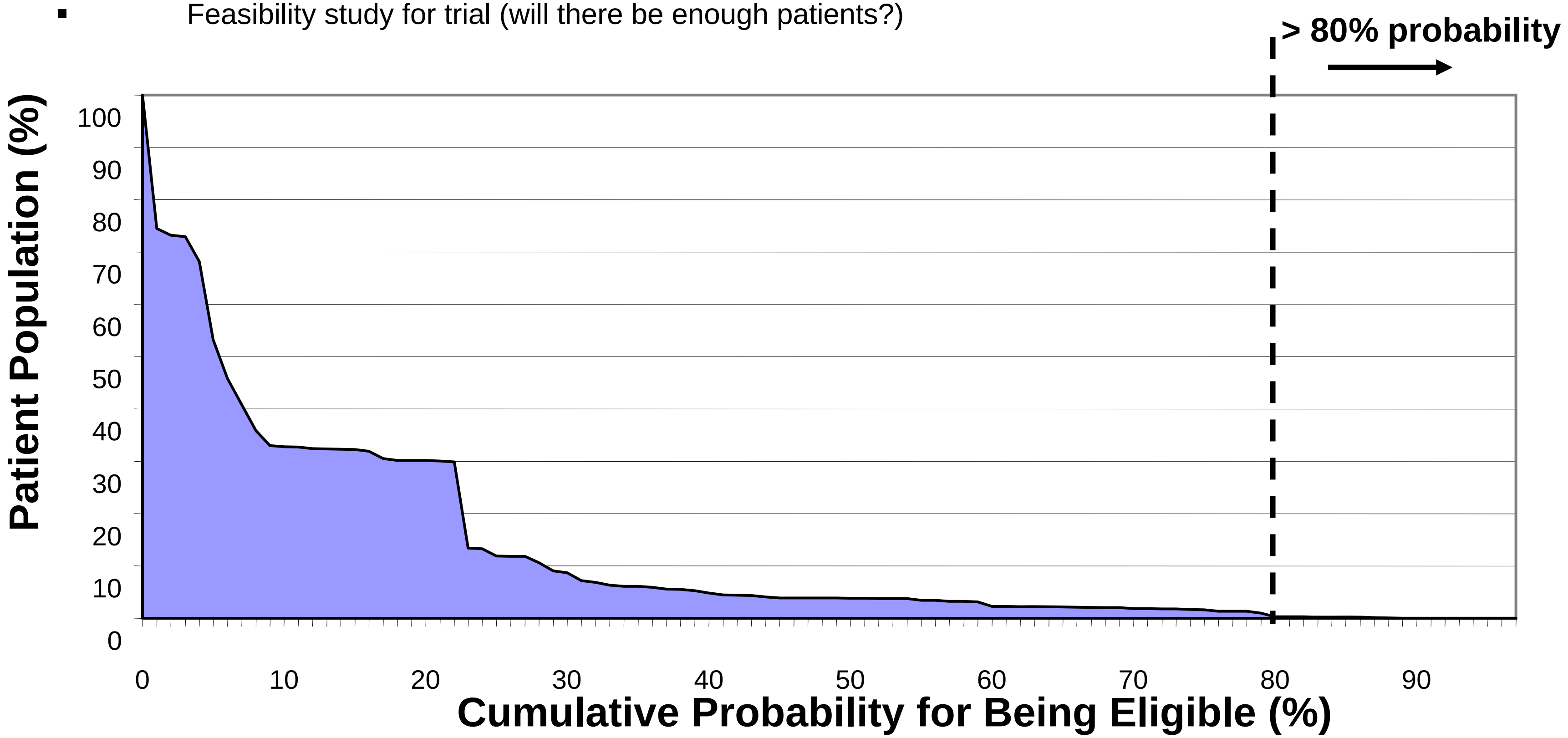
High-Quality Structured Clinical Patient Data

Knowledge Discovery



Patient Identification for Clinical Trials enabled by the REMIND Platform

- Two use cases
  1. Clinician: Assess what clinical trials for which current patient is eligible
  2. Researcher: Assess which patients are eligible for trial
     - Contact clinicians or patients to consider trial
     - Feasibility study for trial (will there be enough patients?)



Venk Gottipaty, et al. “Automated Identification Of Madit-II Eligible Patients Using Remind Artificial Intelligence Software”, in the 6th Scientific Forum on Quality of Care and Outcomes Research in Cardiovascular Disease and Stroke, American Heart Association (AHA), 2005.

Automated Identification of Patients for Clinical Trials**

SIEMENS

REMIND SmartTrials* accelerates and improves the selection process of appropriate patients for clinical studies**

5 million patients in hospital database	85 found by REMIND SmartTrials	44 eligible (52% eligible)	3 patients enrolled

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