

Diabetes prediction model in Korea

아주의대 예방의학교실

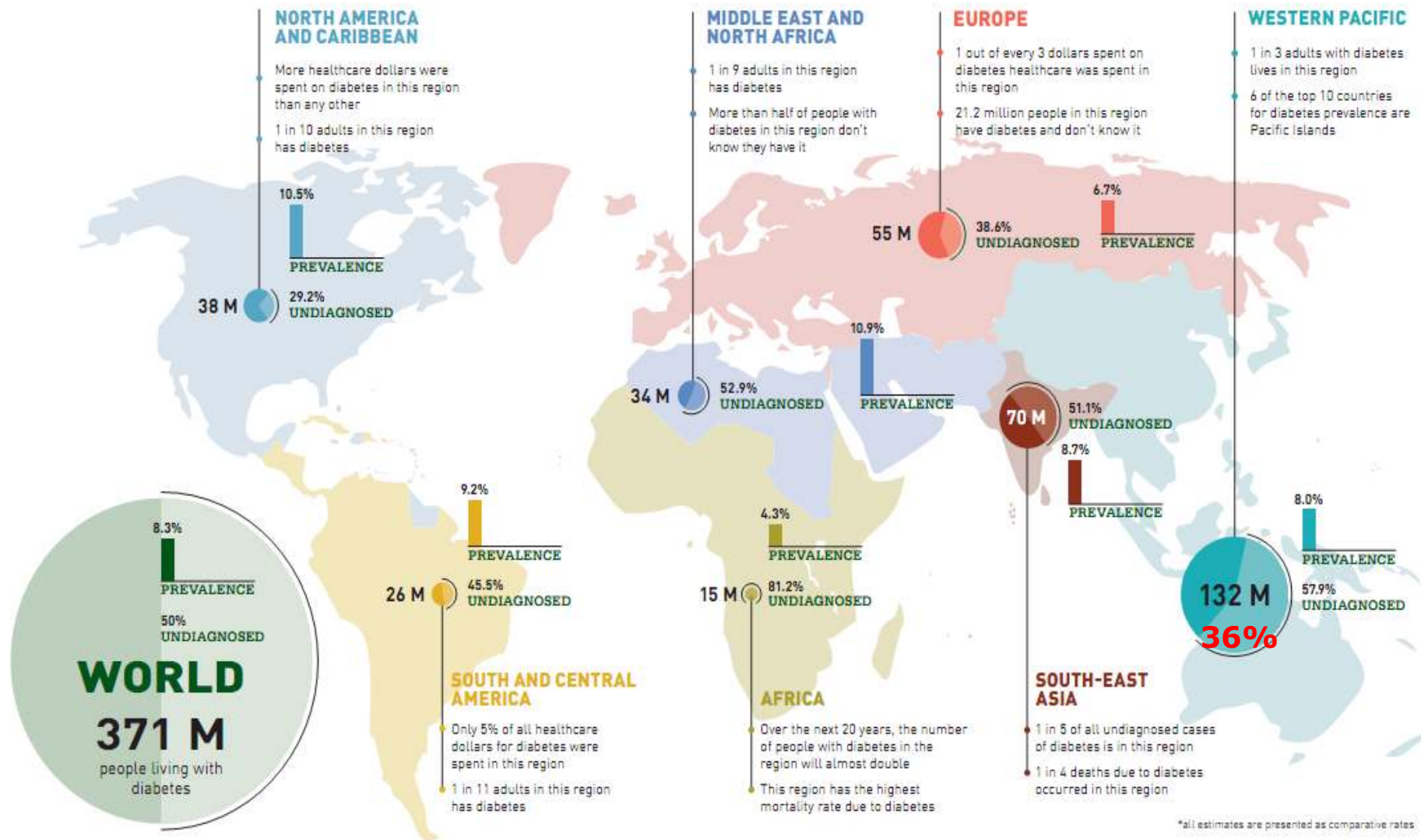
조 남 한

A high-angle, close-up photograph of a massive blue ocean wave crashing. The water is a deep, vibrant blue, and the crest of the wave is breaking into white foam and spray. The wave is moving from the top right towards the bottom left, creating a sense of immense power and scale.

Diabetes

**the health tsunami
of the 21st century**

IDF Diabetes Atlas 2012



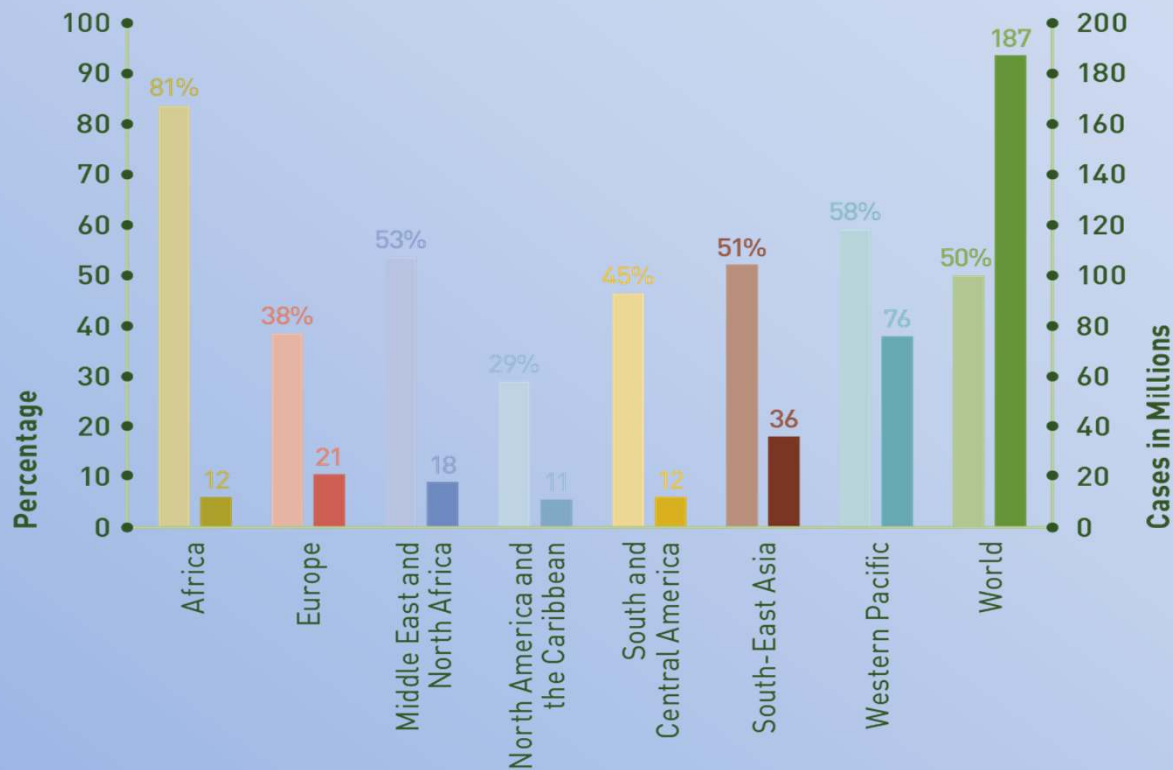
More than **371 million** people have diabetes.

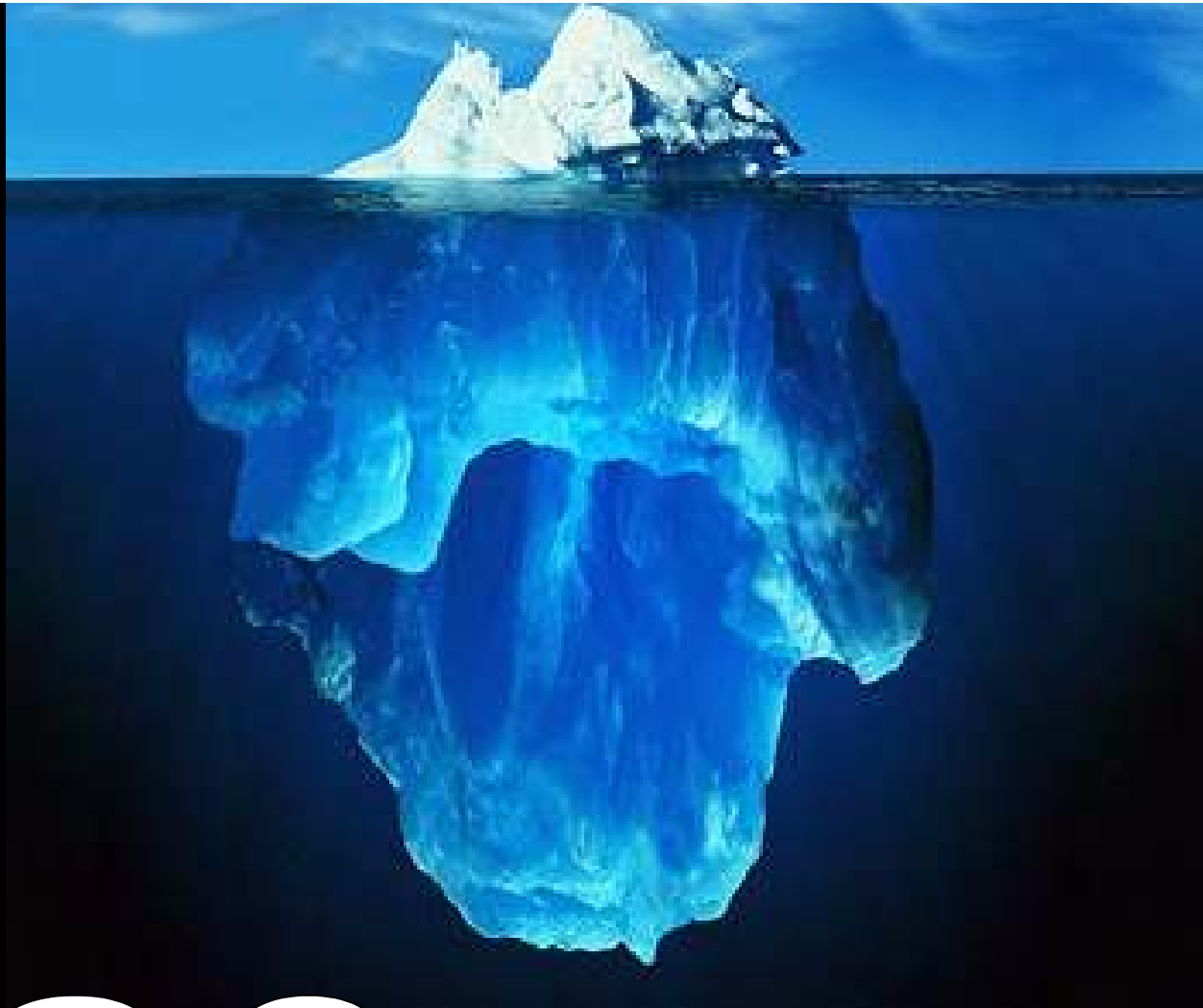
TOP 10 COUNTRIES/TERRITORIES FOR PEOPLE WITH DIABETES (20-79 YEARS)



Half of people with diabetes don't know they have it.

UNDIAGNOSED PERCENTAGE AND UNDIAGNOSED CASES OF DIABETES (20-79 YEARS) BY REGION

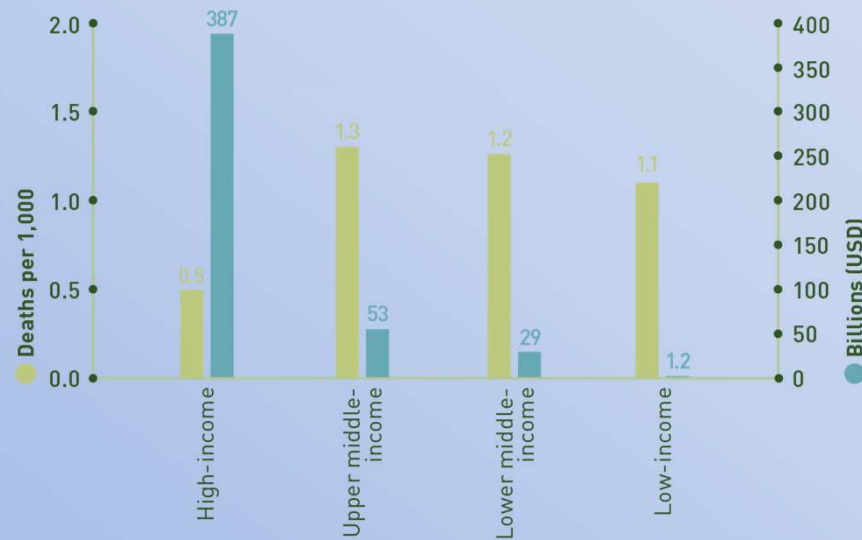




280 Million with IGT

4.8 million people died and 471 billion USD were spent due to diabetes in 2012.

HEALTHCARE EXPENDITURES AND DEATHS PER 1,000 DUE TO DIABETES BY INCOME GROUP



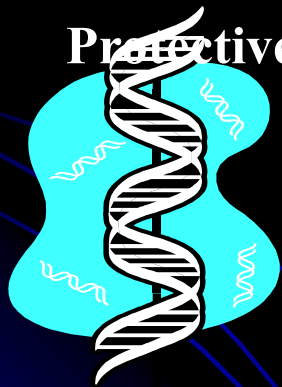
STUDY GOAL



Risk Factors

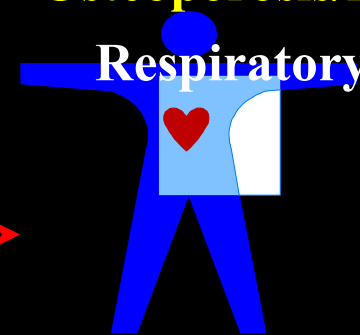
- Strength
- Magnitude
- Quality
- Quantity
- Variants

Responsible
Susceptible
Protective



Community
Cohort Since 2001
n=10,038

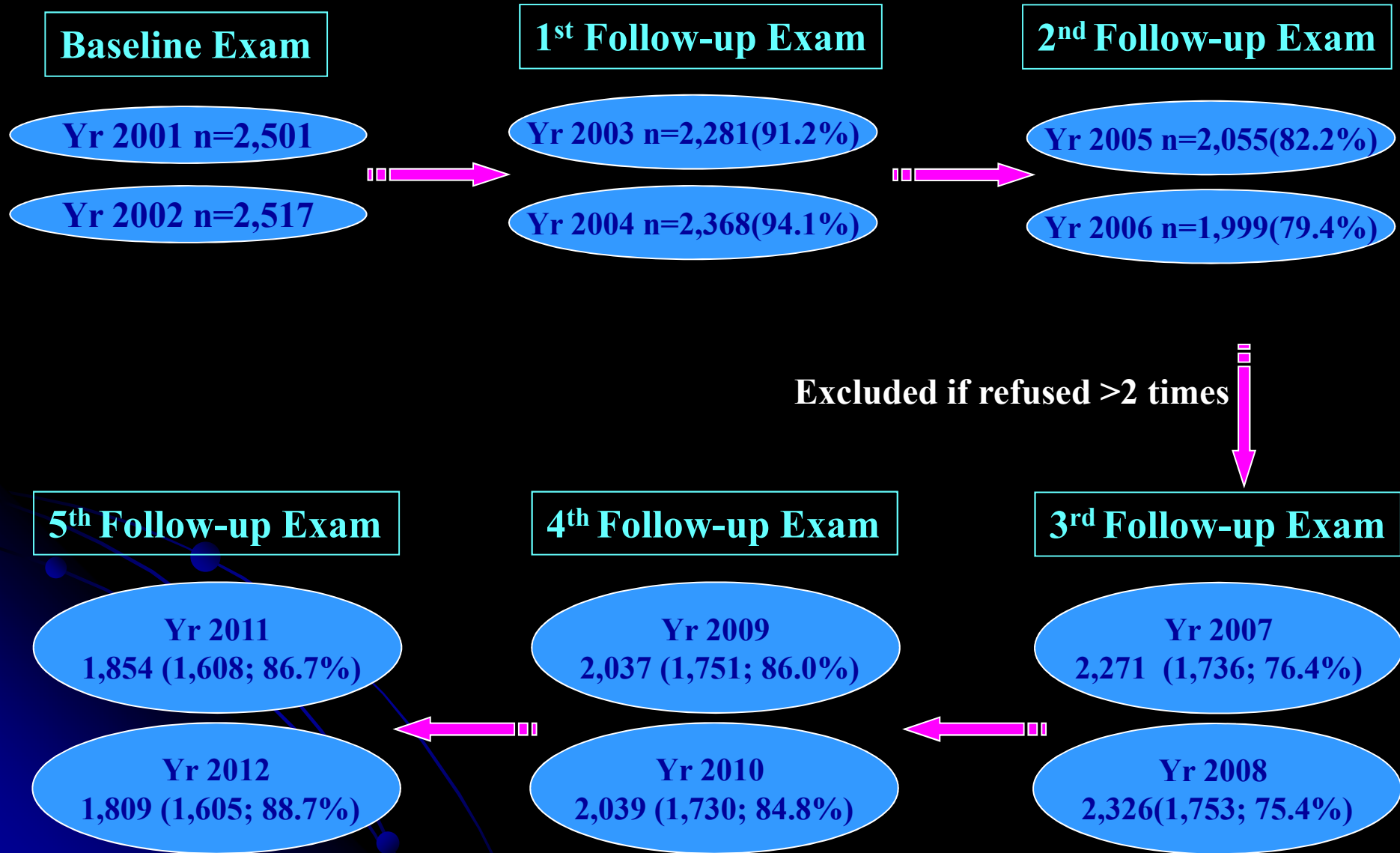
DM
HPT/CVD
Dementia
Osteoporosis/RA
Respiratory



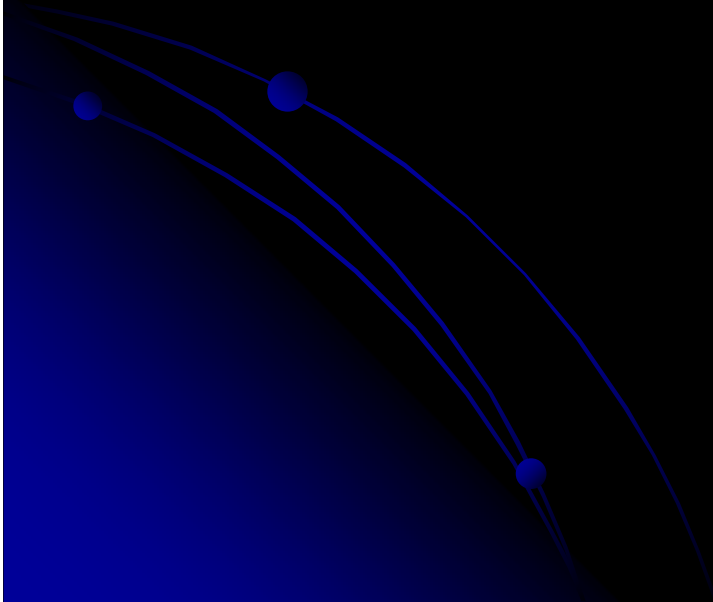
Gene variants distribution
Genetic-environmental Interaction, Gene mutation?
Disease Specific gene
Multiple Disease Associated gene

Prevalence
Incidence
Disease Pattern
Force of Morbidity/Mortality

Follow-up Status



Descriptive



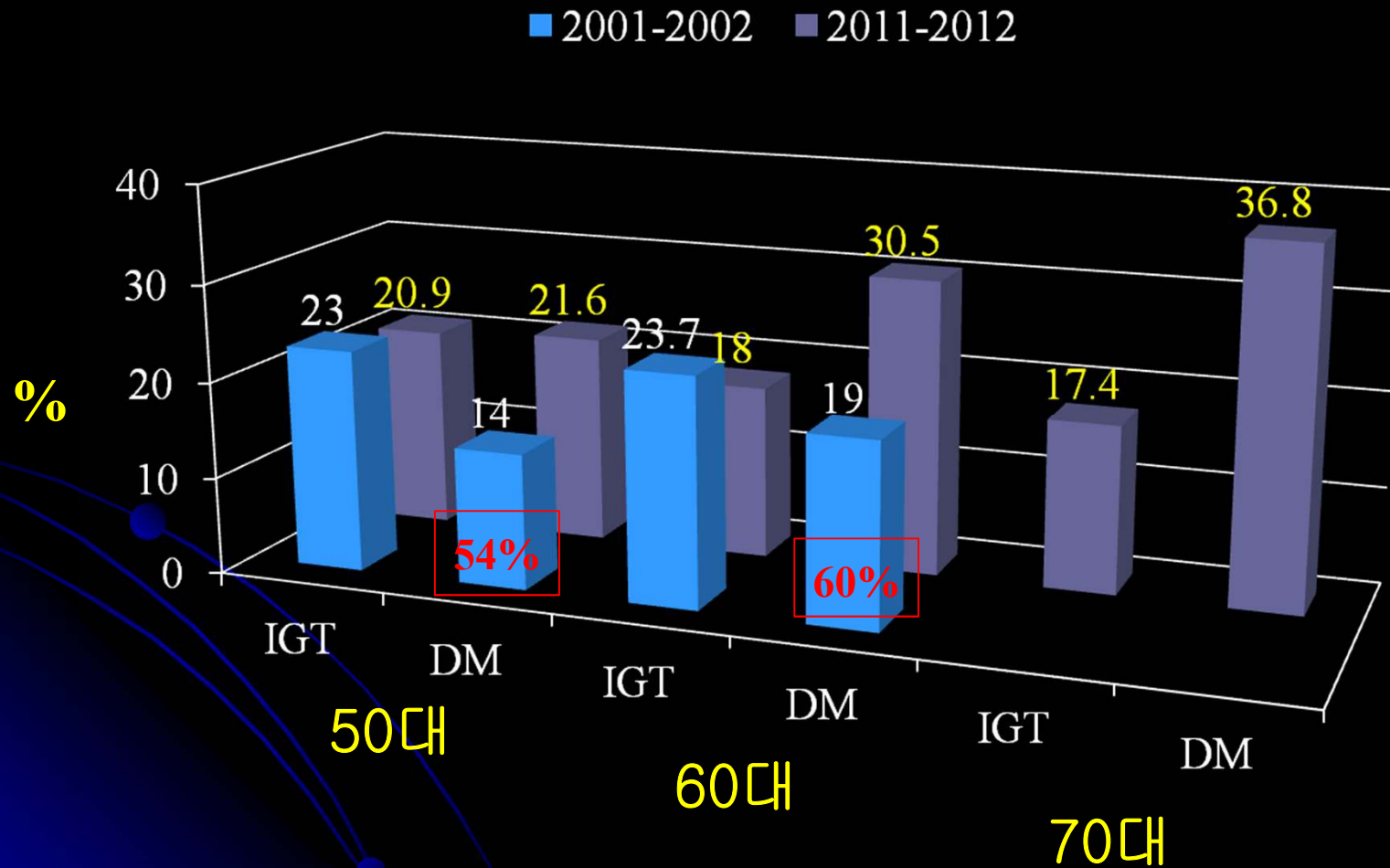
T2DM Prevalence: At baseline (2001-2001)

Age groups	Sex	DM status				Total
		Normal	IGT	Unknown DM	Known DM	
40th	Male	1,753(74.9%)	370(15.8%)	145(6.2%)	72(3.1%)	2,340(49.9%)
	Female	1,727(73.5%)	498(21.2%)	74(3.2%)	50(2.1%)	2,349(50.1%)
	Total	3,480(74.2%)	868(18.5%)	219(4.7%)	122(2.6%)	4,689(100%)
50th	Male	785(64.3%)	245(20.1%)	91(7.5%)	100(8.2%)	1,221(47.2%)
	Female	848(62.0%)	350(25.6%)	89(6.5%)	80(5.9%)	1,367(52.8%)
	Total	1,633(63.1%)	595(23.0%)	180(7.0%)	180(7.0%)	2,588(100%)
60th	Male	688(59.7%)	250(21.7%)	88(7.6%)	126(10.9%)	1,152(43.1%)
	Female	844(55.6%)	382(25.2%)	148(9.7%)	144(9.5%)	1,518(56.9%)
	Total	1,532(57.4%)	632(23.7%)	236(8.8%)	270(10.1%)	2,670(100%)
Total	Male	3,226(68.4%)	865(18.4%)	324(6.9%)	298(6.3%)	4,713(47.4%)
	Female	3,419(65.3%)	1,230(23.5%)	311(5.9%)	274(5.2%)	5,234(52.6%)
	Total	6,645(66.8%)	2,095(21.1%)	635(6.4%)	572(5.8%)	9,947(100%)

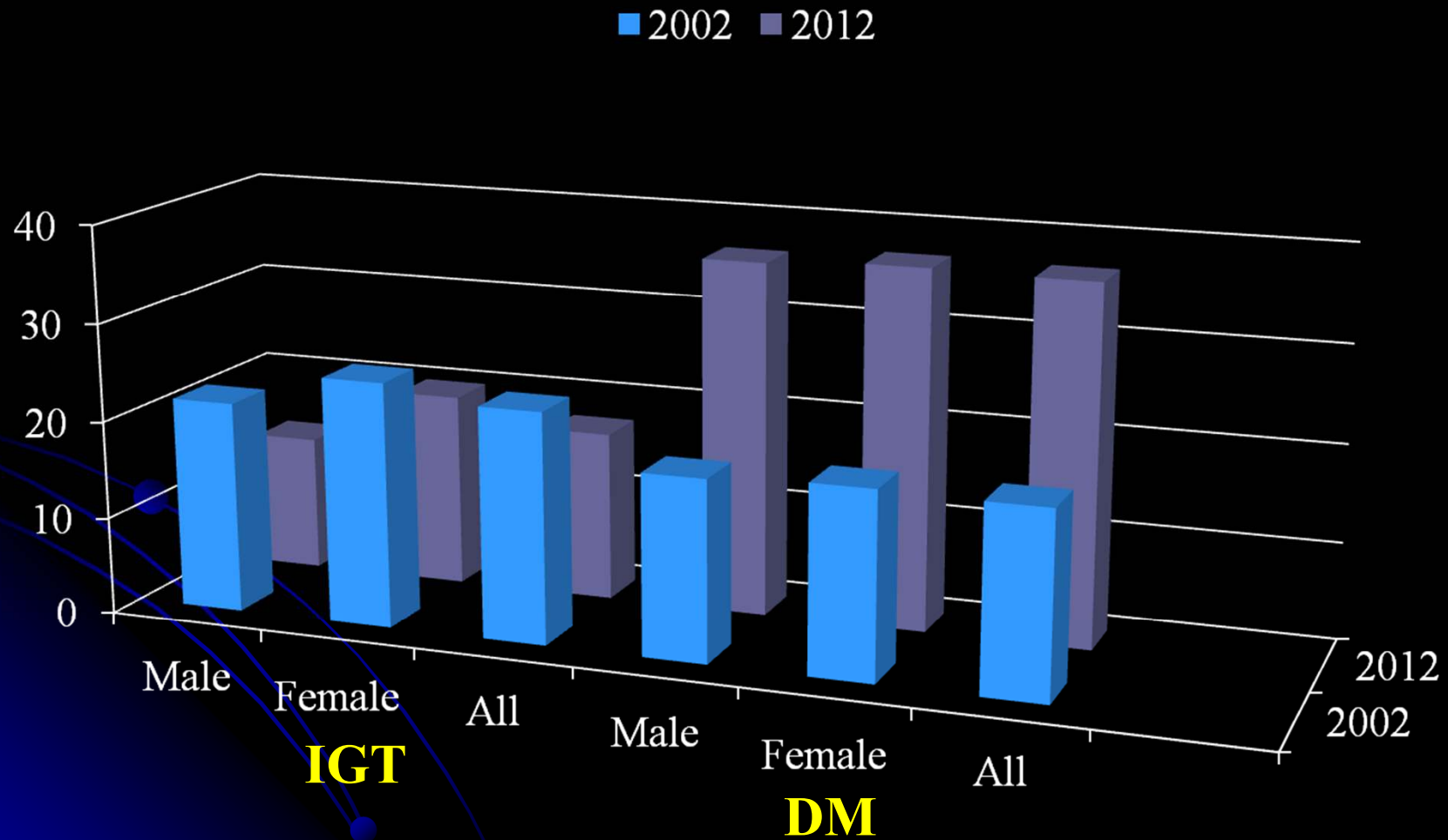
T2DM Prevalence: At baseline(2011-2012)

Age groups	Sex	DM status			Total
		Normal	IGT	DM	
50th	Male	839(57.1%)	247(16.8%)	384(26.1%)	1,470(49.3%)
	Female	934(61.8%)	316(20.9%)	261(17.3%)	1,511(50.7%)
	Total	1,773(59.5%)	563(18.9%)	645(21.6%)	2,981(100%)
60th	Male	420(52.4%)	114(14.2%)	268(33.4%)	802(46.8%)
	Female	462(50.8%)	193(21.2%)	255(28.0%)	910(53.2%)
	Total	882(51.5%)	307(17.9%)	523(30.5%)	1,712(100%)
70th	Male	285(49.7%)	80(13.9%)	209(36.4%)	574(41.3%)
	Female	352(43.1%)	162(19.9%)	302(37.0%)	816(58.7%)
	Total	637(45.8%)	242(17.4%)	511(36.8%)	1,390(100%)
Total	Male	1,544(54.3%)	441(15.5%)	861(30.3%)	2,846(46.8%)
	Female	1,748(54.0%)	671(20.7%)	818(25.3%)	3,237(53.2%)
	Total	3,292(54.1%)	1,112(18.3%)	1,679(27.6%)	6,083(100%)

Prevalence of T2DM :10 years later

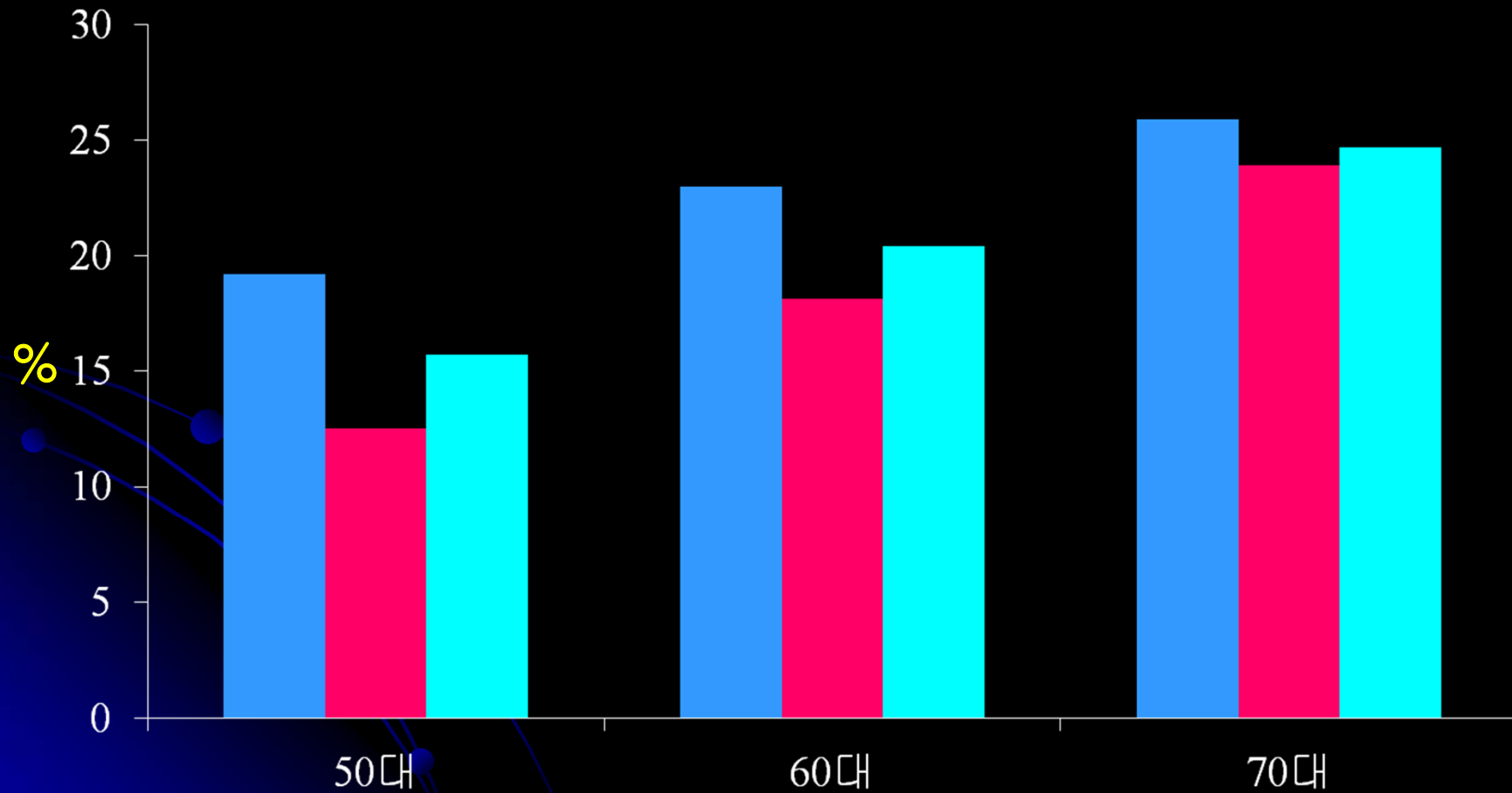


T2DM changing pattern after 10 yrs of follow-up: 60+ yr age group

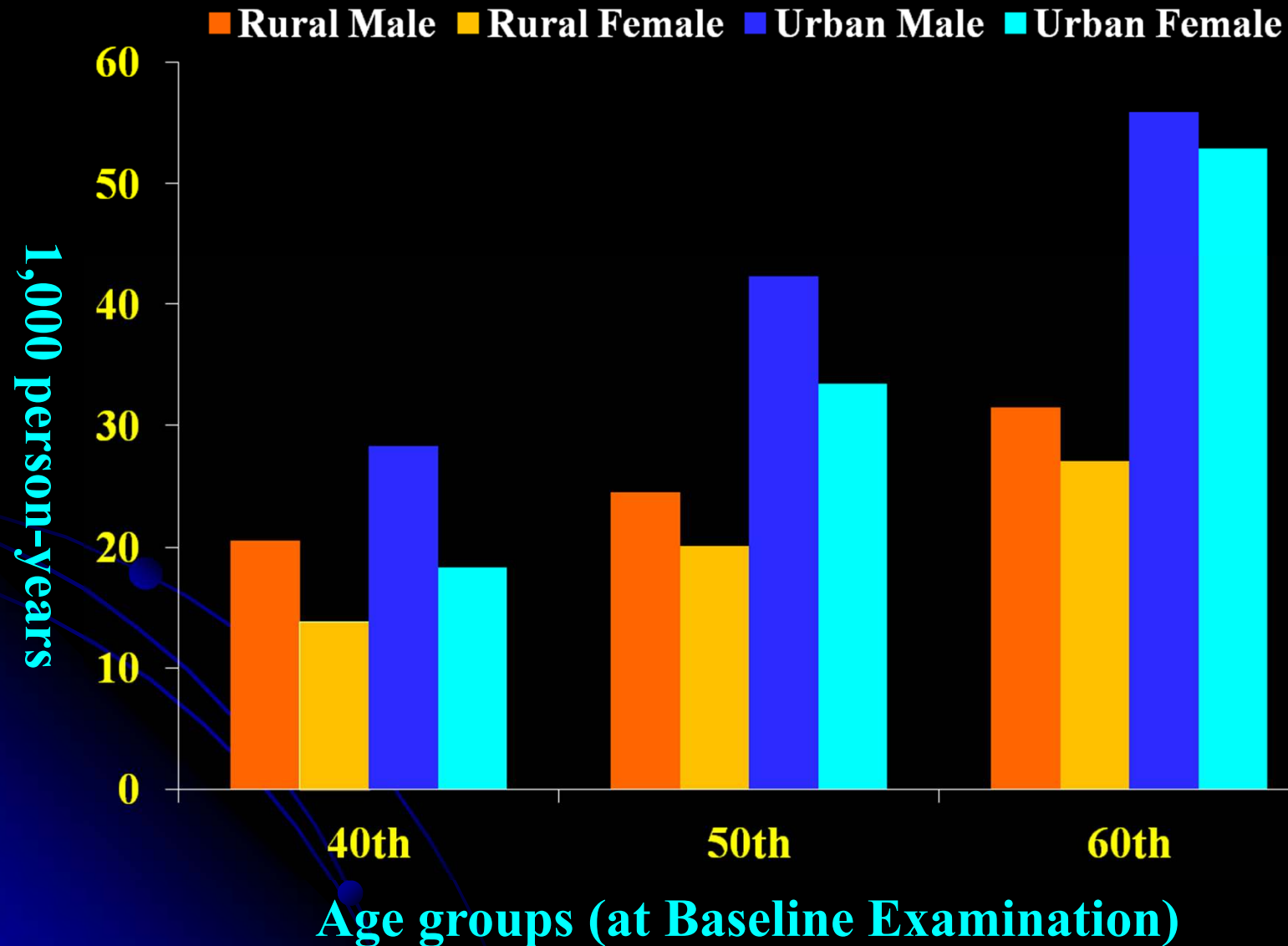


10 yr cumulative Incidence of T2DM by the age groups

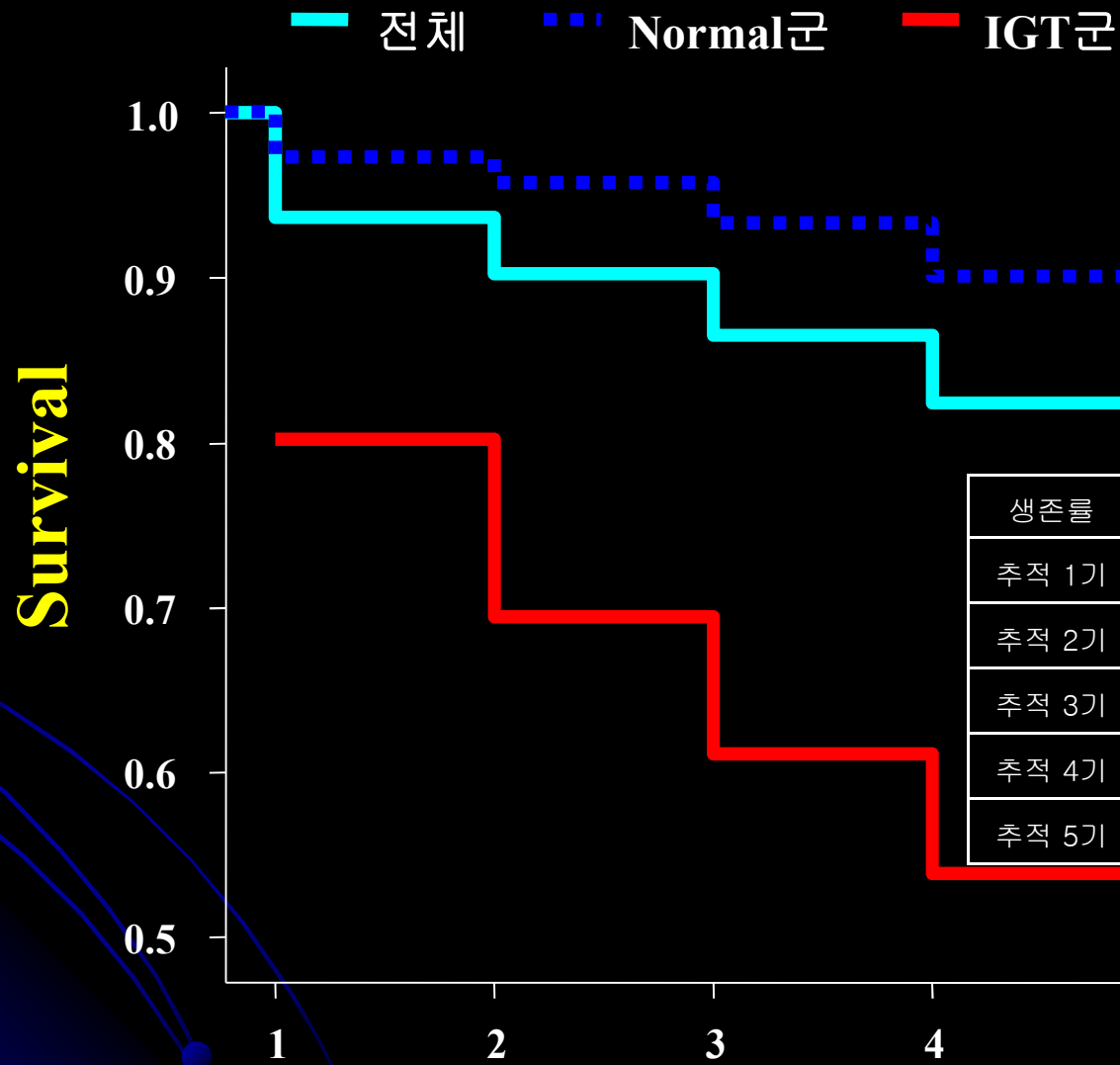
■ 남 ■ 여 ■ All



Incidence Density of T2DM

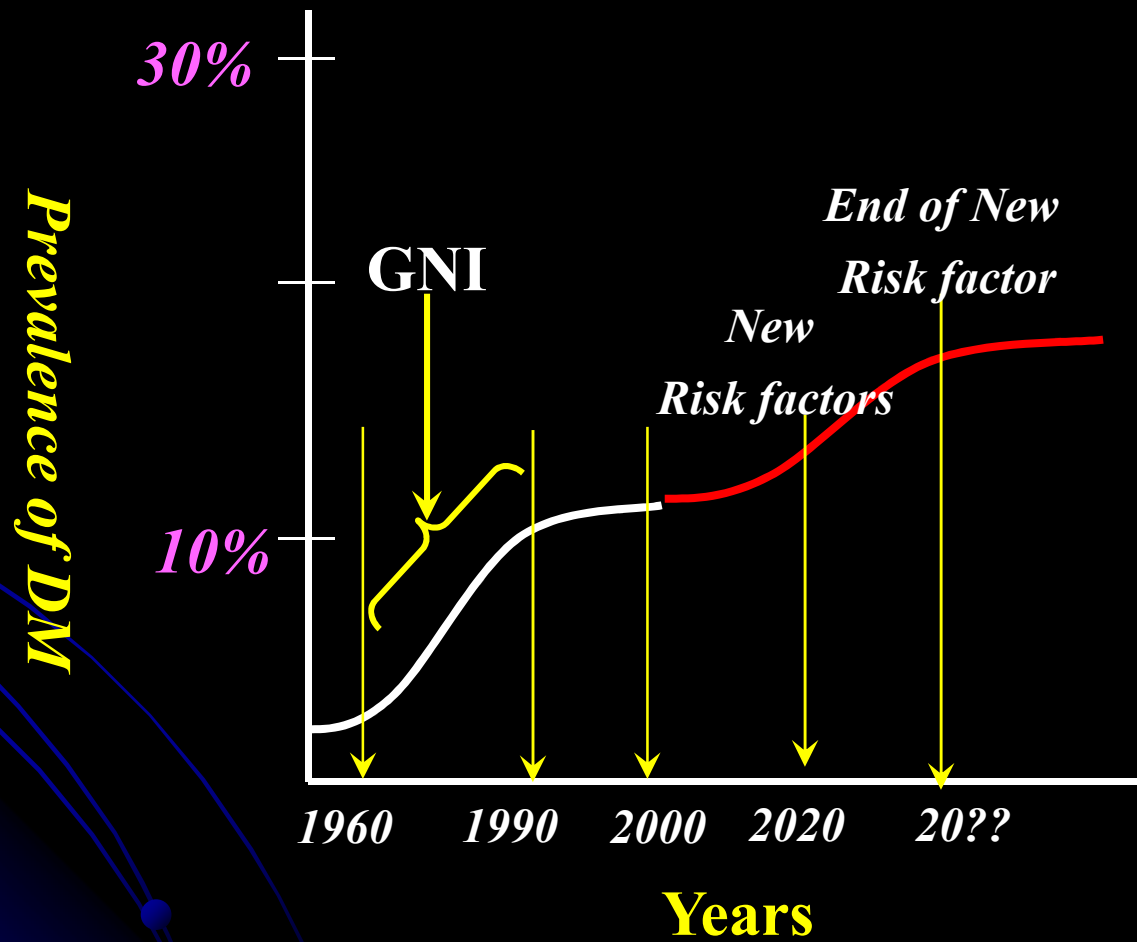


당뇨병 생존곡선

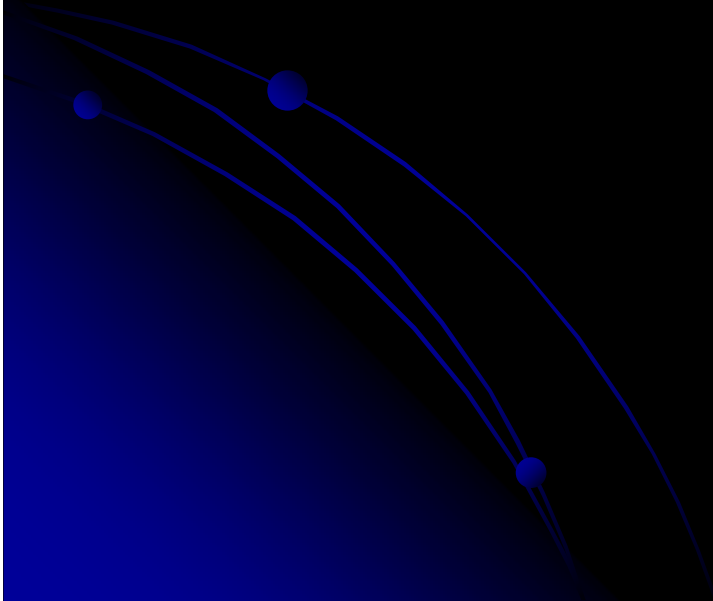


Duration of the follow-up

Changing Pattern of DM in Korea



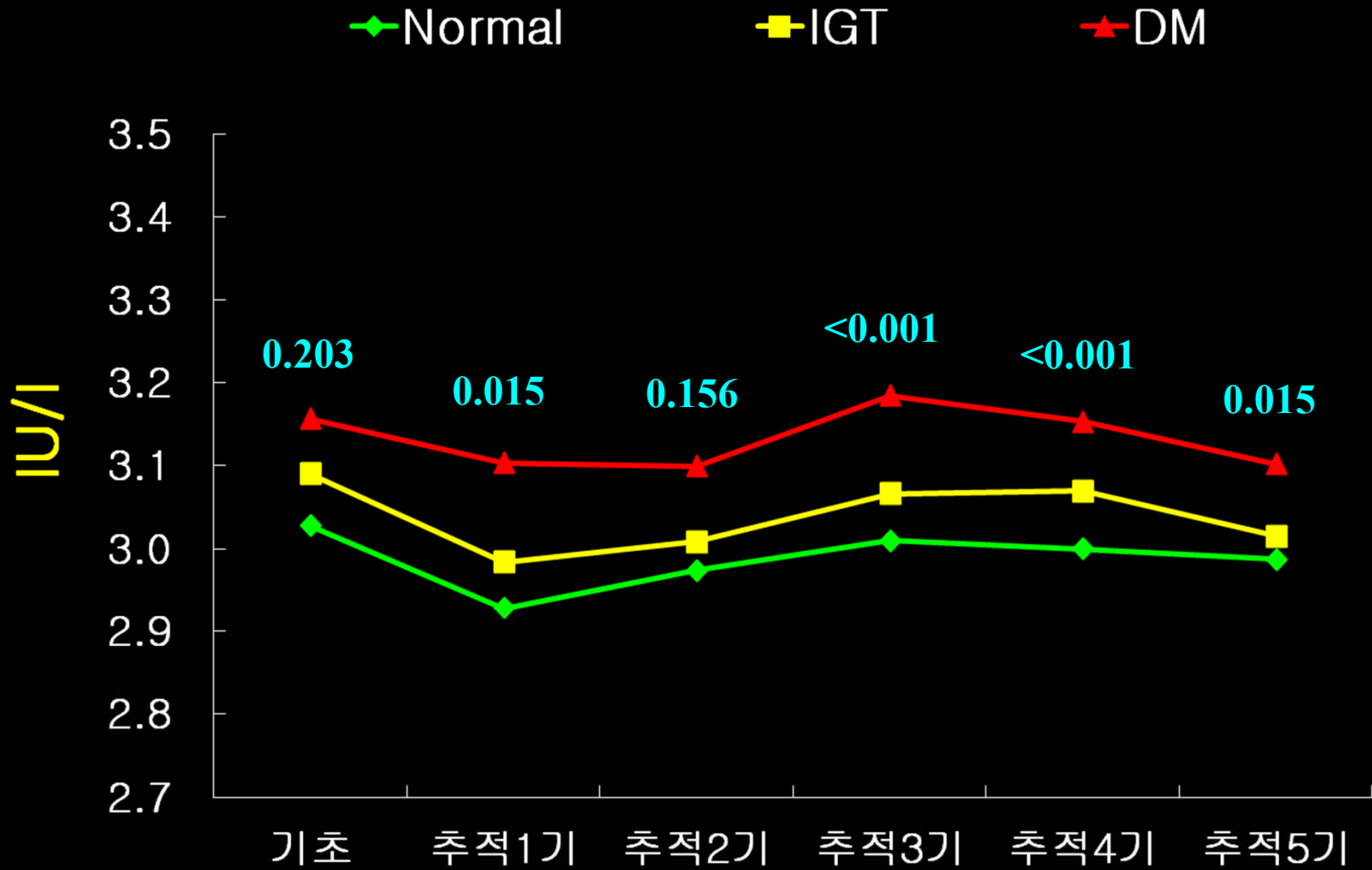
Analytical



Cox Proportional Hazard Prediction Model for DM

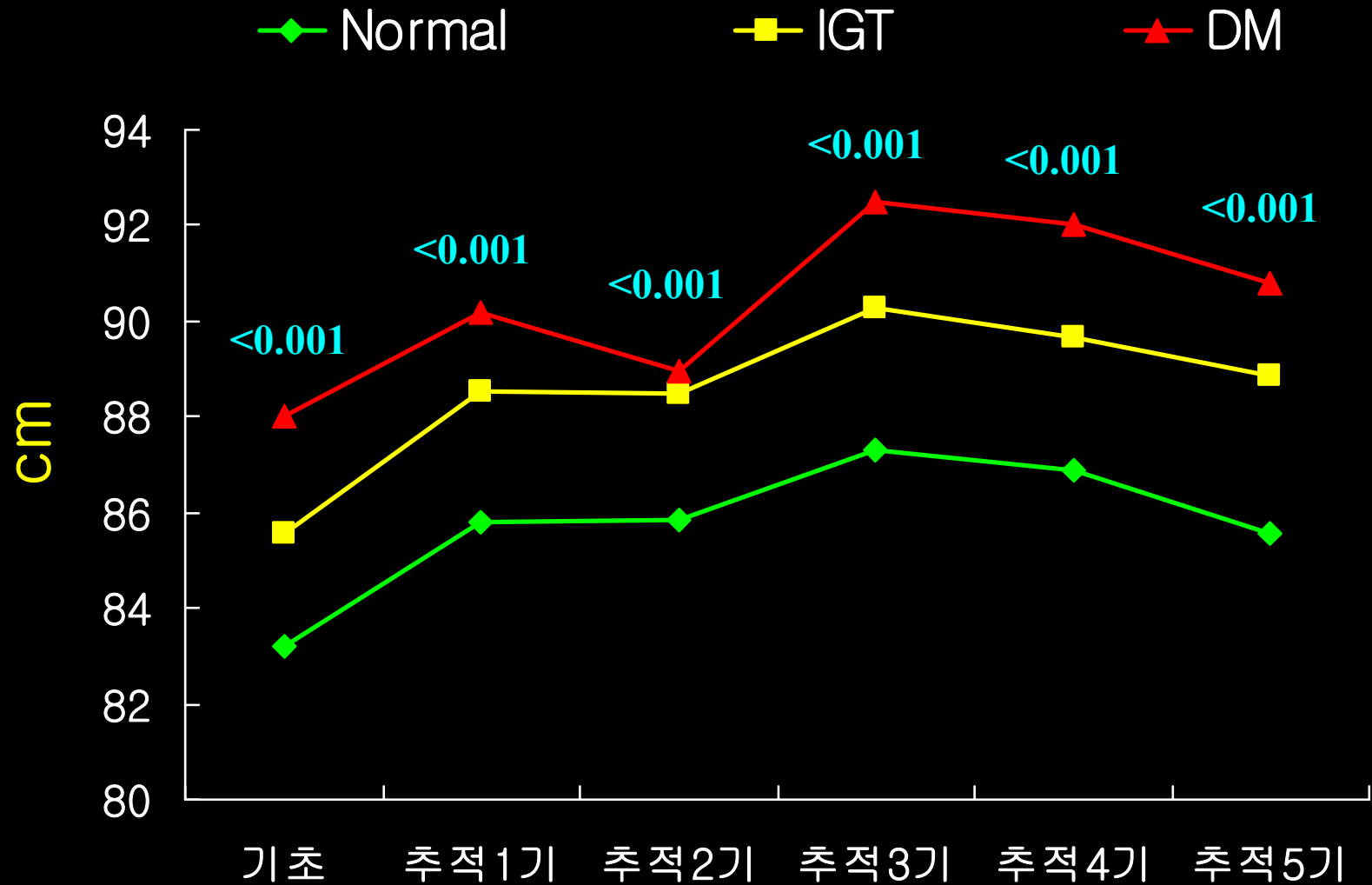
Variables	β	p-value	RR (95% CI)
ALT	0.005	<0.001	
age	0.023	<0.001	
β -cell function	-0.002	<0.001	
HOMA-IR	0.096	0.005	
Total Protein	-0.083	<0.001	
WBC	0.047	0.003	
Normal			1
IFG	1.042	<0.001	2.84 (2.15~3.73)
IGT	1.316	<0.001	3.73 (3.28~4.24)
IFG+IGT	1.734	<0.001	5.66 (4.55~7.04)
MetS	0.433	<0.001	1.54 (1.36 ~1.75)
Family history of DM	0.368	<0.001	1.44 (1.23 ~1.70)
City dweller	0.455	<0.001	1.58 (1.39 ~1.79)
HbA1c 5.6	0.892	<0.001	2.44 (2.16 ~2.75)
Non- smoker			1
Ex-smoker	0.211	0.007	1.23 (1.06~1.44)
Current smoker	0.413	<0.001	1.51 (1.31~1.74)

ALT(IU/l)



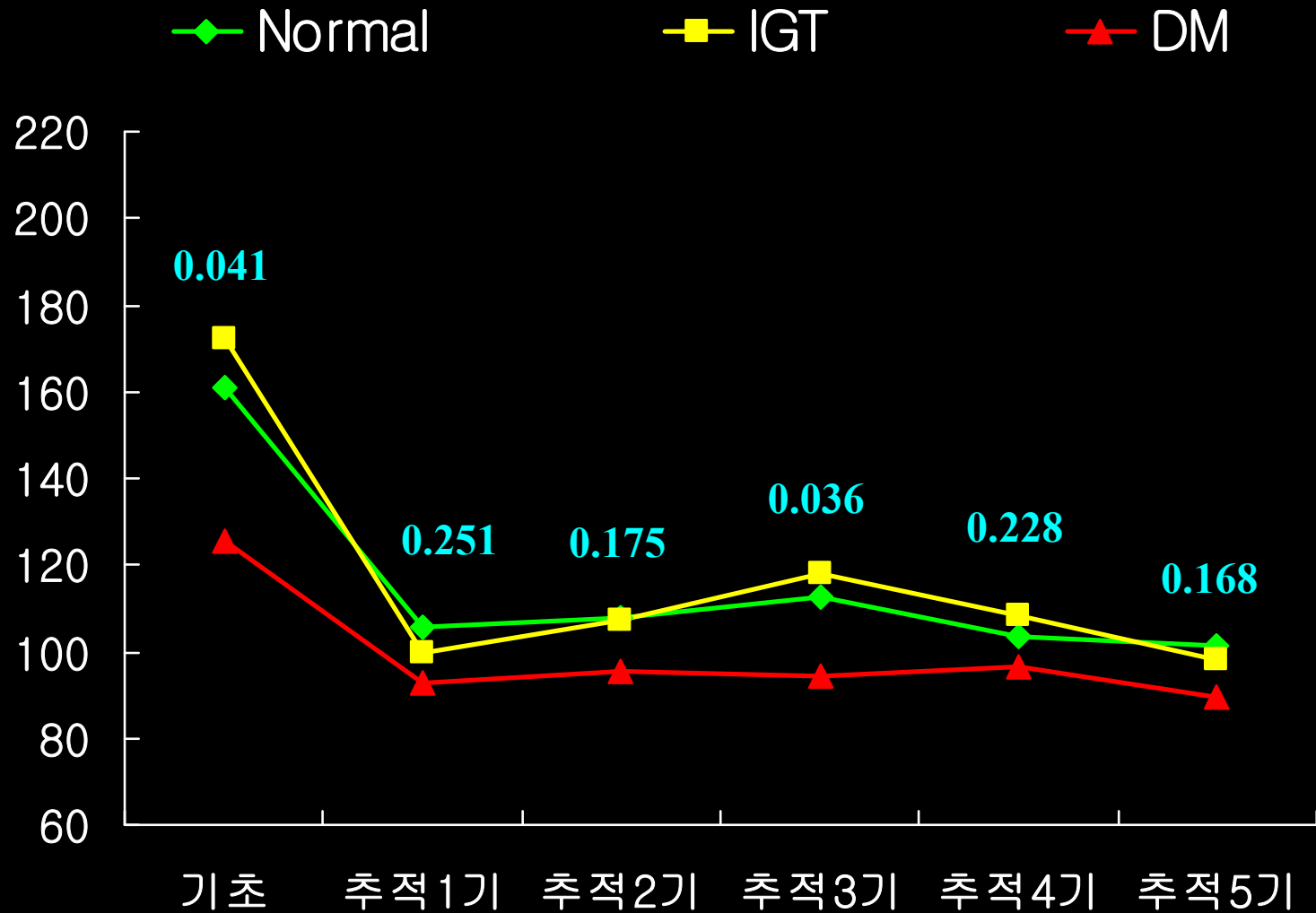
Ln transformation

허리둘레(cm)



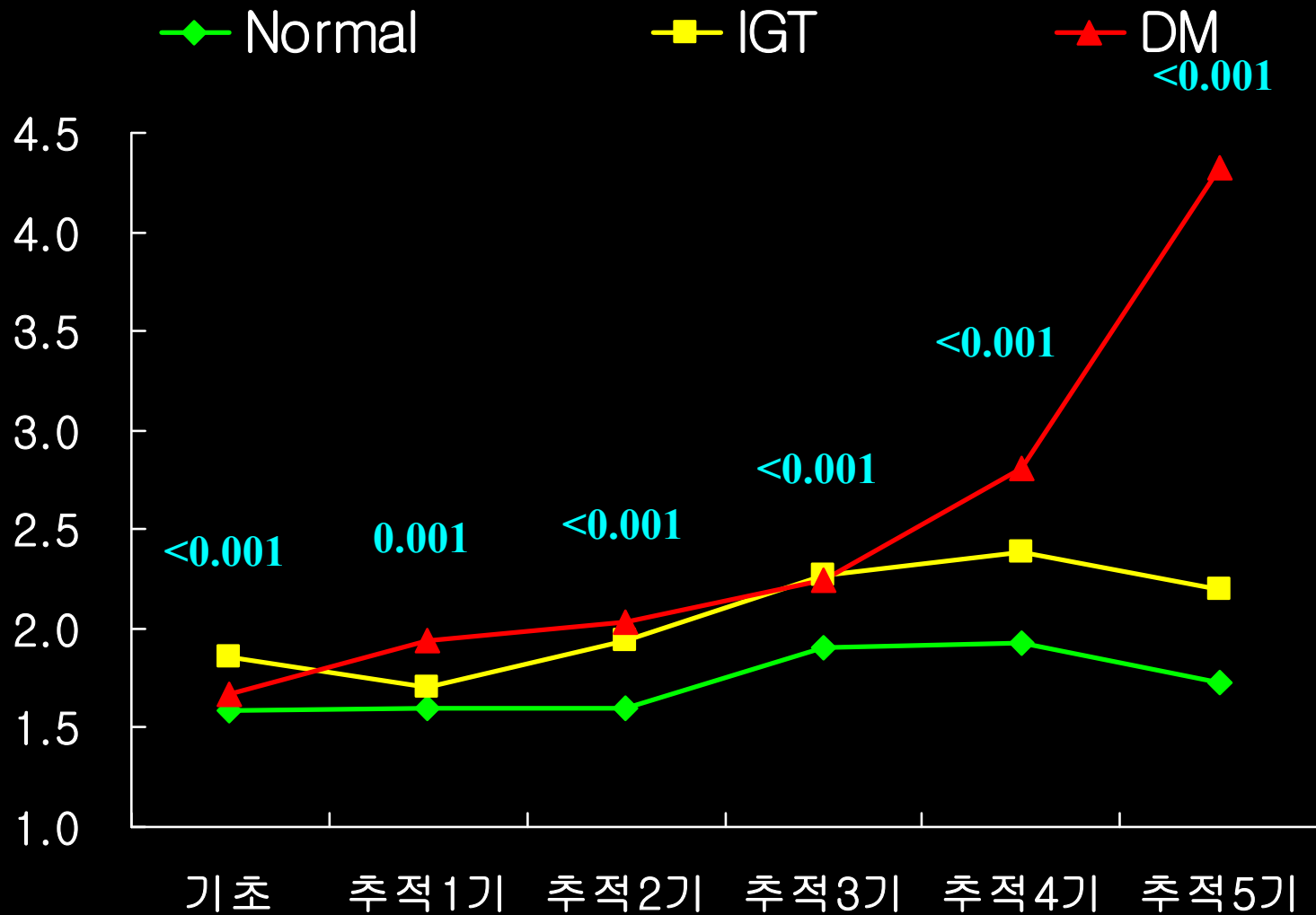
β -cell function

Basal Insulin Secretion

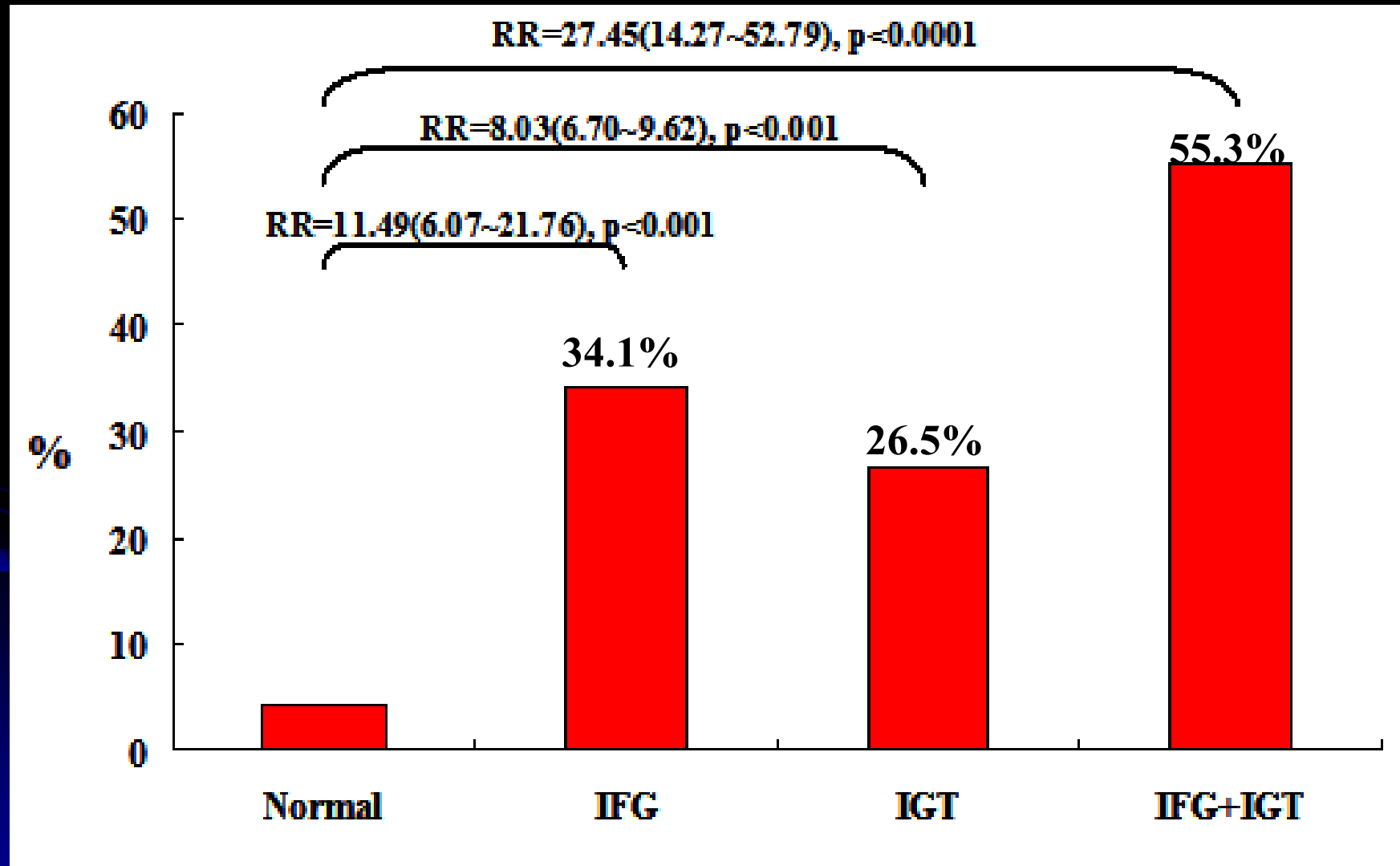


HOMA Insulin resistance

Hepatic Insulin Resistance



Incidence of T2DM by the baseline glucose status



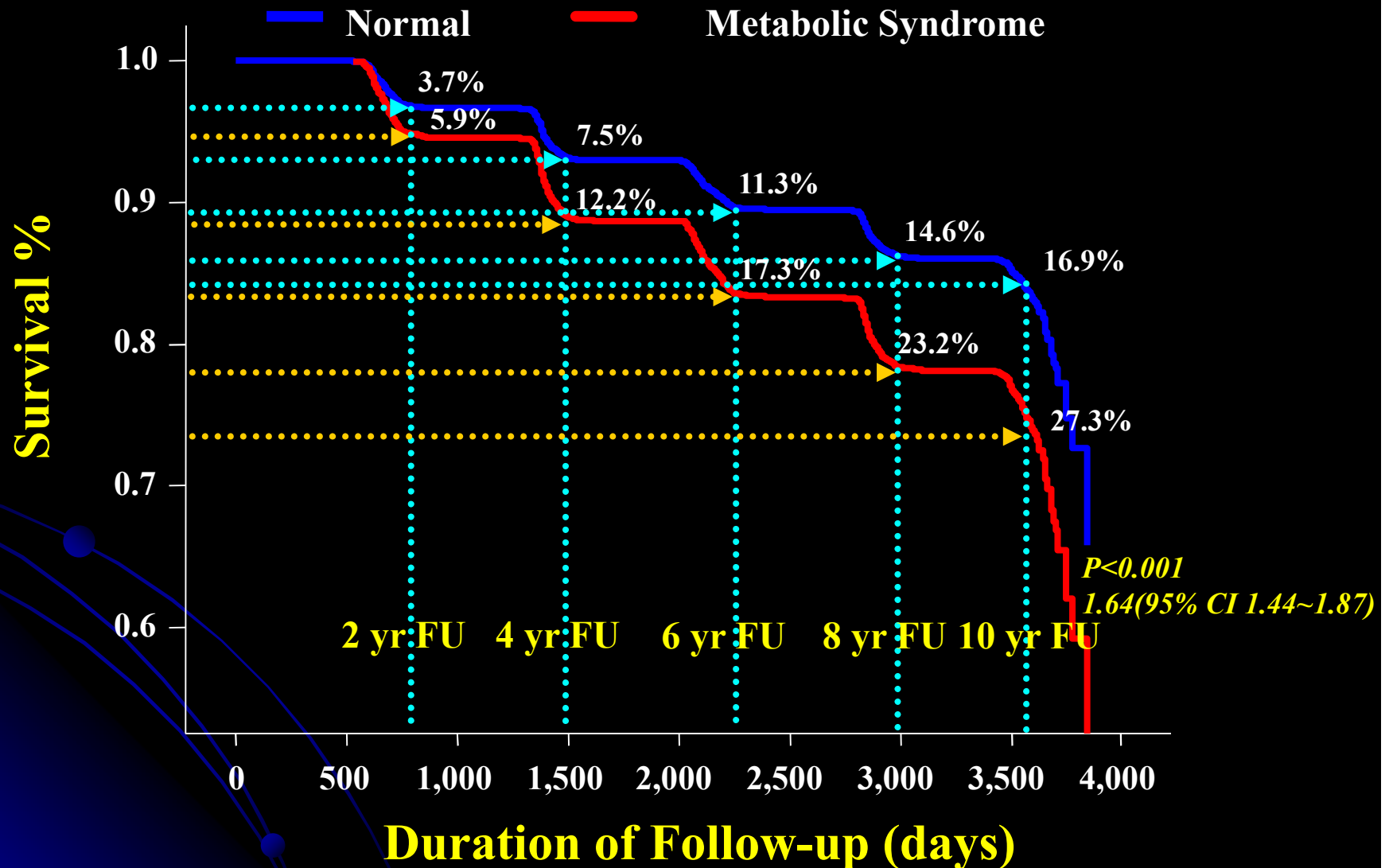
Hypertension and T2DM incidence

	Normal	Hypertension	p-value
Normal	4948(93.6%)	339(6.4%)	0.865
DM	527(93.8%)	35(6.2%)	

	Normal	DM	p-value
Normal	4433(83.1%)	902(16.9%)	<0.001
HPT	442(65.7%)	231(34.3%)	

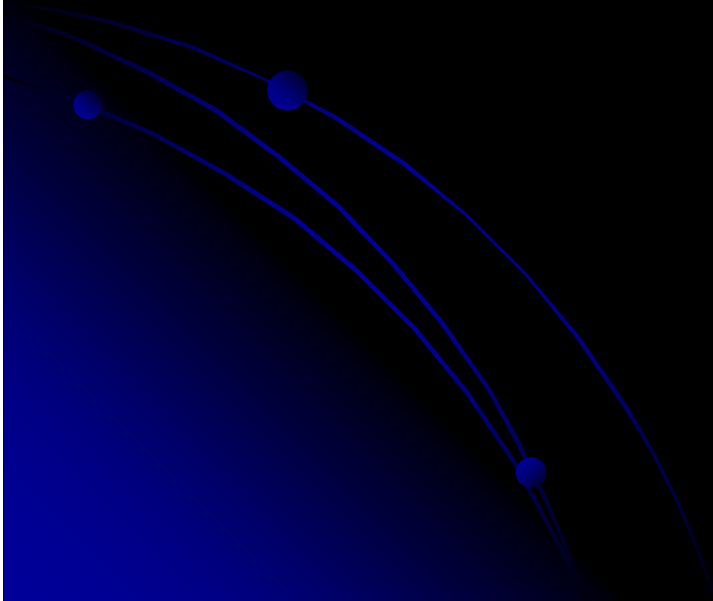
How well MetS predicts future Diabetes?

After adjustment



Adjusted for sex, Fam Hx DM, Residence, Smk, Exer., Alcho, age, stress, ALT, TCH, WBC, CRP, Renin, HbA1c, Beta cell function, HOMA-IR, QuicKi index

Construction of the 10 yr T2DM Risk Assessment model



Purpose:

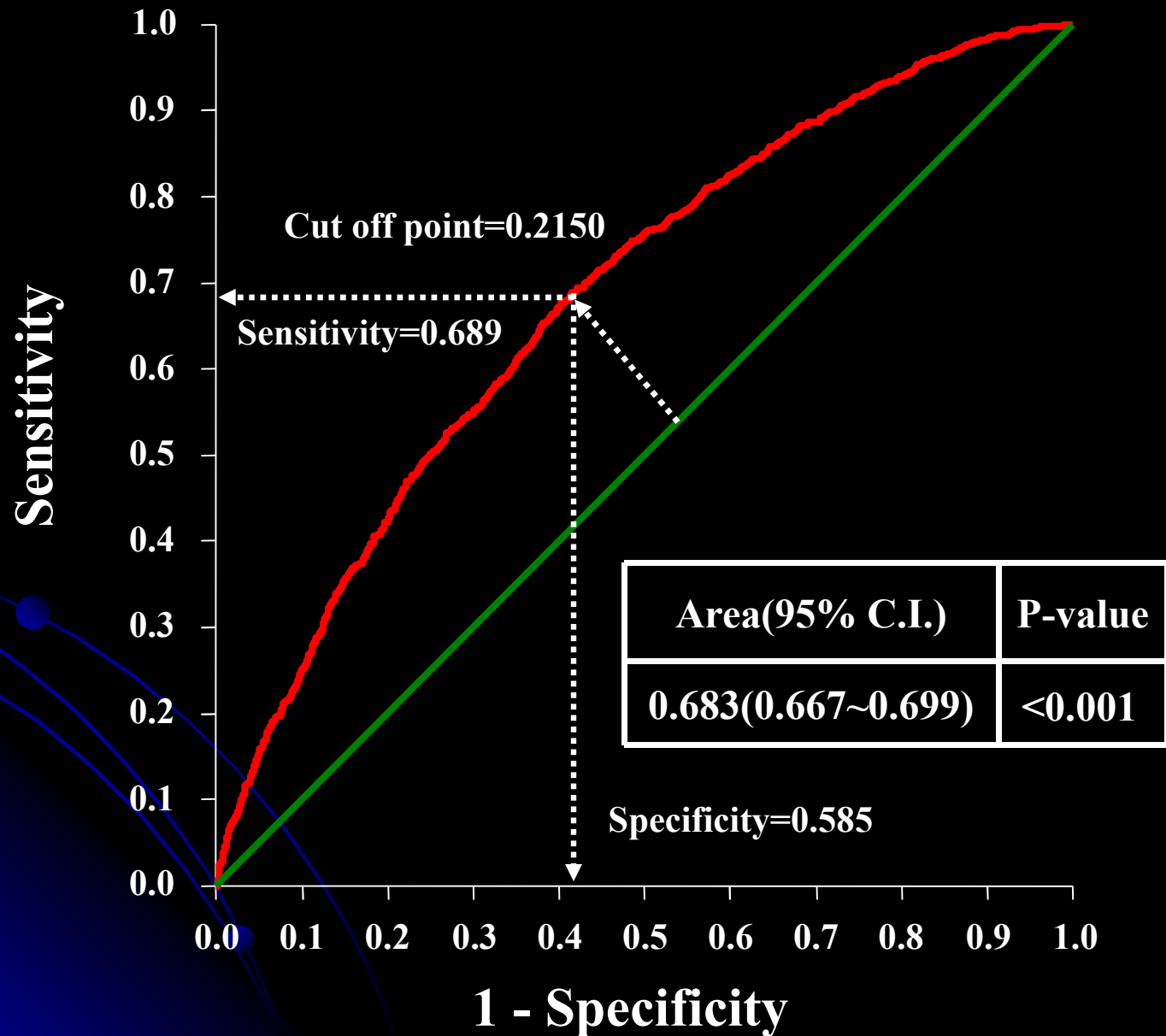
- **Early diagnosis of T2DM in General population**
- Based on the incidence
- Simple to use for general model “Pen and Paper model”, and sensitive one for medical professionals

10 -yr Risk Assessment General Model

variables	β	p-value	RR(95% C.I.)
Urban	0.864	<0.001	2.37(2.04~2.76)
Family History of DM	0.537	<0.001	1.71(1.40~2.08)
Non-smokers		Reference	
Ex-smokers	0.213	0.019	1.24(1.03~1.48)
Current smokers	0.511	<0.001	1.67(1.42~1.95)
Age	0.035	<0.001	
sBP	0.017	<0.001	
Waist circumference	0.041	<0.001	

Adjusted for sex, alcohol drinking, exercise

10-yr Risk Assessment General Model using ROC



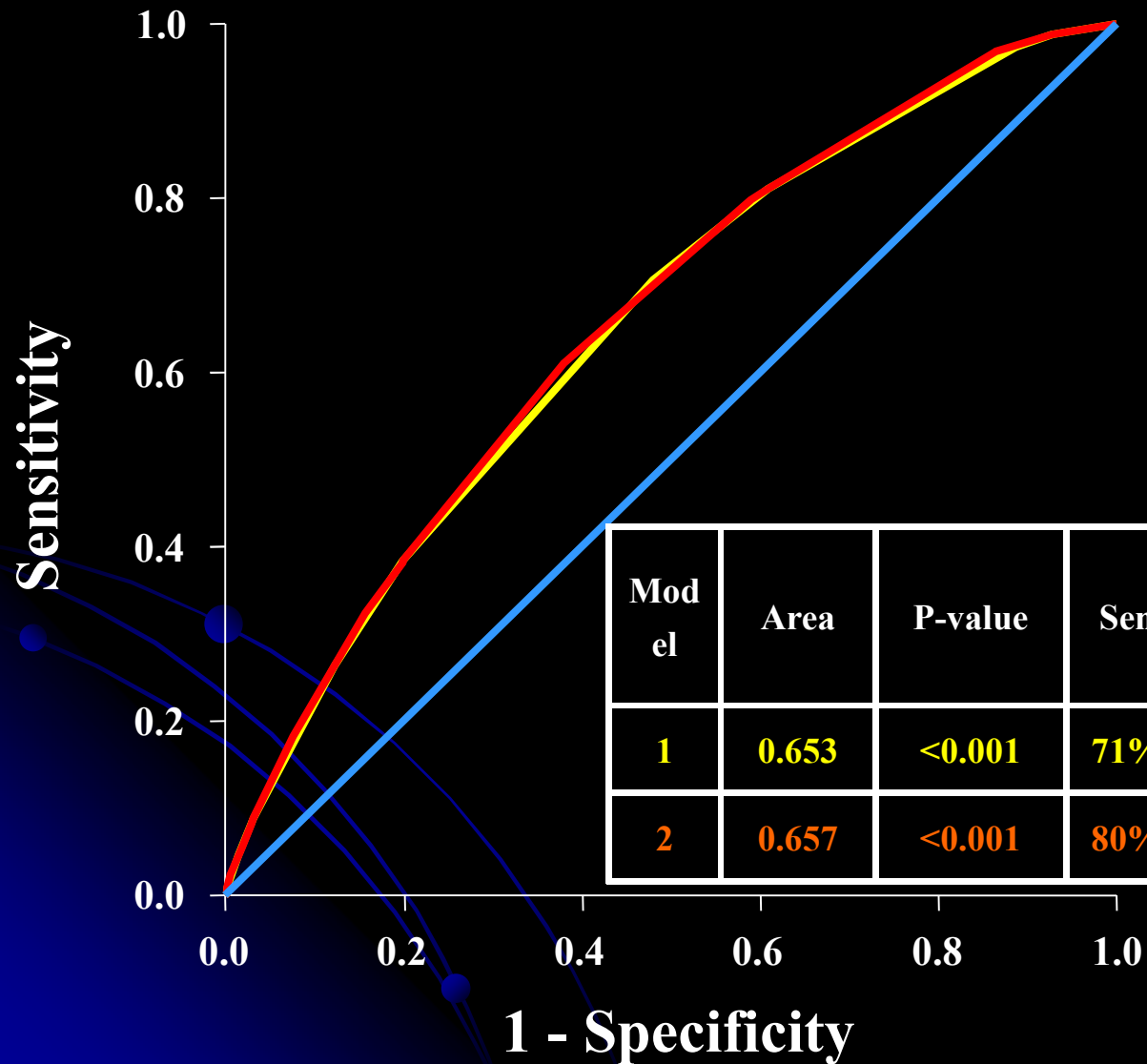
10 -yr Risk Assessment General Model based on the RR

Variables	B	p-value	RR(95% C.I.)	model 1 RR	model 2 RR
Urban	0.748	<0.001	2.11(1.82~2.45)	2	4
Fam Hx DM	0.496	<0.001	1.64(1.35~2.00)	2	3
Non-smokers		Reference		0	0
Ex-smokers	0.411	<0.001	1.51(1.26~1.80)	2	3
Current smokers	0.636	<0.001	1.89(1.62~2.21)	2	4
Age group 40th		Reference		0	0
50th	0.396	<0.001	1.49(1.26~1.75)	1	3
60th	0.800	<0.001	2.22(1.86~2.66)	2	4
sBP ≥140mmHg	0.588	<0.001	1.80(1.47~2.20)	2	4
WC M 90cm/F 85cm	0.691	<0.001	2.00(1.73~2.31)	2	4

Adjusted for sex, alcohol drinking, exercise

Comparison of the two RR models by ROC

— Model 1 — Model 2 — Reference Line



Model	Area	P-value	Sen	Spec	Cut off point	RR(95% C.I.)
1	0.653	<0.001	71%	52%	4	2.61(2.28~2.98)
2	0.657	<0.001	80%	41%	7	2.75(2.37~3.19)



10 yr T2DM Assessment Model

“Pen and Paper Model”



Name : John Doe

Living
 Rural Urban

Fam Hx DM
 No Yes

Smoking Status
 No Ex-smoker Current-smoker

Age Group
 40th 50th 60th

SBP
 <140 mmHg ≥140 mmHg

WC Male 90cm/Female 85cm
 Lesser greater

Result	
Score : 0	4.9%
Score : 1~3	8.0%
Score : 4~6	15.6%
Score : 7~10	24.4%
Score : 11~14	36.8%
Score : 15~	46.9%
Score : 14	

Check Result

Print

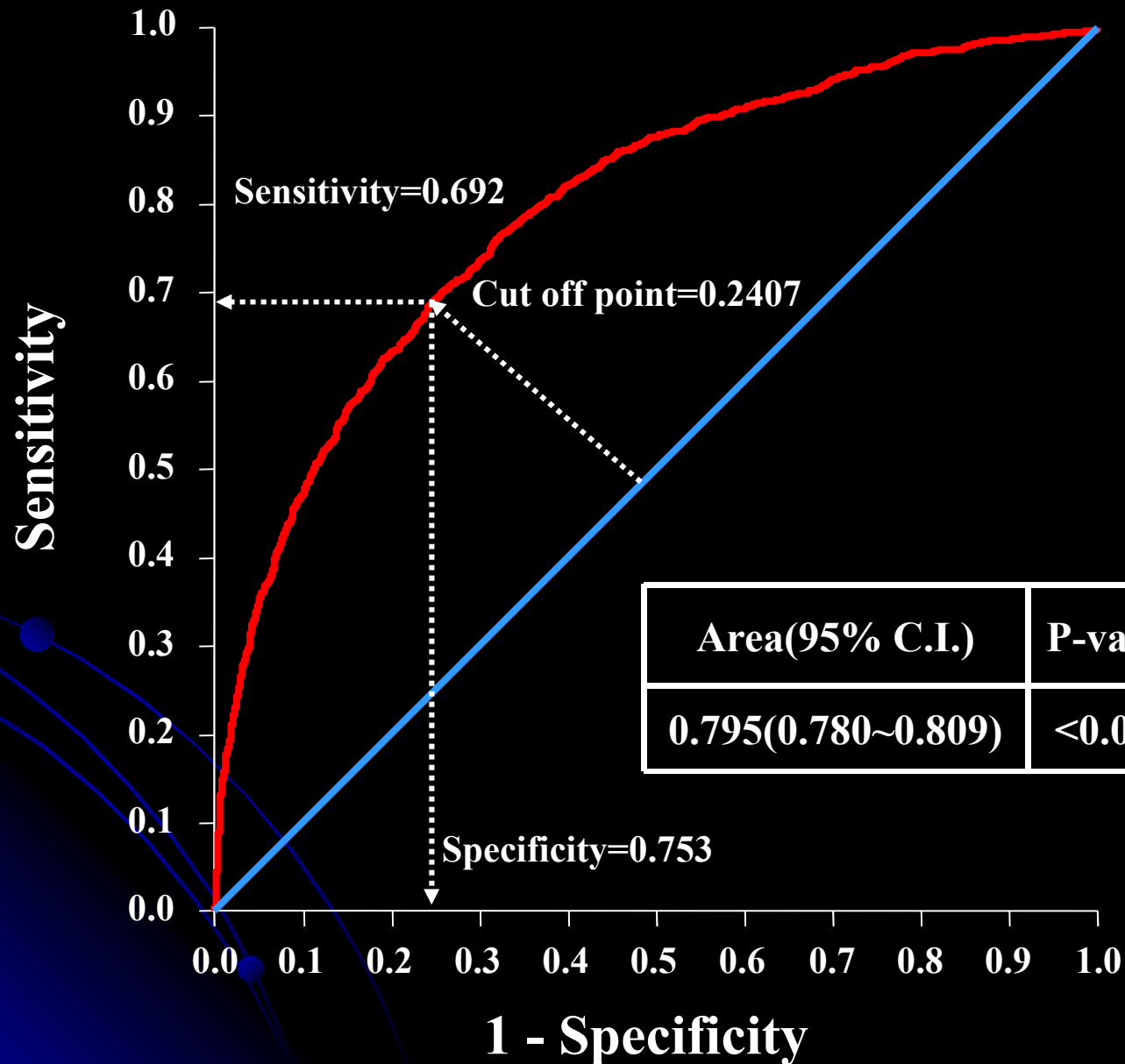
End

10 –yr Risk Assessment Clinical Model

variables	β	p-value	RR(95% C.I.)
Urban	0.967	<0.001	2.63(0.23~3.11)
Family History of DM	0.438	<0.001	1.55(1.25~1.92)
Age	0.027	<0.001	
sBP	0.014	<0.001	
WC	0.014	0.004	
HbA1c	2.139	<0.001	
HOMA-IR	0.291	<0.001	
β -cell function	-0.004	<0.001	
Tg	0.002	<0.001	
WBC	0.061	0.003	
ALT	0.008	<0.001	

Adjusted for sex , family history of DM, alcohol drinking, exercise, Quicki index, T.Chol, RBC

10 -yr Risk Assessment Clinical Model using ROC



Testing validity using the General Model

Living ⁽¹⁾	1	1	1	1	1	1	1	1	2	1	1	1	2	2
Fam Hx DM ⁽²⁾	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Smoking Status ⁽³⁾	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Age	56	55	59	52	60	62	49	49	43	60	63	60	68	62
SBP	101	115	113	131	127	111	113	150	103	135	119	120	115	111
WC	84	79	71	88	81	84	92	83	72	97	92	87	75	79
모델 예측 결과	0	0	0	0	0	0	0	0	0	1	1	1	1	1
당뇨병 진단	1	0	0	1	0	0	1	0	0	1	0	1	1	1

(1: Urban=1 Rural=2 (2: No=0 yes=1 (3: No=0 Ex-smoker=1 Smoker=2

Testing validity using the General Model

Living ⁽¹⁾	1	1	1	1	1	1	1	1	2	1	1	1	2	2
Fam Hx DM ⁽²⁾	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smo ⁽³⁾	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SBP	101	115	113	131	127	111	113	115	120	119	120	115	111	111
WC	84	79	71	88	81	84	92	83	72	97	87	75	79	79
모델 예측 결과	0	0	0	0	0	0	0	0	0	1	1	1	1	1
당뇨병 진단	1	0	0	1	0	0	1	0	0	1	0	1	1	1

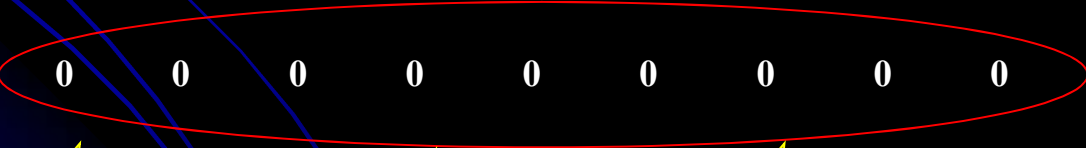
모델 예측에서 위험군으로 14명중 5명 예측, 10년 후 5명 중 4명 당뇨병발병(Sensitivity=80%)

(1: Urban=1 Rural=2 (2: No=0 yes=1 (3: No=0 Ex-smoker=1 Smoker=2

Testing validity using the General Model

Living ⁽¹⁾	1	1	1	1	1	1	1	1	2	1	1	1	2	2
Fam Hx DM ⁽²⁾	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smo	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SBP	101	111	113	150	103	135	119	120	115	111				
WC	84	79	71	88	84	92	83	72	97	92	87	75	79	
모델 예측 결과	0	0	0	0	0	0	0	0	0	1	1	1	1	1
당뇨병 진단	1	0	0	1	0	0	1	0	0	1	0	1	1	1

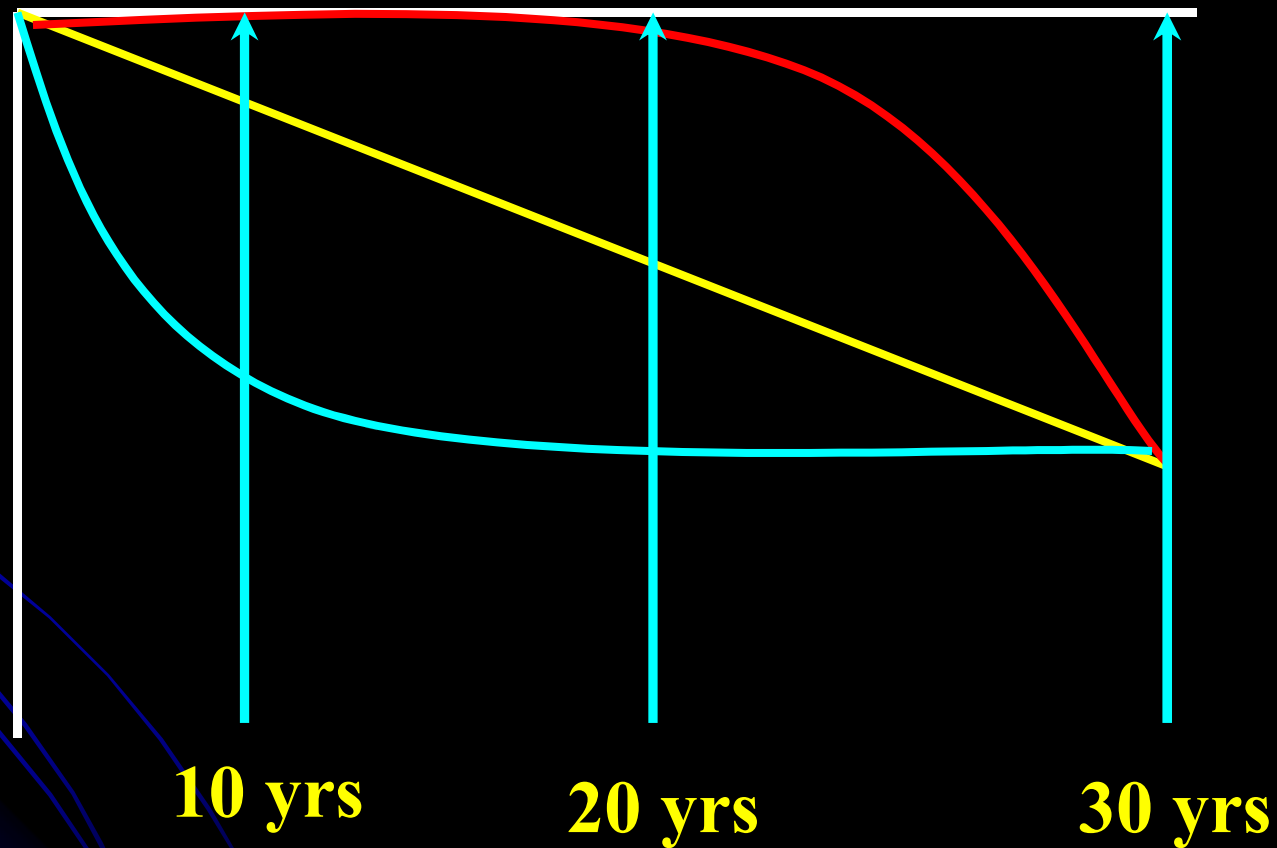
모델 예측에서 정상군으로 14명중 9명 예측, 10년 후 정상 9명 중 6명 정상(Specificity=66.7%)



(1: Urban=1 Rural=2 (2: No=0 Ex-smoker=1 Smoker=2

Drop out

Force of Morbidity and Mortality for disease assessment model



Summary and Conclusion

- It is the first model based on the incidence,
 - Simple, Reliable, and Valid,
 - Further validation and has a room for improvement.
- Quick, simple, cheap, and less invasive. Thus, it is an ideal screening tool for an early detection of T2DM.

Thank you for your attention!
Many thanks to Center for Clinical Epidemiology, Ajou University Medical Center staff

