#### ARTIFICIAL INTELLIGENCE, CLINICAL DECISION SUPPORT AND BREAST CANCER TREATMENT

# COGNITIVE ARTIFICIAL INTELLIGENCE: IBM WATSON FOR ONCOLOGY



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# DISCLOSURE

- Representations and opinions expressed are solely my own and do not reflect those of any other party.
- Received no compensation from any party related to views expressed or performance of this work
- Thank collaborators: Manipal Oncology fellows, M-J. Sepúlveda M.D. Sc.D.,

# Manipal Comprehensive Cancer Center





# Manipal ANNADEL ADALATA

# Manipal Hospital, Bangalore

- ▶ 600 bed Quaternary care facility
- ▶ 53 specialties & 60 sub-specialties
- Ranked in the top 10 multi-specialty hospitals in India\*

ManipalHospitals

LIFE'S ON

\*(The Week-Hansa survey 2012)

 Best hospital in Bangalore for 10 consecutive years\*

\*(The Week - AC Nielsen Survey 2013)

- 1<sup>st</sup> Hospital in Karnataka, India to introduce Robotic Surgery
- NABH and NABL accredited
- ISO 9001:2000

#### **Smart Hospital**



- Triad of Technology and New evidence based access, Early adaption
- And Integration and making most Patient Friendly Hospital
- And giving world class health care

Intelligent hospital is one that works better and smarter. It's better because it's resourceful, creative, and perceptive about what patients and doctors need and it's smarter because it's astute and inventive when it comes to weaving together diverse technologies to enhance patient care.





Manipal Integrated Services



Manipal Hospitals

Manipal Education



# Manipal Education

# PURPOSE AND OBJECTIVES

#### **Objectives:**

- Define AI and illustrate its growth in health care.
- Discuss selected clinical decision support system considerations.
- Present the breast cancer concordance study.

#### <u>Purpose:</u>

to describe concordance of treatment recommendations made by the Manipal Hospital Multidisciplinary Tumor Board (MMDT) and an AI treatment decision support system (IBM Watson for Oncology) for breast cancer in India.

#### Term Al origin:

AI was coined by John McCarthy, an American computer scientist, in 1956

at The Dartmouth Conference where the discipline was born.

However, there exists No standard universally accepted definition AI

Numerous definitions generally grouped into 4 system categories

• After describing "Systems that Think Like Humans—based on modeling cognitive functions of reasoning, inference and learning

#### **Background**

**Turing Test** (http://theconversation.com/person-or-computer-could-you-pass-the-turing-test-6769)

- One of Turing's many signal contributions was a <u>1950 article</u> that defined what is now known as the <u>Turing Test</u>.
- In it, he proposed a test in which a human "converses" with two entities one human and one computer program over a text-only channel (i.e., a computer keyboard/screen), and then
  attempts to determine which is the human and which is the computer.
- If after, say, five minutes of testing, the majority of human interrogators are unable to determine which is which, Turing said that we could claim the computer system has achieved a certain level of intelligence.

#### Deep Blue

At the heart of Deep Blue's ability to play chess is its evaluation function. The evaluation function is an algorithm that measures the "goodness" of a given chess position. Positions with positive values are good for White, and conversely, positions with negative values are good for Black. If the overall score is negative, for example, this means that Black has the advantage. Deep Blue's evaluation function looks at four basic chess values: material, position, King safety and tempo. Material is based on the "worth" of particular chess pieces. https://www.research.ibm.com/deepblue/meet/html/d.3.2.html

# COGNITIVE SYSTEMS



Corpus of Clinical Knowledge Has Expanded Beyond Capacity of Human Cognition



... and vast amounts of data that can have a great impact on our health remains untapped.

#### Health Determinents

60% Exogenous Factors

30% Genomics Factors

Clinical Factors





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# **Breast cancer and Oncologist**

- As of Oct 2017 there are 67 approved new drugs to treat Breast cancer not including combination treatment regimens
- The growth of massive Genetic and clinical database leaves little time for accessing relevant information at point of care

A study that surveyed 1117 Oncologists, reported an average of 4.6 hours per week were spent to update and keep abreast of recent trials and drugs

- Seidman AD. Computer-Assisted Decision Support in Medical Oncology: We Need It Now. In ASCO Post 2016. http://www.ascopost. com/issues/april-10-2016/computer-assisted-decision-support-in-medi cal-oncology-we-need-it-now/ (16 December 2017, date last accessed).
- Pusic M, Ansemnino JM. Clinical decision support systems. BCMJ 2004; 46: 236–239.

#### On a daily basis clinicians are challenged with...

Understanding the patient	Formulating treatmen	t Selecting personalized
condition	options	treatment plans

...given disparate sources and ...based varying completeness

...based on latest guidelines and medical literature ...based on comorbidities, conditions, contraindications, side effects for a patient's specific clinical attributes

#### On a daily basis researchers are challenged with...

Staying up to date on researc literature	Exploring and uncovering novel connections	Generating new insights for future research
like rapidly increasing volume of research literature	looking across scientific domains for new relationships between diseases, genes, and drugs	to develop valid hypotheses with the potential to lead to groundbreaking discoveries



# AI REINVENTING MEDICAL PRACTICE

# THE DIGITAL HOSPITAL: 82 COMPANIES REINVENTING THE PRACTICE OF MEDICINE



# AI HEALTHCARE MARKET FORECAST, U.S. (MILLIONS US)



CDS Global Market Forecast P&S Market Research

https://www.psmarketresearch.com/market-analysis/clinical-decision-support-system-market



# I CLINICAL DECISION SUPPORT



Adoption, Use, Value Factors

- Content: e.g. relevant, complete, current
- Information provided: e.g. valid, reliable, references accessible
- Usability: e.g. comprehensible, simple, efficient, easy to use
- Workflow integration
- EHR integration
- CDS-related Patient Safety

BATES ET AL. J AM MED INFORM ASSOC. 2003;10:523 - 530. KHALIFA M. PROCEDIA COMPUTER SCIENCE 37 ( 2014 ) 422 - 427.

# Selected AI CDS Evaluation Criteria

CDS are interactive computer applications that are designed to assist clinicians and other providers of care to make decisions.

### Adoption, Use and Value Factors:

A CDS system must provide scientific proof, that it meets these key performance requirements with rigorous evaluation in the design, development, implementation and maintenance of the CDS.

		Strength of
	<u>Description</u>	<u>Evidence</u>
<u>Component</u>		
Natural Language Processing: Understanding and Supported Input Data	Structured & Unstructured Clinical Information	
	<u>Structured &amp;</u> <u>Unstructured</u> Medical Knowledge	
	<u>Structured &amp;</u> <u>Unstructured</u> Clinical Guidelines	
Medical Logic	Generates Attributes, inputs and Insights for the Inference Engine	
Expert Training	Coverage & Depth of Training Cases	
Usability	Comprehensibility, Ease, Simplicity, Efficiency, Accessibility	
EHR/HIS Integration	System automates data identification, abstraction, input	
Workflow Integration	Right place, time, person in natural workflow	
This presentation	n is the intellectual r	operty of the author/pr

# Watson for Oncology: How it Works



# What is the Watson System?

IBM Watson is a technology platform that uses natural language processing and machine learning to reveal insights from large amounts of unstructured data.



# Software, Hardware, and Data

 Uses IBM's DeepQA software and Apache UIMA (Unstructured Information Management Architecture)
 generate hypotheses, gather massive evidence, and analyze data



Watson can process 500 gigabytes, the equivalent of a million books, per second

- D Written using Java, C++, Prolog
- sources of information for Watson include encyclopedias, dictionaries, thesauri, newswire articles, and literary works

# WFO Training: Memorial Sloan–Kettering Cancer Center



#### WATSON'S BACKGROUND EWADING ON ONCOLOGY





# **Medical journal concept annotations**

**IBM Watson** 

#### **Natural Language Processing (NLP)**

		Diseases Symptoms
Relations causeOf	1	Chamarthi, Bindu; Morris, Charles A.; Kaiser, Ursula B.; Katz, Joel T.; Loscalzo, Joseph
modifierOf negationOf	2	Stalking the Diagnosis
partOf	з	362/9/834
remedyOf resultOf	4	http://content.nejm.org/cgi/content/full/362/9/834 A 58-year-old woman presented to her primary care physician after several days of dizziness, anorexia, dry mouth, increased thirst, and frequent urination. She had also had a fever and reported that food would "get stuck" when she was swallowing. She reported no pain in her abdomen, back, or flank and no cough, shortness of breath, diarrhea, or dysuria. Her history was notable for cutaheous lupus, hyperlipidemia,
	5	osteoporosis, frequent urinary tract infections, three uncomplicated cesarean sections, a left oophorectomy for a benign cyst, and primary hypothyroidism, which had been diagnosed a year earlier. Her medications were levothyroxine, hydroxychloroquine, pravastatin, and alendronate. She lived with her husband and had three healthy adult children. She had a 20-pack-year history of smoking but had <u>quit 3 weeks before</u> presentation. She reported no alcohol or drug abuse and no exposure to tuberculosis. Her family history included oral and bladder cancer in her mother, Graves' disease in two sisters, hemochromatosis in one sister, and idiopathic thrombocytopenic purpura in one sister.
		Medications

# WFO Case Attribute Summary and Help Screens

View More	DEMOGRAPHICS Age: <b>55</b> Gender: <b>Female</b>	DISEASE Cancer ty	E STATUS	Select to informati the treatr	submit your new clir on to Watson and up nent plan options.	date	Ask Watsor
linical Ir	nformation					Sele	ect to view atment plan ions.
ummary	All Attributes	Notes 1	limeline	Diary	Filt	ter: <b>T</b> Filter	-
nown patie	nt attributes						
Patient chara	acteristics						
Gender	Female ~	Age	55	years old	Weight	89	kgs
Perform status	ECOG 0 (Asymptomatic) or KPS 90-100	Menopausal status	Postmenopaus	sal 🗸	Family history and risk factors for	Yes	~
Select to view de	etails				breast cancer		



## WFO Output

- Analyzes >100 patient attributes for breast cancer
- Some user attribute abstraction and WFO entry
- RX recommendations ranked in 3 color categories:
  - Green: Recommended Rx (REC)
  - Amber: For Consideration (FC)
    - Meet: Not RECommended (N-REC)

Provides supporting evidence

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Select a clinical that	Chemotherapy followed by surgery followed b	y endocrine therap	y and radiation therapy	1
Chenotherapy followed by surgery followed by endocrine therapy and radiation therapy	Tensine for Treethert Plan (shown in plant)			
More healthent plan options	Concerning Support	н н.	e 19 1	
	Treatment Options	Conditional II McDaca	cooki :	Sectored plan
	E Chendherapy	I logg	I lines	E faiste
	Dona-dense AC (Docendrice / Carlsphosphamole) Molesed by T (Packland)	Advecto ->	(anomalianti )	Referantion admitter of a
Click on the ">" beside each treatment			Automated 3	
regimen OR click on the title of the regimen to see	PEC (Flamoratil: Epitation / Epitation/Amination Monethy Section		Secondary (	
regimen	FEC Flamanal - Epindece - Optightinghemater			

# MDA Levels of Evidence Definition

#### Levels of Evidence explained

#### Level of Evidence

×

For drug effectiveness in a specific tumor type harboring a specific biomarker



#### Can compare two treatment options with evidence

IBM Watson™ for Oncology						_ mhbdc1136	🗢 Feedback 🕐 Inform	ation ① Notices
View more     DEMOGRAPHICS     Age: 68 Gender: Female	Performance	e status: 0 C	DISEASE STATUS Cancer type: <b>Breast can</b>	cer Cancer stage: IIB	TREATMENT HIST Surgery: Mastectomy	ORY Chemotherapy: Not specified		
Chemotherapy followed b	y radiati	ion therapy						
Chemotherapy		Dose-dense AC (D	ovorubicin / C	olophosphamid	e) followed by T	(Paclitavel)		nt comparison
Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)	>	Overview Additiona	I Publications	Administration [	Drug Information	(Facilitatei)		Print ouidonas
TAC (Docetaxel / Doxorubicin / Cyclophosphamide)	> -						<b>U</b>	- Frint evidence
AC (Doxorubicin / Cyclophosphamide) followed by Docetaxel	>	Rationale						Î
EC (Epirubicin / Cyclophosphamide) followed by T (Paclitaxel)	>		Dose-dense AC followed by T (P	(Doxorubicin / Cyclo aclitaxel)	phosphamide)	AC (Doxorubicin / Cyclop Docetaxel	bhosphamide) followed b	y V
FAC (Fluorouracil / Doxorubicin / Cyclophosphamide followed by Paolitaxel	>	Treatment Recommendation	Recommended			For Consideration		
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel	>	Supporting Rationale	This treatment is rec when zero to three ly	ommended for patients wit mph nodes are positive.	h triple-negative tumors	This treatment is acceptable for when zero to three lymph nodes	patients with triple-negative tum are positive.	ors
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Paclitaxel	>	Refuting Rationale						
CMF (Cyclophosphamide / Methotrexate / Fluorouracil)	>	(≆) MSK curated lit	erature about the	se treatments				
TC (Docetaxel / Cyclophosphamide)	>	0						
FAC (Fluorouracil / Doxorubicin / Cyclophosphamide	>	Randomized	trial of dose-der	ise versus convei	ntionally schedule	ed and sequential versu	s concurrent	$\ominus$
CAF (Cyclophosphamide / Doxorubicin / Fluorouraci	>	combination (	chemotherapy a oroup Trial C97	s postoperative a 41/Cancer and L	djuvant treatmen eukemia Group P	t of node-positive prima 3 Trial 9741	ry breast cancer: firs	t
EC (Epirubicin / Cyclophosphamide)	>	Citron ML, Berry DA, C	Cirrincione C, Hudis C, Wi	ner EP, Gradishar WJ, David	son NE, Martino S, Livingsto	n R, Ingle JN, Perez EA, Carpenter J, H	Hurd D, Holland JF, Smith BL,	
CEF (Cyclophosphamide / Epirubicin / Fluorouracil)	>	Sartor CI, Leung EH, A chemotherapy as post	Abrams J, Schilsky RL, Mu operative adjuvant treatm	iss HB, Norton L. Randomize ant of node-positive primary b	ed trial of dose-dense versus preast cancer: first report of l	conventionally scheduled and sequenti Intergroup Trial C9741/Cancer and Leuk	ial versus concurrent combination kemia Group B Trial 9741. J Clin	
AC (Doxorubicin / Cyclophosphamide)	>	Uncol. 2003 Apr 15;21	(o):1431-9. Pubmed PMIL	/. 12008091.				
Radiation		Outcome	Result	Additional Information				
Referral to radiation oncology	>	Disease Outcom	es					
		Disease-Free Sun	vival. 1 vr 95%	936 out of 985				~

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# Can compare two treatment options with evidence

BM Watson™ for Oncology							👤 mhbdc1138	Feedback	<li>? Information</li>	Notices
View more     DEMOGRAPHICS     Age: 68 Gender: Femal	e Performa	nce status: 0	DISEASE STATUS Cancer type: Breast cancer C	ancer stage: IIB	TREATMENT HISTOR Surgery: Mastectomy	Υ Chemotherapy:	Not specified			
← Chemotherapy followed I	oy radi	ation therapy								
Chemotherapy	^	Dose-dense AC	(Deverybicin / Cycle	bosphamide	) followed by T (F	Paclitavel	,	⊕ Sel	ect a treatment to c	ompare
Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)	>	Overview Addit	ional Publications Adm	inistration D	rug Information	acintaxei	,	0	C Print	evidence
TAC (Docetaxel / Doxorubicin / Cyclophosphamide)	>	Rationale								~
AC (Doxorubicin / Cyclophosphamide) followed by Docetaxel	>	This nega	treatment is recommended for tive tumors when zero to thre	or patients with tri ee lymph nodes a	ire	The cumulat treatments s	ive lifetime dos hould be taken	e of previous a into considera	inthracycline tion for this	
EC (Epirubicin / Cyclophosphamide) followed by T (Paclitaxel)	>		ive.			treatment.				
FAC (Fluorouracil / Doxorubicin / Cyclophosphamide) followed by Paclitaxel	>									
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel	>	Disease-Free Surv	val, 1 yr	Disease-Free Su	urvival, 2 yr		Disease-Free Sun	vival, 2 yr		
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Paclitaxel	>	95*	B	87	%	₿	90	1 %	B	
CMF (Cyclophosphamide / Methotrexate / Fluorouracil)	>	936 out of 985		857 out of 985			446 out of 495	• •		
TC (Docetaxel / Cyclophosphamide)	>									
FAC (Fluorourscil / Doxorubicin / Cyclophosphamide)	>	Disease-Free Surv	val, 2 yr	Disease-Free St	urvival, 2 yr	B	Disease-Free Sun	vival, 3 yr	B	
CAF (Cyclophosphamide / Doxorubicin / Fluorouracil)	>	81.	4	90	.4		81			
EC (Epirubicin / Cyclophosphamide)	>	272 out of 334		1462 out of 1618	в		798 out of 985			
CEF (Cyclophosphamide / Epirubicin / Fluorouracil)	>	Disease-Free Surv	ival, 4 yr	Disease-Free St	urvival, 4 yr		Overall Survival, 2	yr		
AC (Doxorubicin / Cyclophosphamide)	>		B	00	<b>•</b> %	B	04	<b>^</b> %	B	
Radiation		(5)	E	80	.2		94	.3	E	~
Referral to radiation oncology	> ~									

# Supporting Evidence for the Recommended Treatment with Recent Trials

IBM Watson™ for Oncology					<b>2</b> -	nhbdc1138	🤿 Feedback	Information	() Notices
View more     DEMOGRAPHICS     Age: 68 Gender: Female	Performance status: (	DISEASE : Cancer type	STATUS : <b>Breast ca</b>	ncer Cancer stage: IIB	TREATMENT HISTORY Surgery: Mastectomy Chemotherapy: Not s	pecified			
Chemotherapy followed b	y radiation t	herapy							
Chemotherapy	^ Doso	dense AC (Deveruh	icin / C	volophosphamid	a) followed by T (Paclitaxel)		⊕ se	ect a treatment to	compare
Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)	> Overvie	ew Alditional Publica	ations	Administration D				O Pri	int evidence
TAC (Docetaxel / Doxorubicin / Cyclophosphamide)	>	MSK curated literature a	about thi	s treatment				<b>.</b>	^
AC (Doxorubicin / Cyclophosphamide) followed by Docetaxel	>	Randomized trial of o	dose-de	ense versus conver	ntionally scheduled and sequenti	al versus	s concurrent		$\overline{\bigcirc}$
EC (Epirubicin / Cyclophosphamide) followed by T (Paclitaxel)	5	combination chemoti report of Intergroup	herapy a Frial C9	as postoperative a 741/Cancer and Le	djuvant treatment of node-positiv eukemia Group B Trial 9741.	e prima	ry breast ca	ncer: first	
FAC (Fluorouracil / Doxorubicin / Cyclophosphamide) followed by Paclitaxel	>	Citron ML, Berry DA, Girringione C Sartor CI, Leung EH, Abrams J, Se chemotherapy as postoperative ad	<u>Hudis C, W</u> chilsky RL, N ljuvant treatn	liner EP, Gradishar WJ, Davids Iuss HB, Norton L. Randomize nent of node-positive primary b	on NE, Martino S, Livingston R, Ingle JN, Perez EA, ( d trial of dose-dense versus conventionally scheduled reast cancer: first report of Intergroup Trial C9741/Ca	arpenter J. H and sequentiation and Leuk	lurd D. Helland JF. al versus concurren emia Group B Trial	Smith BL, combination 9741. J Clin	
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel	>	Oncol. 2003 Apr 15;21(8):1431-9.	Pubmed PM	ID: 12668651.					
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Paclitaxel	>	Outcome Disease Outcomes	Result	Additional Information					
CMF (Cyclophosphamide / Methotrexate / Fluorouracil)	>	Disease-Free Survival, 1 yr	95%	936 out of 985					
TC (Docetaxel / Cyclophosphamide)	>	Disease-Free Survival, 2 yr	87%	857 out of 985					
FAC (Fluorouracil / Doxorubicin / Cyclophosphamide)	>	Disease-Free Survival, 2 yr	90.1%	448 out of 495					
CAF (Cyclophosphamide / Doxorubicin / Fluorouracil)	>	Disease-Free Survival, 3 yr	81%	798 out of 985	_				
EC (Epirubicin / Cyclophosphamide)	>	Disease-Free Survival, 4 yr	75%	739 out of 985					
CEF (Cyclophosphamide / Epirubicin / Fluorouracil)	>	Disease-Free Survival, 4 yr	80.2%	397 out of 495					
AC (Doxorubicin / Cyclophosphamide)	>	Overall Survival, 2 yr	94.3%	929 out of 985					
Radiation		Overall Survival, 2 yr	94.9%	470 out of 495					~
Referral to radiation oncology	> ~								

#### INFORMATION ABOUT DRUG ADMINISTRATION

IBM Watson™ for Oncology					nhbdc1136	🗢 Feedback	Information	Notices
View more     DEMOGRAPHICS     Age: 68 Gender: Female	Perform	ance status: 0	DISEASE STATUS Cancer type: Breast cancer Cancer stage: IIB	TREATMENT HISTORY Surgery: Mastectomy Chemothe	rapy: Not specified			
← Chemotherapy followed b	y radi	iation therapy						
Chemotherapy	^	Doco donco AC	C (Deverybicin / Cyclopherpham	ide) followed by T (Paelita	avel)	⊕ se	lect a treatment to cr	ompare
Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)	>	Overview Addit	tional Publications Administration	Drug Information	ixel)		Print a	avidance
TAC (Docetaxel / Doxorubicin / Cyclophosphamide)	>	Treatment: Cher	motherapy				<b>1</b>	^
AC (Doxorubicin / Cyclophosphamide) followed by Docetaxel	>	Administration (cho	ose one):					
EC (Epirubicin / Cyclophosphamide) followed by T (Paclitaxel)	>	Doxorubicin 60 m on day 1: Cycled	g/m2 on day 1; Cyclophosphamide 600 mg every 14 days for 4 cycles. This dosing regi	/m2 on day 1; Cycled every 14 day	ys for 4 cycles. Foll imen with weekly p	owed by: Paclit aclitaxel, vet re	axel 175 mg/m2 quires 3 addition	al
FAC (Fluorouracil / Doxorubicin / Cyclophosphamide) followed by Paclitaxel	>	cycles of growth fa complete the regin	factor support. For patients experiencing gro men.	wth factor-related bone pain durin	ng AC chemotherap	y, consider we	ekly paclitaxel to	
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel	>	Doxorubicin 60 m	ng/m2 on day 1; Cyclophosphamide 600 mg arv 7 days for 12 cycles	/m2 on day 1; Cycled every 14 day	ys for 4 cycles. Foll	owed by: Paclit	taxel 80 mg/m2 o	n
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Paclitaxel	>	Base treatment administ	tration information is provided by MSK for reference p	urposes only. Patient-specific dosing must	t be determined based o	on the patient's ind	ividual presentation a	and
CMF (Cyclophosphamide / Methotrexate / Fluorouracil)	>	calculated separately.						
TC (Docetaxel / Cyclophosphamide)	>							
FAC (Fluorourscil / Doxorubicin / Cyclophosphamide)	>							
CAF (Cyclophosphamide / Doxorubicin / Fluorouracil)	>							
EC (Epirubicin / Cyclophosphamide)	>							
CEF (Cyclophosphamide / Epirubicin / Fluorouracil)	>							
AC (Doxorubicin / Cyclophosphamide)	>							
Radiation								~
Referral to radiation oncology	×							

#### DRUG INFORMATION

<form></form>	IBM Watson™ for Oncology	👱 mhbdol 138 🗢 Feedback 🗇 H	nformation 🔅 Notice
• Chance of a constraint of	DEMOGRAPHIC8     Age: 68 Gender: Female Perfor	Ance status: D DIBEASE STATUS DIBEASE STATUS Cancer type: Breast cancer Cancer stage: IBB Urgery: Macteotomy Chemotherapy: Not specified	
• Conductors   • Constructor	Chemotherapy followed by rac	iation therapy	
TA: Electrical / Economical / Economical / Contraindications (Porture Reactions Reported Incidence %   Adverse Reactions Reported Incidence %   Contraindication / Contraindications (Porture Reactions Reported Incidence %   Contraindication / Contraindication / Contraindications (Porture Reactions Reported Incidence %)   Contraindication / Contraindication / Contraindication (Porture Reactions Reported Incidence %)   Contraindication / Contraindication / Contraindication (Porture Reactions Reported Incidence %)   Contraindication / Contraindication / Contraindication (Porture Reactions Reported Incidence %)   Contraindication / Contraindication / Contraindication (Porture Reactions Reported Incidence %)   Contraindication / Contraindication (Porture Reactions Reported Incidence %)   Contraindications (Precautions / Contraindications (Precautions (Porture Reactions Reported Incidence %)   Contraindications (Precautions (Porture Reactions Reported Incidence %)   Contraindications (Precautions (Precau	Chemotherapy Doce-dence AC (Doxorubioin / Cyclophocphamide) followed by T (Paolitaxel)	Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)	satment to compare
Advancement (2) space space in the spa	TAC (Docetaxel / Doxorubicin / Cyclophosphamide)		C Princevidence
No. distribution / Option parametai biological Parametai / Option parametai biological Parametai / Option parametai parame	AC (Doxorubicin / Cyclophosphamide) followed by Docetavel	Adverse Reactions Reported Incidence %	â
The control / Control (Purport (Pu	EC (Epirubicin / Cyclophosphamide) followed by T > (Pacitaxel)	Cyclophosphamide	⊝
Education (Cyclophoneprined) > Churcher (Cyclophoneprined) >	FAC (Fluorourscil / Doxorubicin / Cyclophosphamide) >	Doxorubicin	⇒
Tel:// Luncimutation / Opticipationary (Sectionary Processing)       Image: Sectionary (Sectionary Processing)       Image: Sectionary Procesing)       Image: Sectionary Processing)	FEC (Fluorouracii / Epirubicin / Cyclophosphamide) 5		0
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I Closethaser(-Closethase	CMF (Oyclophosphamide / Methotrexate / Fluorouracii)	B Black Box Warning     D	
PAC // Buonuschi //	TC (Docetaxel / Cyclophosphamide)	Expand All	I Collapse All
CAP (0) clopping planeticies / Planeticie	FAC (Fluorouracii / Doxorubicin / Cyclophosphamide)	Cyclophosphamide	
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ICLEF (Clyclophosphamide / Epinuloich / Pluorouse)       >         A C (poconucich / Clyclophosphamide)       >         Image: Closense (Closense	EC (Epirubicin / Cyclophosphamide)	<ul> <li>Contraindications/Precautions</li> </ul>	
A c (Docorubicity / Cyclophosophemidie) <ul> <li>Rediction</li> </ul> <ul> <li>Reference is no collogy</li> </ul> <ul> <li>a cardiac cardiac cardiaction</li> <li>a cardiac cardiaction</li> <li>a cardiaction</li> <li></li></ul>	CEF (Cyclophosphamide / Epirubicin / Fluorouracii)	Contraindications 00	
Reduction       N         Reternal to radiation oncology       N         Reternal to radiation oncology       N         Image: Comparison on cology       N	AC (Doxorubicin / Cyclophosphemide)	bladder obstruction     bladder obstruction	
Patternal to radiation ancology         Interculting intercultin	Radiation	- Precautions ()	
Implicit organization       Implicit organization       Implicit organization       Implicit organization         Implicit organization       Implicit organization       Implicit organization       Implicit organization       Implicit organization	Referral to radiation oncology >		
<ul> <li>cardiac antrydninias</li> <li>cardiac disease</li> <li>dental disease</li> <li>dental work</li> <li>dataysis</li> </ul> <ul> <li>dental disease</li> <li>dental disease</li> <li>heart failure</li> <li>hemotinis</li> <li>hemotinis</li></ul>		Gone marrow suppression	
<ul> <li>dental disease</li> <li>dental work</li> <li>dental uses</li> <li>heart failure</li> <li>hematuria</li> <li>hematuria</li></ul>		cardiac antrythmias     cardiac disease     cardiac tamponade	
<ul> <li>geniatric IM</li> <li>heart fallure</li> <li>heart fallure</li> <li>hementuria</li> </ul> <ul> <li>hemonihagic cystils</li> <li>infection</li> <li>infectility</li> <li>leukopenia</li> </ul> <ul> <li>myocarditis</li> <li>pericarditis</li> <li>pericarditis</li> </ul> <ul> <li>pericarditis</li> <li>pericarditis</li> </ul> <ul> <li>pericarditis</li> <li>pericarditis</li> </ul> <ul> <li>pericarditis</li> <li>pericarditis</li> </ul> <ul> <li>pericarditis</li> <li>pericarditis</li> <li>pericarditis</li> <li>pericarditis</li> </ul> <ul> <li>pericarditis</li> <li>peri</li></ul>		▶ dental disease ▶ dental work ▶ dialysis	
<ul> <li>hemorrhagic cystits</li> <li>hepatic disease</li> <li>herpes infection</li> </ul> <ul> <li>infection</li> <li>intertity</li> <li>intertity</li> </ul> <ul> <li>infection</li> <li>intertity</li> <li>pericardial effusion</li> </ul> <ul> <li>pericardial effusion</li> </ul>		geriatric IX     Pheart failure     Pheart failure     Pheart failure	
Image: Infection     Image: Infection     Image: Infection     Image: Infection     Image: Infection       Image: Im		hemonhagic cystils     hepatic disease     hepatic disease     herpes infection	
implementation     implementation     implementation     implementation		► Infection ► Infertility ► leukopenia	
Image: performance of the performa		▶ myocarditis ▶ neutropenia ▶ pericardial effusion	
Image: surgery     Image: renal impairment     Image: secondary malignancy imag		pericardits     preumonits     pulmonary florosis	
surgery thrombocytopenia tumor lysis syndrome (TL8)		radiation therapy > renal impairment > secondary malignancy x	
		surgery  thrombocytopenia tumor lysis syndrome (TL8)	
urinary tract Infection (UTI)     vaccination     varicella		urinary tract Infection (UTI)     vaccination     varicella	

IBM Watson™ for Oncology	nhbdo1138 🗢 Feedback 🕐 Information	
View more     DEMOGRAPHICS     Age: 68 Gender: Fernal	Adverse Reactions Reported Incidence % for Doxorubicin	
Chemotherapy followed	Adverse Reactions Doxorubicin 🗸 Sort by: Incidence Percentage 🗸 🔶 Severe 🔶 Moderate 🔷 Mild	
Chemotherapy	alopecia	npare
Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)		idence
TAC (Docetaxel / Doxorubicin / Cyclophosphamide)	nausea • • • • • • • • • • • • • • • • • • •	<u>^</u>
AC (Doxorubicin / Cyclophosphamide) followed by Docetaxel	heart failure	
EC (Epirubicin / Cyclophosphamide) followed by T (Paclitaxel)	weight loss	•
FAC (Fluorouracil / Doxorubicin / Cyclophosphamid followed by Paclitaxel	weight gain  leukopenia	
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel	leukopenia • · · · · · · · · · · · · · · · · · ·	<b>)</b>
FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Paclitaxel	Infection	
CMF (Cyclophosphamide / Methotrexate / Fluorouracil)	Box Warning	
TC (Docetaxel / Cyclophosphamide)	Expand All Collapse /	All
FAC (Fluorouracil / Doxorubicin / Cyclophosphamid	Cyclophosphamide	
CAF (Cyclophosphamide / Doxorubicin / Fluorourad		
EC (Epirubicin / Cyclophosphamide)	Contraindications/Precautions	
CEF (Cyclophosphamide / Epirubicin / Fluorouracil)	Contraindications ①	
AC (Doxorubicin / Cyclophosphamide)	bladder obstruction     bladder obstruction	
Radiation		
Referral to radiation oncology	Precautions ①	
	QT prolongation     Anemia     bone marrow suppression	~

#### SELECT TREATMENT OPTIONS AND SAVE OR PRINT

IBM Watson™ for 0	Oncology					9	mhbdc1138	🗢 Feedback	Information	۱ ()
	DEMOGRAPHICS Age: 68 Gender: Female Performs	ance status: O	DISEASE STATUS Cancer type: Breast cancer	Cancer stage: IIB	TREATMENT HISTO Surgery: Mastectomy	DRY Chemotherapy: <b>No</b>	t specified		💮 As	k Wats
Back to cli	inical information									
Treatment Plan As recommended by MSK	Options for: Mrs									
Select a clinical trial		Chemotherapy f	ollowed by radiation th	erapy 1						
Chemotherapy follow	ved by radiation therapy	Timeline for Treatmen	nt Plan (shown in months)							
More treatment plan op	tions	Chemotherapy (Radiation)	م ۱ 2	. 3	4	5	6	7	8	-
		Treatment Optio	ns Recommended	For Consideration	Not Recommended		Save selec	tions 🖶 Print	t selections	>
		Chemotherapy					Radiatio	on		
	(	Dose-dense AC	(Doxorubicin / Cyclophosphamide	) followed by T (Paclitax	(el)		Referral	to radiation oncol	097	
		AC (Doxorubicin	/ Cyclophosphamide) followed by	Docetaxel >						
		FAC (Fluorourac	il / Doxorubicin / Cyclophosphami	de) followed by Paclitax	el >					
		FEC (Fluorourac	il / Epirubicin / Cyclophosphamide	) followed by Docetaxel	>					
		FEC (Fluorourac	il / Epirubicin / Cyclophosphamide	) followed by Paclitaxel	>					
		TAC (Docetaxel)	/ Doxorubicin / Cyclophosphamide	e) >						
		EC (Epirubicin / C	Cyclophosphamide) followed by T	(Paclitaxel) >						
		CMF (Cyclophos	phamide / Methotrexate / Fluorou	racil) >						
		TC (Docetaxel / C	Cyclophosphamide) >							
		CAF (Cyclophos	phamide / Doxorubicin / Fluoroura	cil) >						
		AC (Dexorubicin	/ Cyclophosphamide) >							
		<i>″</i>	· ·· ·= · ·· · ·= ·							

#### TREATMENT PLAN THAT CAN BE SHARED WITH THE PATIENT

IBM Watson™ for O	Oncology		nhbdc1138	Feedback		
View more	DEMOGRAPHICS Age: 68 Gender: Female Perform	Share Treatment Plan	(X)			
Back to cli	nical information	Specify the treatment information to share. Select Treatments to share				
Treatment Plan ( As recommended by MSK	Options for: Mrs Anasuy	S Pose-dense AC (Doxorubicin/Cyclophosphamide) followed by T (Paclitaxel)				
Select a clinical trial		Chemic Clinical Information Rationale Additional Publications				~
Chemotherapy follows	ed by radiation therapy >	Timelin       Patient Education Material:         Chema       English ✓         (Radia       ✓ Cyclophosphamide Oral capsule         ✓ Cyclophosphamide Solution for injection       ✓ Doxorubicin Hydrochloride Solution for inj         Treatm       Treatm	jection 6	7	8 It selections	
		Print Save	File Radiat	ion		
		Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel)     AC (Doxorubicin / Cyclophosphamide) followed by Docetaxel	Referra	al to radiation onco	kogy >	
		FAC (Fluorouracil / Doxorubicin / Cyclophosphamide) followed by Paclitaxel >				
		FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel      FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Paclitaxel				
		TAC (Docetaxel / Doxorubicin / Cyclophosphamide) >				
		CMF (Cyclophosphamide / Methotrexate / Fluorouracil) > CMF (Cyclophosphamide / Methotrexate / Fluorouracil) >				
		TC (Docetaxel / Cyclophosphamide) >				
		CAF (Cyclophosphamide / Doxorubicin / Fluorouracil)				
		AC (Doxorubicin / Cyclophosphamide) >				~

#### Doctors appointment list active

Se	earch For H	Hosp No		🛱 <u>Find</u> < Prev Day	<u>Next Day &gt;</u> App	t Sumi	mary	49 New							
	Select	▲ Time	Hosp No.	Name	Age	(	QC Status	IconProfile	Ask Watson	Consult Order	Telephone	Status	Arrive Time	Service	Remarks
		09:00	MHB01483384		51/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		09:10	MHB00809334		69/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		09:20	MHB01898624		57/Fem	ale	Electronic File	<b>a</b> (	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		09:30	MHB00480408		72/№	Iale	Electronic File	đ	ASK WATSON	Not Ordered	3460604	<u>Booked</u>		Review Appointment	
		09:40	MHB01619563		40/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered	26693295	<u>Booked</u>		Review Appointment	
		09:50	MHB02031574		43/M	Iale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		10:00	MHB00206261		54/M	lale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		10:10	<u>MHB01591905</u>		72/№	lale	Electronic File	đ	ASK WATSON	Not Ordered	23642682	<u>Booked</u>		Review Appointment	
		10:20	<u>MHB00702910</u>		73/№	lale	Electronic File	đ	ASK WATSON	Not Ordered	26711777	<u>Booked</u>		Review Appointment	
		10:30	MHB01546086		40/M	Iale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		10:40	MHB01465207		54/M	lale	Electronic File	đ	ASK WATSON	Not Ordered	9036943237	<u>Booked</u>		Review Appointment	
		10:50	MHB01861713		65/M	Iale	Electronic File	đ	ASK WATSON	Not Ordered	04872642230	<u>Booked</u>		Review Appointment	
		11:00	<u>MHB01935071</u>		6/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		11:10	MHB02018694		68/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		11:20	MHB00638146		74/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered	28476115	<u>Booked</u>		Review Appointment	
		11:30	<u>MHB01618891</u>		53/Fem	ale	Electronic File	đ	ASK WATSON	Not Ordered		<u>Booked</u>		Review Appointment	
		11:40	MHB01589002		66/Fem	ale	Electronic File	ð	ASK WATSON	Not Ordered	2522694	<u>Booked</u>		Review Appointment	

Double-blind Concordance Study of Breast Cancer Treatment Recommendations Between Manipal Multidisciplinary Tumor Board and an Artificial Intelligence Advisor for Oncology IBM's Watson For Oncology



Manipal Comprehensive Cancer Centre Manipal Hospital, Bangalore, India





\* T1 Time of original treatment decision by MMDT in the past (last 1-3 years)
\*\* T2 Time (2016) of WFO' s treatment advice and of MMDT' s treatment decision upon blinded re-review of non-concordant cases

Data Entry Learning Curve





Takes 60 seconds



Figure 1. Treatment concordance between WFO and the MMDT overall and by stage. MMDT, Manipal multidisciplinary tumor board; WFO, Watson for Oncology.



Figure 2. Treatment concordance between WFO and the MMDT by stage and receptor status. HER2/neu, human epidermal growth factor receptor 2; HR, hormone receptor; MMDT, Manipal multidisciplinary tumor board; WFO; Watson for Oncology.

# Overall Concordance: MMDT (@ T1) and WFO (@ T2)



### Concordance by Stage: MMDT (@T1) and WFO (@T2)



# Concordance by Receptor: MMDT (@ T1) and WFO (@ T2)



#### Concordance by Stage and Receptor: MMDT (@ T1) and WFO (@ T2)

	41 41	n	NA	N-REC	FC	REC	REC+FC
	Non-metastatic	140	3%	13.6%	36.4%	47.1%	83.5%
HER2/NeU (+)	Metastatic	44	32%	18.2%	4.5%	45.5%	50.0%
	Non-metastatic	221	0.9%	28.1%	35.7%	35.3%	71.0%
HER2/Neu (-)	Metastatic	40	28%	38%	2.5%	32.5%	35.0%
Triple (-)	Non-metastatic	153	2%	12%	18.3%	68.0%	86.3%
	Metastatic	40	10%	38%	15.0%	37.5%	52.5%

3

Concordance WFO (@T2) and MMDT (@T1\* v. T2\*\*) (N= 638 Breast Cancer Cases)

Time Point/	RE	С	REC + FC		
Concordance	n	%	n	%	
T1*	296	46	463	73	
T2**	381	60	574	93	

\* T1 Time of original treatment decision by MMDT in the past (last 1-3 years) \*\* T2 Time (2016) of WFO's treatment advice and of MMDT's treatment decision upon blinded re-review of non-concordant cases

## **Re-Review of Breast Cases**

		Re-Review Dec	ision (@T2)	Changed to		
Original Decision (@ T1)	Number (% Column Total)	Not Changed (% Row Total)	Changed (% Row Total)	REC	FC	
Not Available	38 (22%)	12 (32%)	26 (68%)			
Red	137 (78%)	52 (38%)	85 (62%)			
Total	175 (100%)	64 (37%)	111 (63%)	85	26	

#### Watson Genomics Overview



Service Analysis, Reports, & Visualizations

#### **Watson Genomics Overview**



# What Watson Discovery Advisor is given



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# Watson Discovery Advisor sees



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It will be like having a capable and knowledgeable 'colleague' who can review the current information that relates to my patient... It is fast, thorough, and has the uncanny ability to understand how the available evidence applies to the unique individual I am treating. "

Dr. James Miser, Bumrungrad's Chief Medical Information Officer

# What Are the Insights ?

- <u>AI is an umbrella term</u>, must understand whether the system is designed to -act rationally (e.g. robot)
  - -think rationally (e.g. Deep Blue chess game logic)
  - -act like a human (e.g. chat-bot)
  - -think like a human think (e.g. cognitive modeling WFO)
- <u>Value of a Clin Decision Support System determined by:</u>
  - Content: e.g. relevant, complete, current
  - Information provided: e.g. valid, reliable, references accessible
  - Usability: e.g. comprehensible, simple, efficient, easy to use
  - Workflow integration
  - EHR integration
  - CDS-related Patient Safety
- <u>Contemporaneous</u>, <u>blinded assessment of concordance is critical</u>: Blinded concordance.93% when MMDT - WFO both at T2
- <u>WFO CDS is a promising cognitive computing tool that warrants further evaluation</u> in a variety of clinical settings and a variety of study designs.
- <u>AI CDS systems require transparency about evidence</u> validating the quality of its components, safety, usability and work flow integration

#### What Are the Insights ?

- This study examined concordance only
- Not designed to evaluate why differences in recommendations occurred, inferiority/superiority of recommendations, impact of WFO on workflow, etc.
- Important to assess blinded concordance between local experts and WFO at the same point in time: Blinded concordance 73% when MMDT@T1- WFO @T2 vs 93% when MMDT–WFO both at T2.
- WFO may reduce the cognitive burden on oncologists by providing clinically actionable insights to assist in treating patients.
- WFO is a promising cognitive computing tool that warrants further evaluation in a variety of clinical settings and a variety of study designs.
- The role of WFO will always be consultative; WFO cannot replace human clinical judgment and the essential patient-doctor relationship

# ANNALS OF ONCOLOGY

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Annals of Oncology





![](_page_60_Picture_6.jpeg)

OXFORD

Annali of Oncology 0: 1-6, 2018 doi:10.1098/annanc/mcb/781

![](_page_61_Picture_1.jpeg)

#### ORIGINAL ARTICLE

#### Watson for Oncology and breast cancer treatment recommendations: agreement with an expert multidisciplinary tumor board

S. P. Somashekhar<sup>1\*</sup>, M.-J. Sepúlveda<sup>2</sup>, S. Puglielli<sup>3</sup>, A. D. Norden<sup>3</sup>, E. H. Shortliffe<sup>4</sup>, C. Rohit Kumar<sup>1</sup>, A. Rauthan<sup>1</sup>, N. Arun Kumar<sup>1</sup>, P. Patil<sup>1</sup>, K. Rhee<sup>3</sup> & Y. Ramya<sup>1</sup>

"Manipal Comprehensive Cancer Centre, Manipal Hospital, Bangalore, India." (BM Rissearch (Retried), Yorktown Heights, "Watson Health, IBM Corporation, Cambridge, "Department of Surgicial Oncology, College of Health Solutions, Arlzona State University, Phoenix, USA

Morespondence to: Prof. Sampige Pratamakumar. Somoshokhar, Manipal Comprehensive Cancer Centrie, Manipal Holpital, Old Airpont Road, Bangalose 560117, Kainataka, India. Tel. 4:91-3845712012; Fax. 4:91-80.25102-3759; E-mail: somoshokhar.spgmanipalhospitalk.com

Background: Breast cancer oncologists are challenged to personalize care with rapidly changing scientific evidence, drug approvals, and treatment guidelines. Artificial intelligence (A) clinical decision-support systems (CDSSs) have the potential to help address this challenge. We report here the results of examining the level of agreement (concordance) between treatment recommendations made by the AI CDSS Watson for Oncology (WFO) and a multiclosciplinary tumor board for breast cancer.

Patients and methods: Treatment recommendations were provided for 638 breast cancers between 2014 and 2016 at the Manipal Comprehensive Cancer Center, Bengaluru, India. WFO provided treatment recommendations for the identical cases in 2016. A blinded second review was carried out by the center's tumor board in 2016 for all cases in which there was not agreement, to account for treatments and guidelines not available before 2016. Treatment recommendations were considered concordant if the tumor board recommendations were designated 'recommended' or 'for consideration' by WFO.

**Results:** Treatment concordance between WFO and the multidisciplinary tumor board occurred in 93% of breast cancer cases. Subgroup analysis found that patients with stage I or IV disease were less likely to be concordant than patients with stage II or III disease. Increasing age was found to have a major impact on concordance. Concordance declined significantly ( $P \le 0.02$ , P < 0.001) in all age groups compared with patients <45 years of age, except for the age group 55–64 years. Receptor status was not found to affect concordance.

Conclusion: Treatment recommendations made by WFO and the tumor board were highly concordant for breast cancer cases examined. Breast cancer stage and patient age had significant influence on concordance, while receptor status alone did not This study demonstrates that the AI dinical decision-support system WFO may be a helpful tool for breast cancer treatment decision making, especially at centers where expert breast cancer resources are limited.

Key words: Watson for Oncology, artificial intelligence, cognitive clinical decision-support systems, breast cancer, concordance, multidisciplinary tumor board

#### Introduction

Oncologists who treat breast cancer are challenged by a large and rapidly expanding knowledge base [1, 2]. As of October 2017, for example, there were 69 FDA-approved drugs for the treatment of breast cancer, not including combination treatment regimens [3]. The growth of massive genetic and clinical databases, along with computing systems to exploit them, will accelerate the speed

of breast cancer treatment advances and shorten the cycle time for changes to breast cancer treatment guidelines [4, 5]. In addition, these information management challenges in cancer care are occurring in a practice environment where there is little time available for tracking and accessing relevant information at the point of care [6]. For example, a study that surveyed 1117 oncologists reported that on average 4.6 h per week were spent keeping

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weloaded from https://academic.oup.com/annonc/advance-article-abstract/doi/10.1093/annonc/mdx701/4703600 / guast / 09 January 2010

#### 4 of 6 mendations after the initial

ndations after the initial and blinded second reviews

Annals of Oncology

.ases (N = 638)	Concordant case	s, n (%)	Non-concordant cases, n (%)				
	Recommended	For consideration	Total	Not recommended	Not available	Total	
Initial seview (T1 <sub>ANNOT</sub> versus T2 <sub>MFO</sub> )	296 (46)	167 (26)	463 (73)	137 (21)	38 (6)	175 (27)	
Second review (TZ <sub>NWDT</sub> versus TZ <sub>WED</sub> )	397 (62)	194 (30)	591 (93)	36 (S)	11 (2)	47 (7)	

T1<sub>MMOT</sub>, original MMDT recommendation from 2014 to 2016; T2<sub>MSD</sub>, WFO advisor treatment recommendation in 2016; T2<sub>MMOT</sub>, MMDT treatment recommendation in 2016; MMDT, Manipal multidisciplinary tumor board; WFO, Watson for Oncology.

![](_page_61_Figure_21.jpeg)

Figure 1. Treatment concordance between WEO and the MMDT overall and by stage. MMDT, Manipal multidisciplinary tumor board; WEO, Watson for Oncology.

![](_page_61_Figure_23.jpeg)

Figure 2. Treatment concordance between WFO and the MMDT by stage and receptor status. HER2/neu, human epidermal growth factor receptor 2; HR, hormone receptor; MMDT, Manipal multidisciplinary tumor board; WFO, Watson for Oncology.

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# Thanks