HIMSS19
CHAMPIONS OF HEALTH UNITE
Global Conference & Exhibition
FEB 11–15, 2019 | ORLANDO

Maccabi
The Best Healthcare in Israel

Lessons from Israel: Finding Cancers with AI and EHR Data

Session 106, February 13, 2019

Prof. Varda Shalev, MD MPA
CEO, Institute for Research and Innovation at Maccabi Health Services

Conflict of Interest

Varda Shalev, Director of Research and Innovation Center, Maccabi Health Services

Salary: No

Royalty: Commercial agreement between Maccabi and Medial EarlySign

Contracted Research: Yes

Other: Mutual patent

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Agenda

1. Maccabi and Healthcare in Israel

2. Precision Medicine & Health Care Data

3. Maccabi's AI-Based CRC intervention

4. Results

5. Takeaways

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Learning Objectives

Session learning objectives:

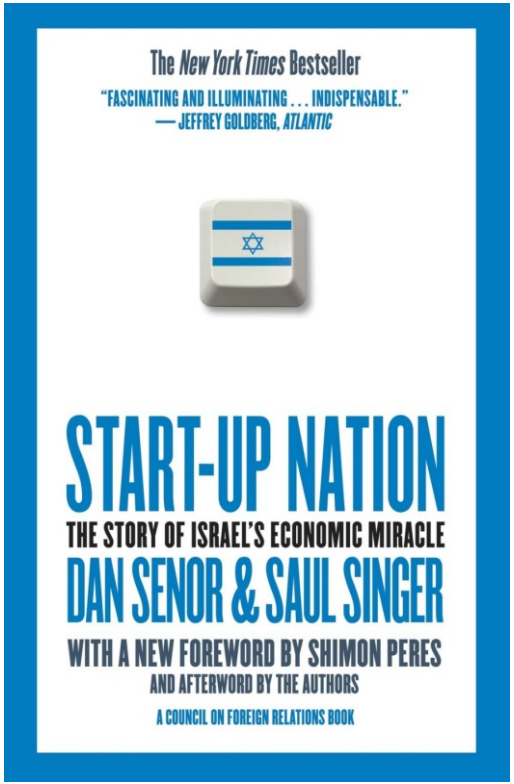
- Demonstrate how the U.S. health system can learn from Israel's approach to digital health and the use of existing EHR data
- Discuss clinical and ROI results of a real-world, machine-learning case study that used only blood count results and demographics to successfully detect individuals at risk of cancer
- Identify the processes necessary for a streamlined and simple AI implementation, aligned with clinical workflow, to support an effective patient-centric health system

Israel at a glance

Population
9 million

Capital
Jerusalem

Languages
Hebrew, Arabic
English, Russian



Maccabi Healthcare

$4.5B Annual Budget

Israel's 2nd largest healthcare provider

Serving **2.3M** people - **25.5%** of Israeli population

< 1% Dropout yearly

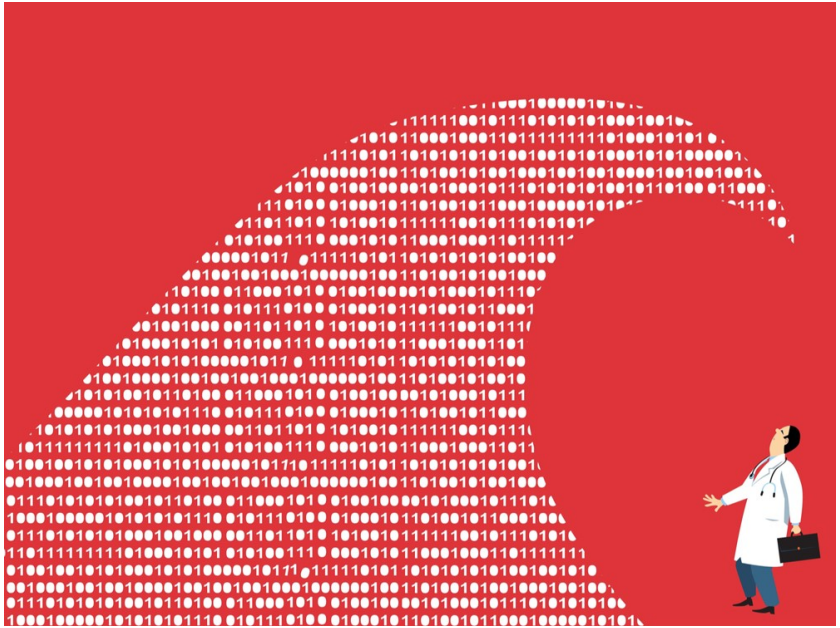
Fully integrated healthcare

13 hospitals | **Thousands** of PCPs and specialists in diverse medical areas

1615 GPs | **110** gastroenterologists | **9** GI centers

63,000 colonoscopies annually

Data: a Natural Healthcare Resource



"Data is the world's next natural resource"

Ginni Rometty, IBM CEO (March 21, 2017)

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Maccabi's Research and Innovation Institute

CEO, Maccabi Research and Innovation Institute

- Maccabitech-Epidemiological Research
- The Clinical Research Unit
- MK&M - Big Data
- BioBank

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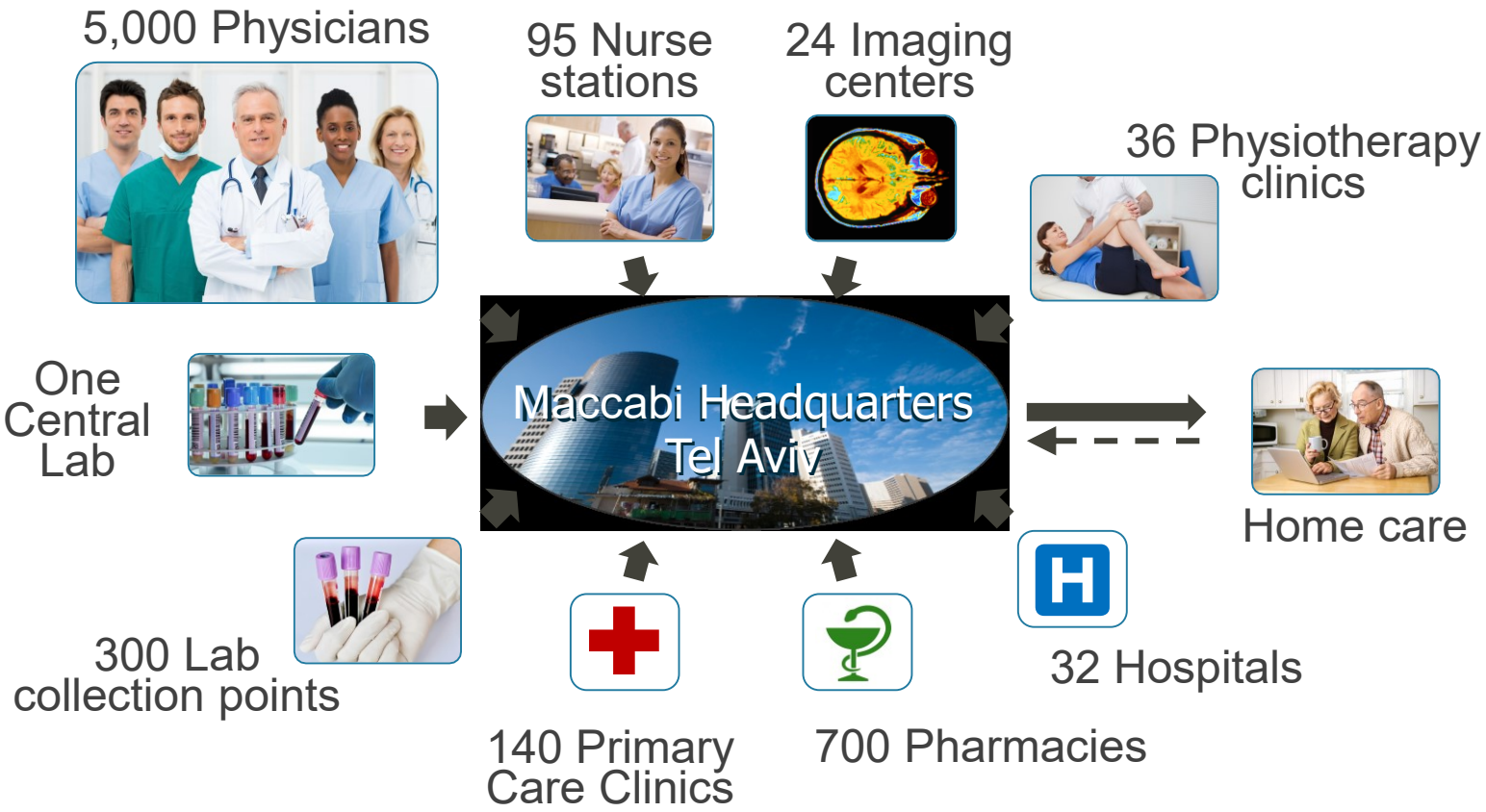
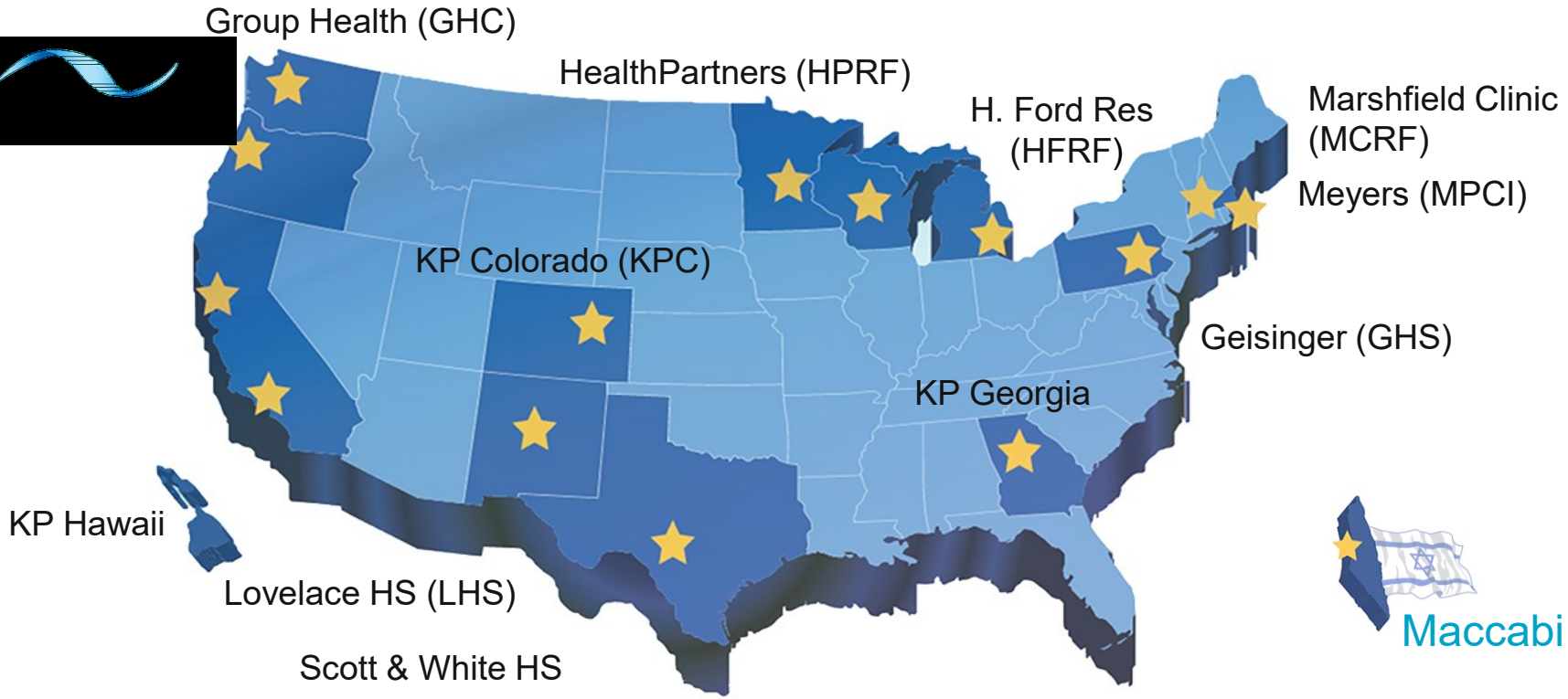
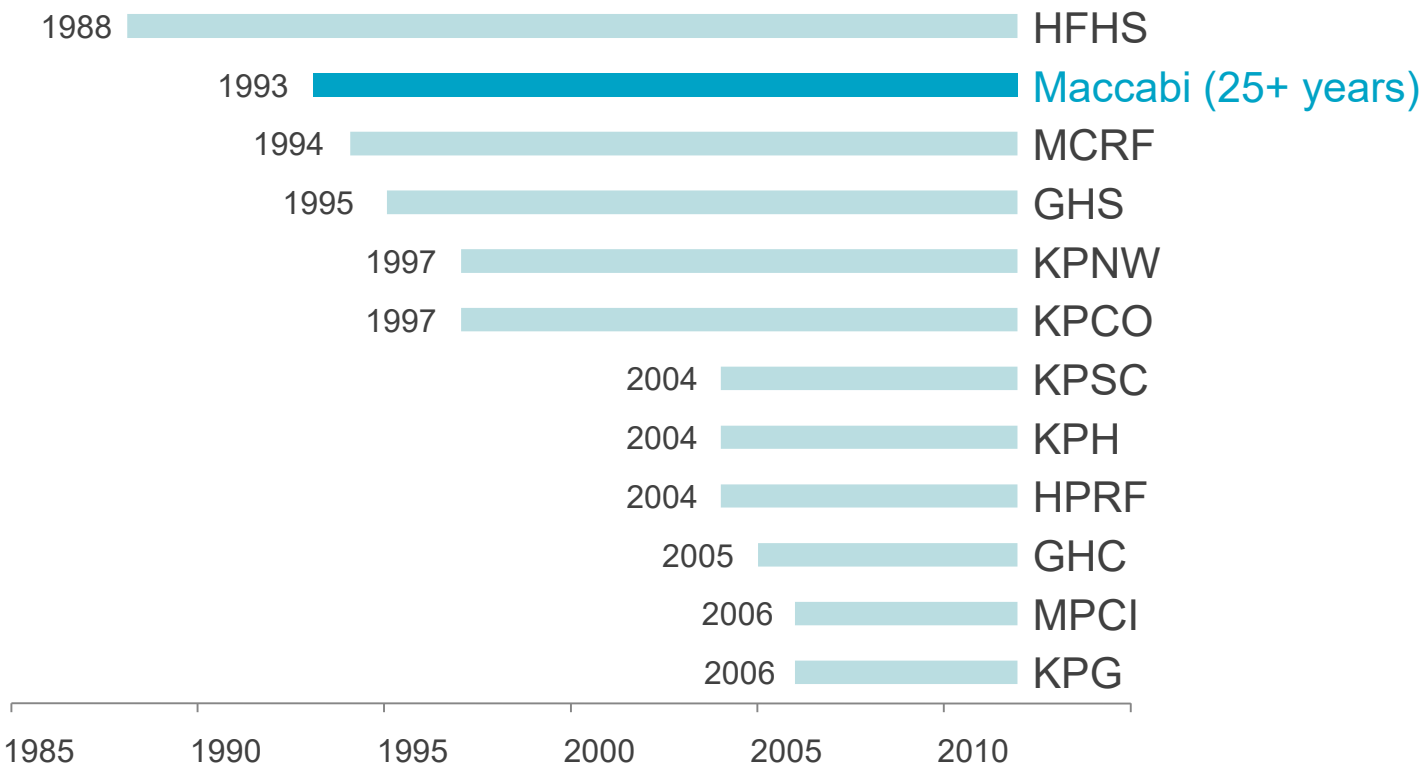
Maccabi's EHR Data Sources



Maccabi & Health Care Systems Research Network (HCSRN)



HCSRN Members: Years with EMR



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TIPA Bio Bank

Personalized Medicine

Is the next step in prevention and cure of disease

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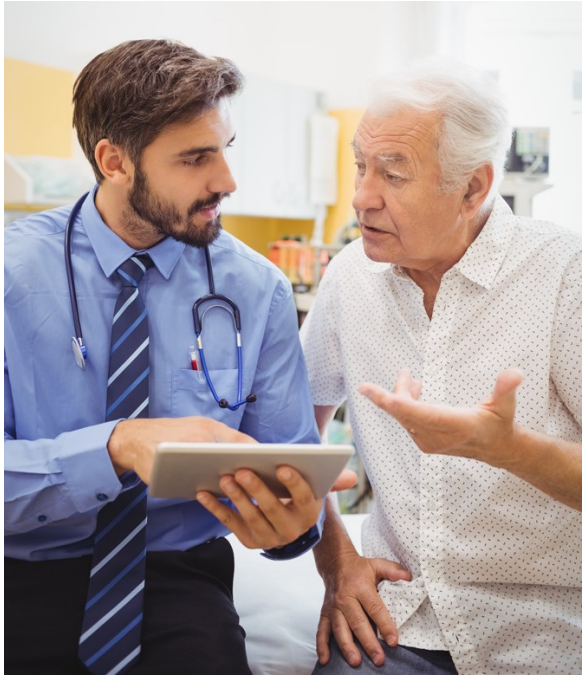
What is Precision Medicine?

"The tailoring of medical treatment to the individual characteristics of each patient"*



Precision Medicines 4 P's:

Predictive

Personalized

Participatory

Preventive

*Priorities for Personalized Medicine
President's Council on Advisors on Science and Technology, September 2008

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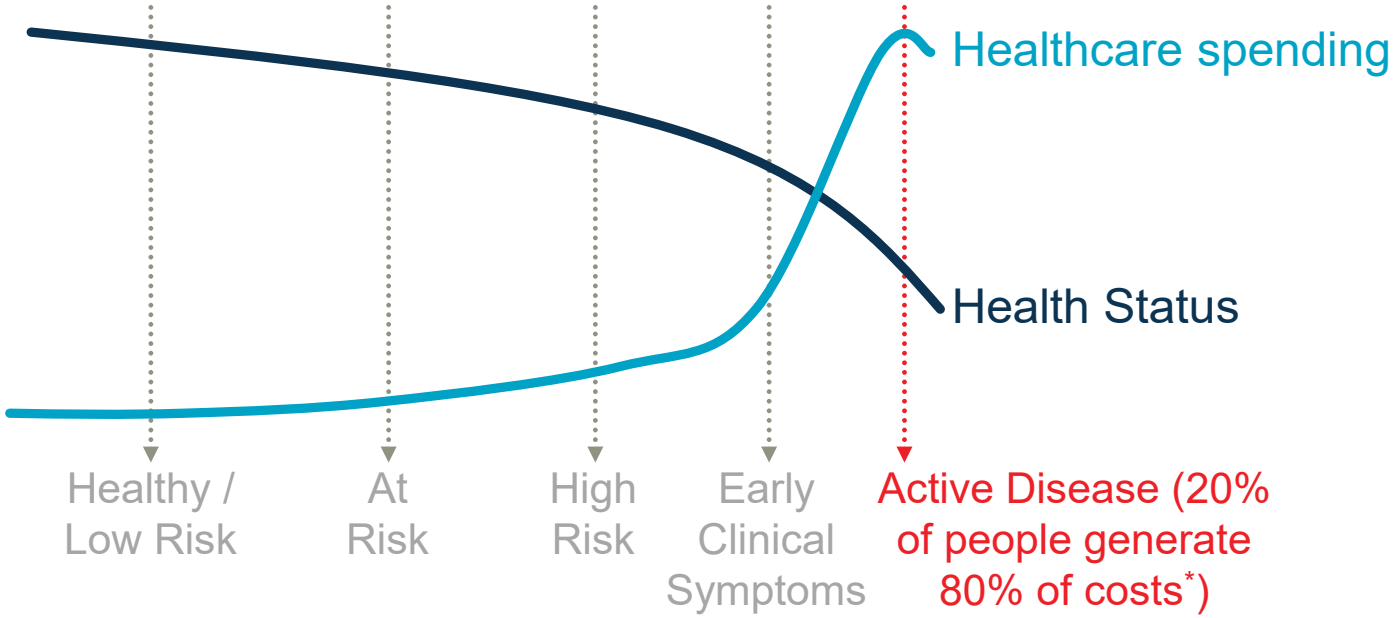
Can We Utilize Medical Data to Intervene Earlier?



- Early detection of at-risk patients
- Provide **personalized** evidence to enable proactive decisions

*Oregon State Sen. Alan Bates, Feb. 14, 2012

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Analytics Categories

Descriptive (85%)
Tells you what happened and often why

Predictive (12%)
Tells you what will happen

Prescriptive (3%)
Tells you what to do about it

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Example: one patient during 3 years (2003–2005)

Standard Complete Blood Counts (CBC) results

Test	16-Jul-03
WBC Leucocytes	8.1
RBC Red Blood Cells	5.48
Hemoglobin	15.7
Hematocrit	44.0
MCV Mean Cell Volume	80.3
MCH Mean Cell Hemoglobin	28.6
MCHC Mean Cell Hb Concent.	35.7
RDW Red Cell Distr. Width	15.0
Platelets	206.0

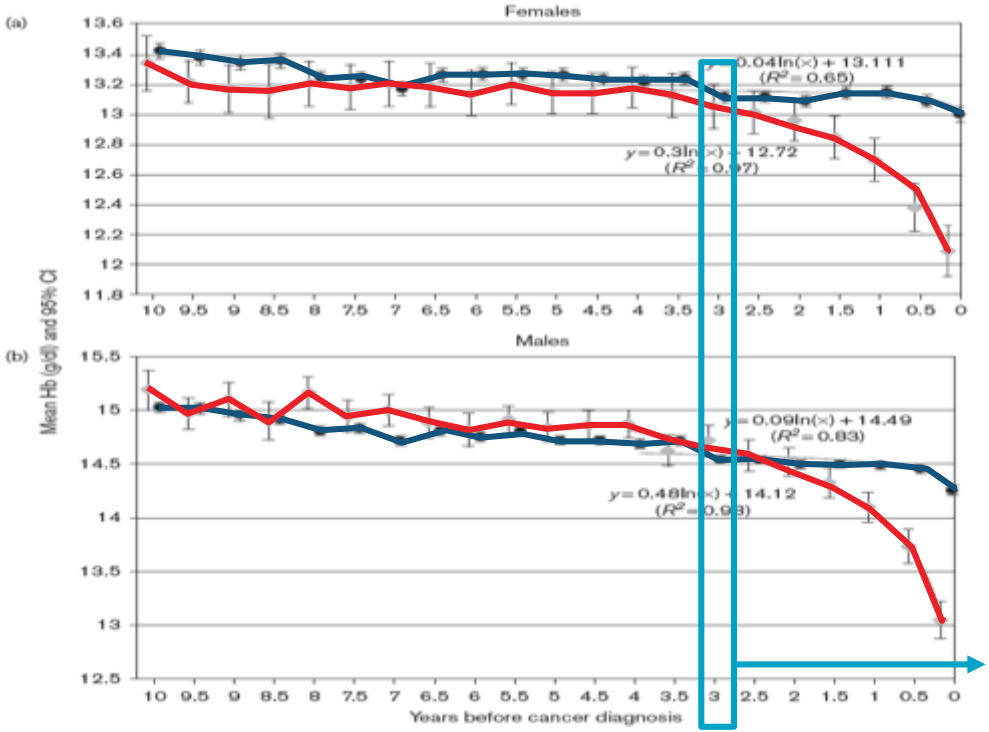
Diagnosis date: 28/12/2006

Within the norm

Previous CRC Work was Descriptive

Variations in hemoglobin before colorectal cancer diagnosis

Inbal Goldshtein, Uri Neeman, Gabriel Chodick and Varda Shalev



Controls: Random age, gender matched

Cases: N=1074, age 45-75

Hemoglobin level drops 3-4 years prior to current cancer diagnosis!

European Journal of Cancer Prevention 2010, 19:342–344

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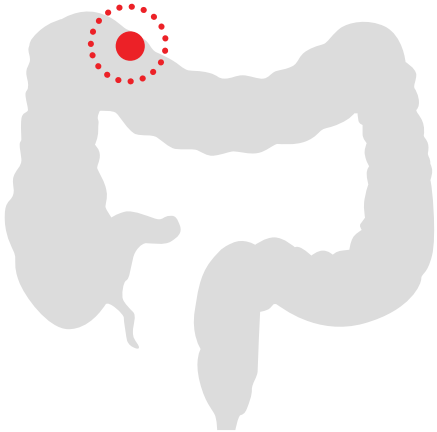
The Shift to Predictive Analytics → Machine Learning



Is it possible to proceed from an epidemiological **observation** to a personalized **predictive** risk score for Colorectal Cancer using Machine Learning?

A meaningful arrow…

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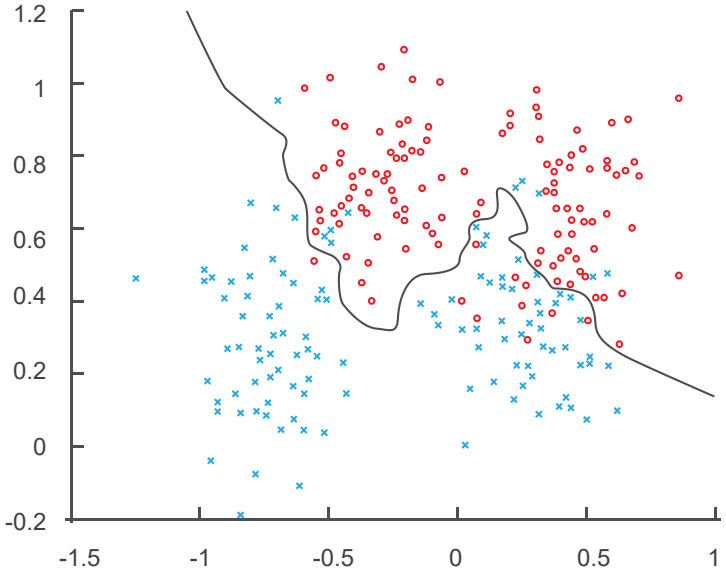
The Shift to Predictive Analytics → Machine Learning

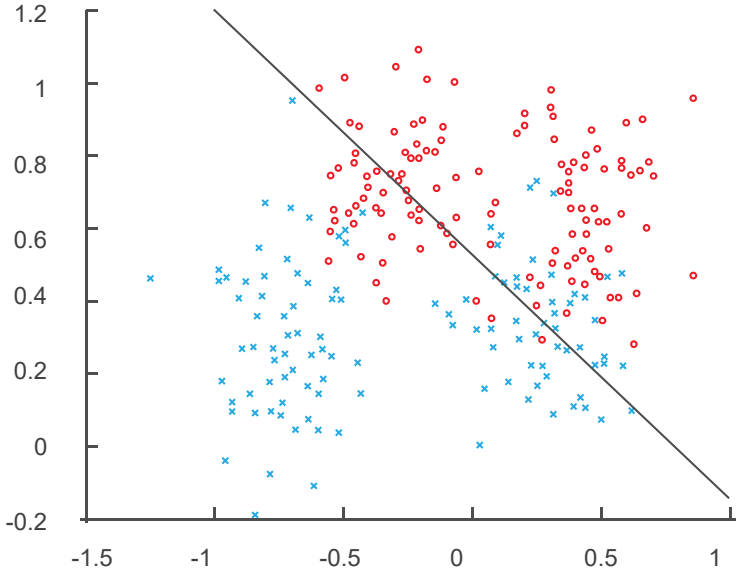
What is Machine Learning?

- A data analysis method which automates analytical model building
- Uses algorithms that learn from data iteratively
- Computers find patterns within a large amount of data without being explicitly programmed where to look

Machine Learning vs Regression Modeling

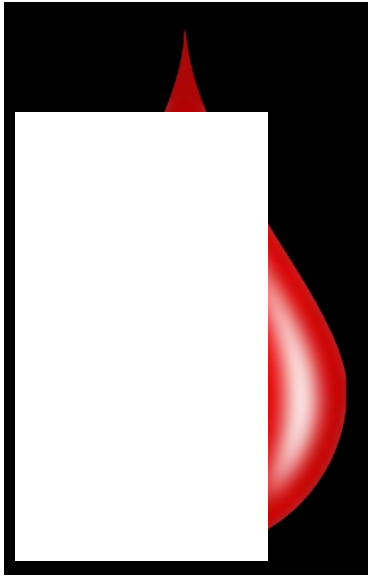


Machine Learning



Regression Modeling

Increased Risk Indicator*



Score
+
Age
+
Sex

Flagged Patient → Expedited Assessment

No Flag → Follow Guidelines

Predictive Model

Implemented by Maccabi, developed by a leading developer of machine learning-based healthcare solutions.

A meaningful arrow…

Model Implemented in Clinical Practice in Israel*

The machine learning-based model finds trends and variations within **normal ranges,** and was used by Maccabi to identify individuals at increased risk of CRC using only complete blood count (CBC) test results, age and sex.

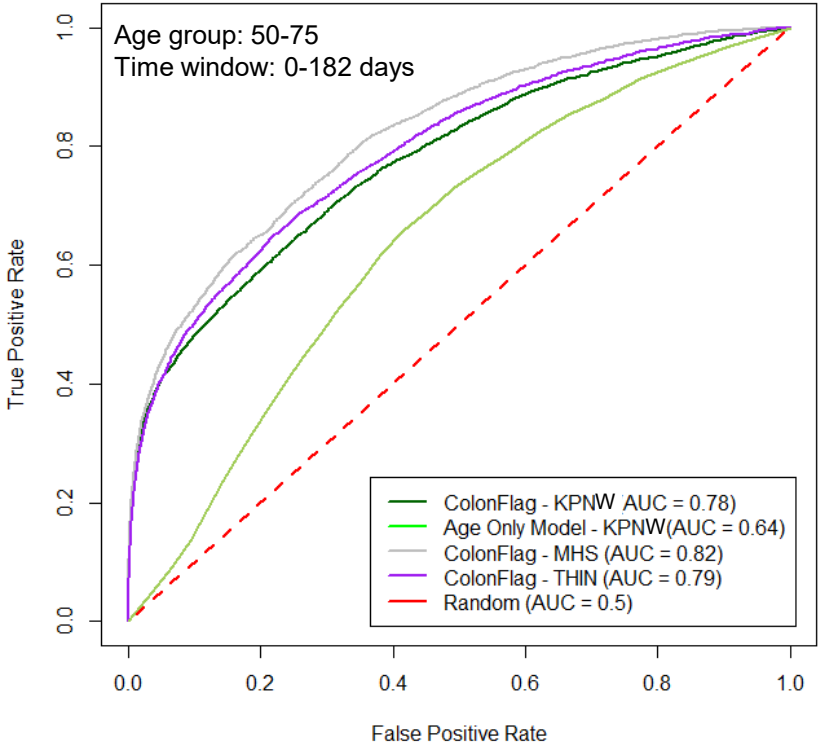
*Implemented by Maccabi, this model was developed by a leading developer of machine learning-based healthcare solutions in collaboration with Maccabi.

Clinical Rigor of AI-Based Algorithm

Create model	Maccabi (Israel)	Train & develop model (Derivation set) 466,107 people (2,437 CRC patients)
Check model performance on **"blind"** part of the same population		Blindly validate the model (Validation set) 139,205 people (698 CRC patients)
Check model performance on different population	THIN* (UK)	Blindly validate on independent data-set 25,613 people (5,061 CRC patients)
Worldwide Validation	World wide	Studies in leading institutions around the world (Oxford, KPNW, KPNC, CUHK) totaling 5M individuals

* The Health Improvement Network

Training & Validation Performance



Results show accuracy for independent studies in different populations

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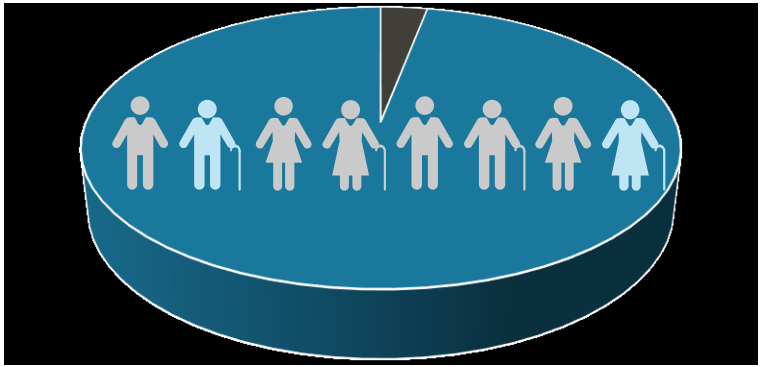
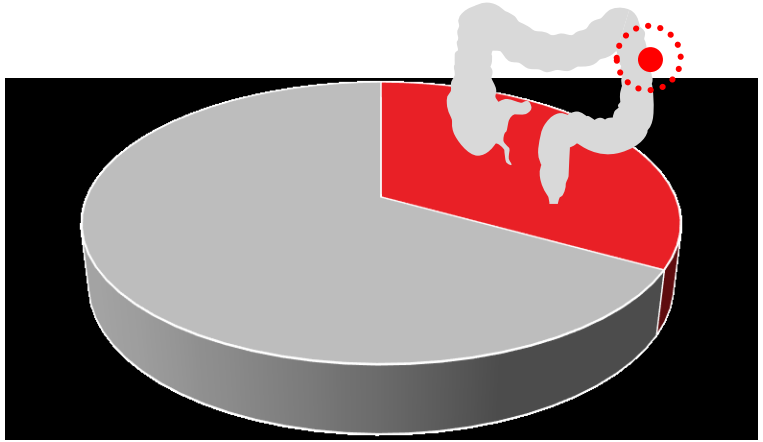
Performance at Curable Stages

3%
Flagged Population



33.1%
In Situ – Stage II
Cancers Detected



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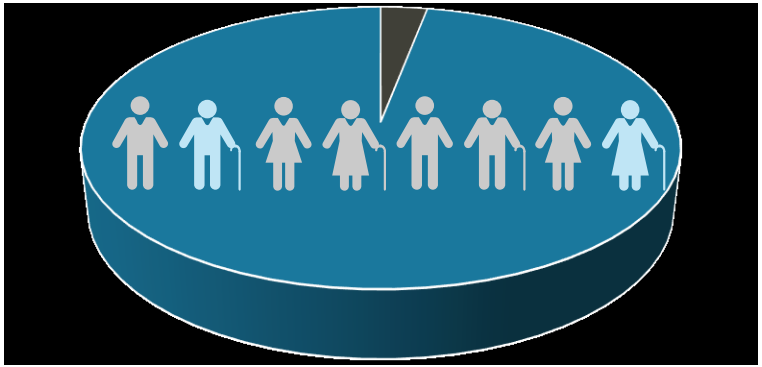
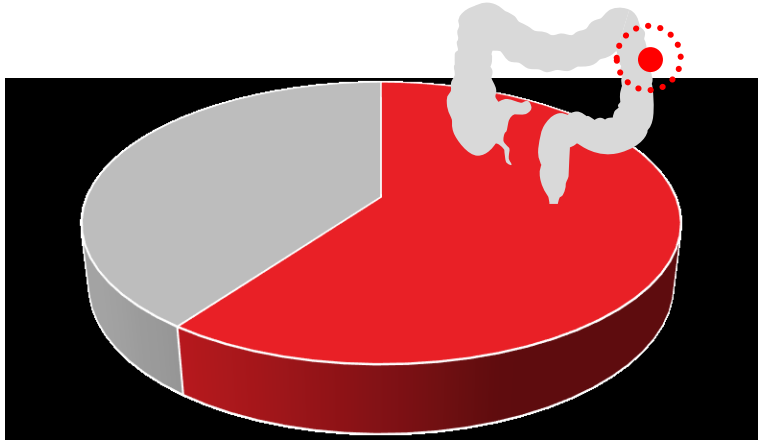
Overall Performance on Right-Sided Cancers

3%
Flagged Population



60%
Right-Sided Cancers Found



The Time Factor in CRC Survival Rate*

Typical 5 year survival rate for CRC decreases with time

90%
Stage I CRC

80%
Stage II CRC

40%
Stage III CRC

10%
Stage IV CRC

And yet…

Only 40%

Are diagnosed
at an early stage

A screening program is in place

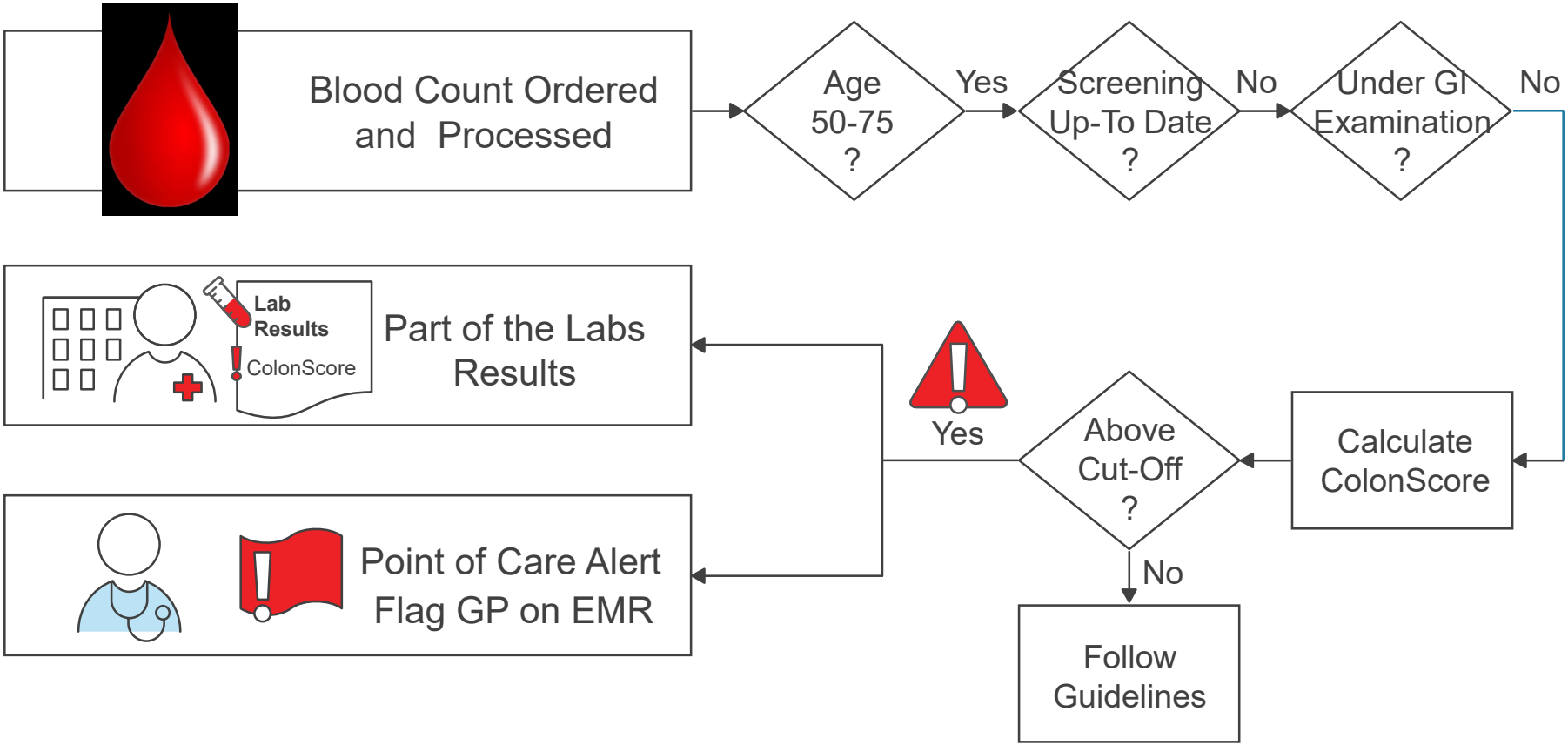
And yet …

~70% compliance

To screening

*National Cancer Institute

MHS Implementation Clinical Work Flow



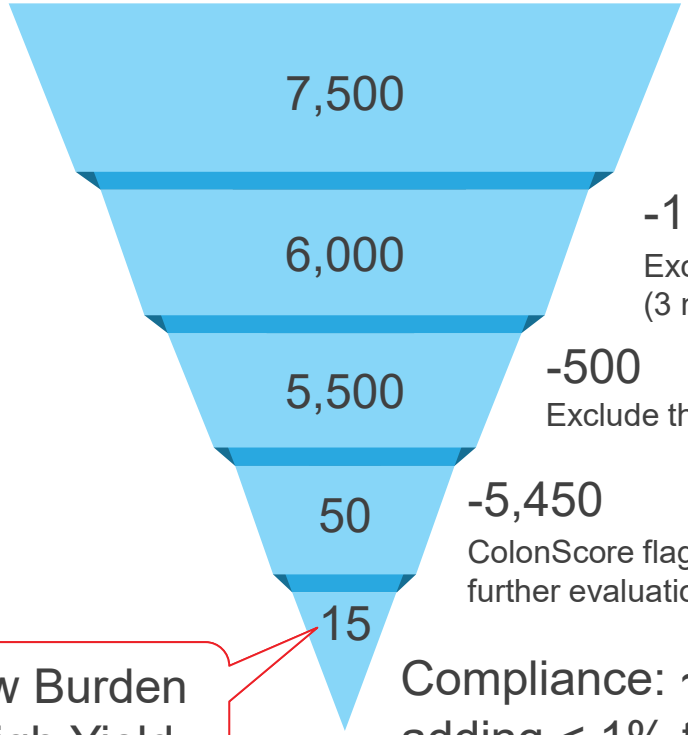
Passive screening – different approach

לכבוד
פרופסור ונדה שלו
מנהלת מכון המחקר ע"ש קלפר חולים מרכזי (מכביטק)

מרים
אני פונה אליך בקשר בתשובה מעניינת שהגיעה מטעם
המגזין של Marketweek מיום 24.12.2015,
בעניין המחקר שערכת לתקני אזורי סכנה בעזרת נתוני GPS.
בהקשר לפרסום אליך, אני רוצה להמליץ בפניה על הרעיון
שהגיע לי אצל דר' [redacted], מנהל אונקולוגיה, ד"ר מוסי 26.5.2016
בעזרת [redacted] יש בבעלות שלו רובוט המשמש לטיפול
[redacted], לשרות הבריאות הקליניקה, ולאחר שהבטיחו
קופות הרוח לי פרוטוקולים שקיבלתי בעזרת הבריקה.
דר' [redacted] אמר לי שהוא לא עושה הבריקה כדי שהיא
תהיה הבריקה יקרה, וכן "אם אם יש לך בעיה סכנה בעזרת GPS,
יקח לך 7-6 שניות עד שאתה תגלה. אז כמה זמן
אתה רוצה לחיות?!"
בסוף הבריקה אצל דר' [redacted] הוא נתן לי מכתב סיכום,
אשר ניתן מעל אני מצרף בזה.
חשבתי לאחר הניאור בבתיה ביתיתן הארץ, באם רובוט
המשמש שלי לבדיקה של סביבה GPS (קלוסקרו), שהוא לא אמור
לחיות הבריקה יקרה. ואם לא, באם אפשר לרשם אותן
לחיות גם מלא [redacted] לבדיקה כדי לרובוט המשמש אלי,

Maccabi's Monthly Volume Estimates

~25,000 monthly (50-75) outpatient blood counts test results



-17,500
Exclude those who are screening compliant

-1,500
Exclude those who are referred for GI consultation (3 m prior to index date)

-500
Exclude those who have a previous diagnoses of cancer

-5,450
ColonScore flags the top 1% highest risk population for further evaluation

Low Burden / High Yield

Compliance: ~20 Colonoscopies adding < 1% to colonscopy capacity

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Recent Publications (Retrospective)

Cancer Medicine
Accepted Aug. 12, 2017
doi: 10.1002/cam4.1183,

Cancer Medicine
Open Access
ORIGINAL RESEARCH

Evaluation of a prediction model for colorectal cancer: retrospective analysis of 2.5 million patient records

Jacqueline Birks[1], Clare Bankhead[2], Tim A. Holt[2], Alice Fuller[2] & Julietta Patnick[3]

[1]Oxford Biomedical Research Centre, Oxford University, Botnar Research Institute, Windmill Rd, Oxford, OX7 3LD, United Kingdom
[2]Nuffield Department of Primary Care Health Sciences, Oxford University, Radcliffe Observatory Quarter, Woodstock Road, Oxford, OX2 6GG, United Kingdom
[3]Cancer Epidemiology Unit, Nuffield Department of Population Health, Oxford University, Richard Doll Building, Old Road Campus, Oxford, OX3 7LF, United Kingdom

Digestive Diseases and Sciences
Accepted Aug. 11, 2017
(2017) 62:2719–2727

Early Colorectal Cancer Detected by Machine Learning Model Using Gender, Age, and Complete Blood Count Data

Mark C. Hornbrook[1] · Ran Goshen[2] · Eran Choman[2] · Maureen O'Keeffe-Rosetti[1] · Yaron Kinar[2,3] · Elizabeth G. Liles[1] · Kristal C. Rust[1,4]

Received: 24 June 2017 / Accepted: 11 August 2017 / Published online: 23 August 2017

Publication of Results of Implementation

JCO Clinical Cancer Informatics
Published March 29, 2018
doi: 10.1200/CCI.17.00130

original reports

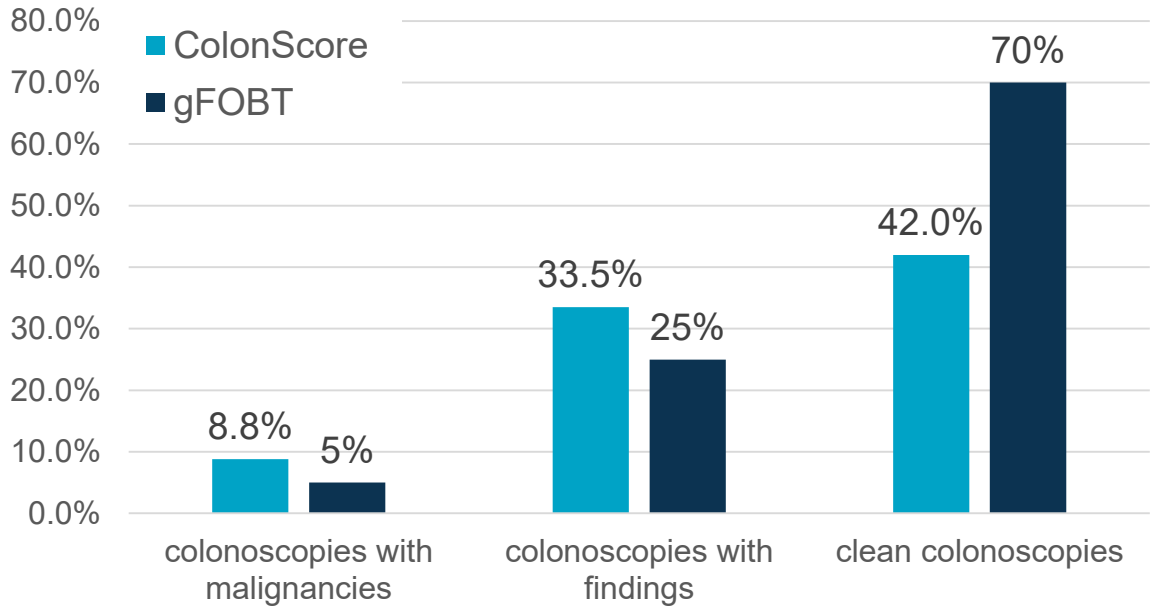
Computer-Assisted Flagging of Individuals at High Risk of Colorectal Cancer in a Large Health Maintenance Organization Using the ColonFlag Test

abstract

Purpose To evaluate in a sample of adults who had been noncompliant with colorectal cancer (CRC) screening whether screening could be enhanced by an automated patient recall system based on identifying high-risk individuals using the ColonFlag test and an electronic medical record database.

Performance of the Model vs. gFOBT

ColonScore Cut-off = 1%
FOBT Positivity rate = 2.5%



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ROI: Actual Results from Maccabi's work in Israel

Many lives saved for people whose cancers most likely would have otherwise been found too late

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Decide and Act - Quickly!

"Decisions should be based on 70% of the information.
If you wait to have 90% - you're too slow.

Making a mistake and correcting it is more efficient than not deciding"

Jeff Bezos, Amazon CEO

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Implementation - Key Lessons Learned

- Must embed within existing clinical path
- Strong champion within organization
- Immediate positive results get quick buy-in
- Personally address each and every stakeholder along the clinical path
- Easy IT integration
- Continuous and relentless commitment to organization
- Track and monitor performance

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Israel Ministry of Health 1st Place for Initiatives in Personalized Medicine

MINISTRY OF HEALTH
For a healthier life

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Thank You!

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