Improving healthcare outcomes in the era of pay-for-value: Empirical examples from Taiwan

Jung-Der Wang, M.D., Sc. D.
National Cheng Kung University College of Medicine, Dept. of Public Health
National Cheng Kung University Hospital
王榮德 成大醫學院講座教授
成大醫院職醫部及內科部主治醫師

OUTLINES

- **Paradigm shift:** pay-by(for)-value
  Survival X (2nd function):
  costs (including out-of-pocket pay)
  quality of life
  functional disability, etc.
- **Practical example(s):**
  Prolonged mechanical ventilation
  (Methadone treatment for heroin users)

(Declaration of interest: My team only receive funding support from the Ministry of Science and Technology of Taiwan)

Redefining health care
重新定義健康照護 (2006):

by Michael Porter and Elizabeth Teisberg

(中文翻譯:醫療革命，黃達夫基金會)

- **Value is the outcome per dollar spent in providing services, and outcome includes not only survival but also quality of life and functional impairments, etc. ……*(New Engl J Med 2009;361:109-12)***
- **Standardization of outcome measurements *(New Engl J Med 2016;374:504-6)***

ICHOM – International Consortium for Health Outcomes Measurement

An elderly suffering from loss of consciousness after falling down

- Age: 89
- Comatose, $E_1V_1M_1$
- Subdural hematoma (by computed tomography), respiratory distress
- Pupils not yet dilated
- Comorbid with diabetes (40+ yrs), hypertension (25 yrs), Parkinson's disease, prostate cancer, old stroke

Clinical decisions:

- **To operate or not (craniotomy to treat the hematoma)?**
- **Would the patient regain consciousness after operation?**
- **Should he be continued mechanical ventilation, if he were still comatose after operation?**

PMV (prolonged mechanical ventilation)

- **After 2005 (U.S.A.)**

  ≧ 21 days of mechanical ventilation for at least six hours per day

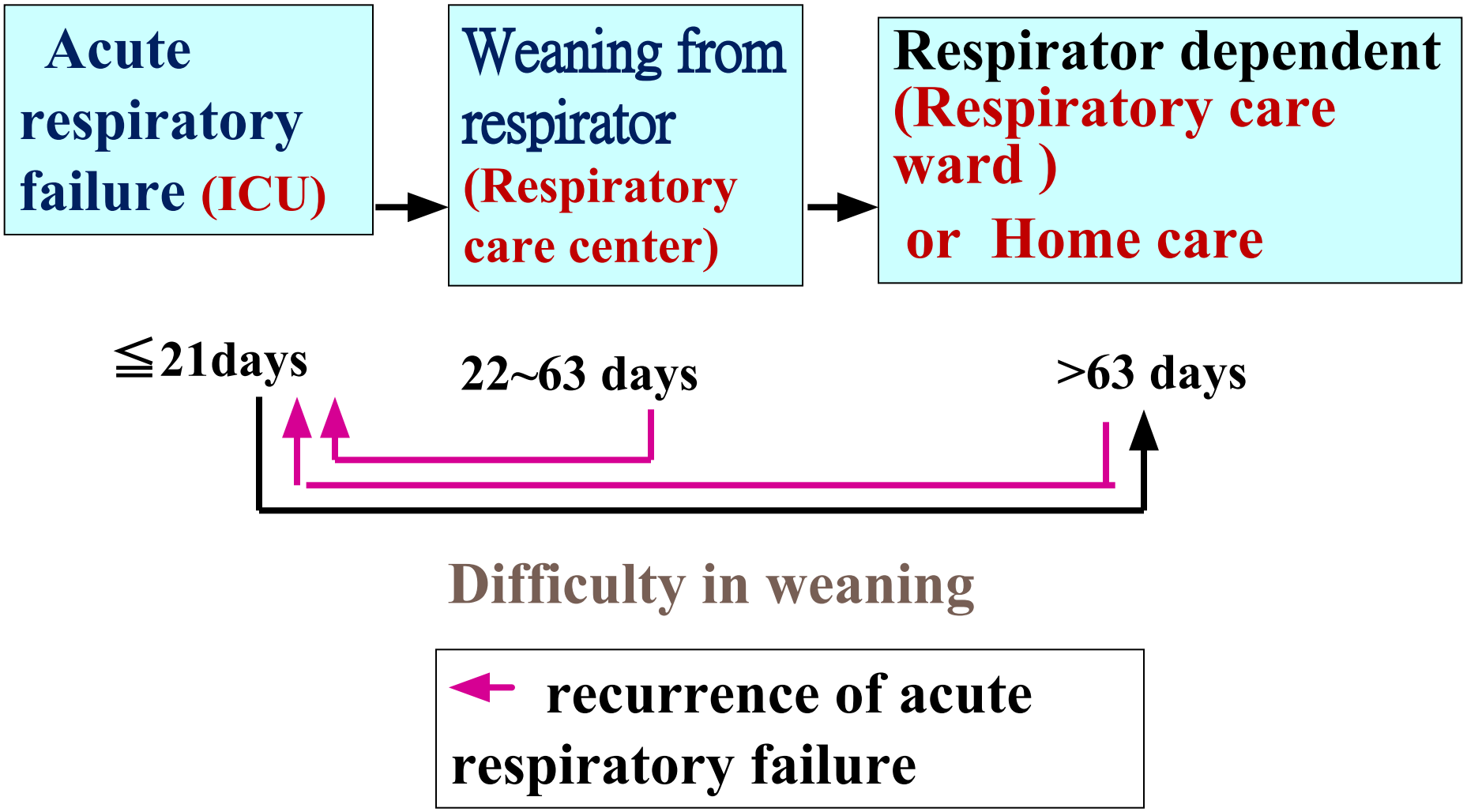
- **10%** of MV patients PMV

  consume up to **40%** of ICU patient days

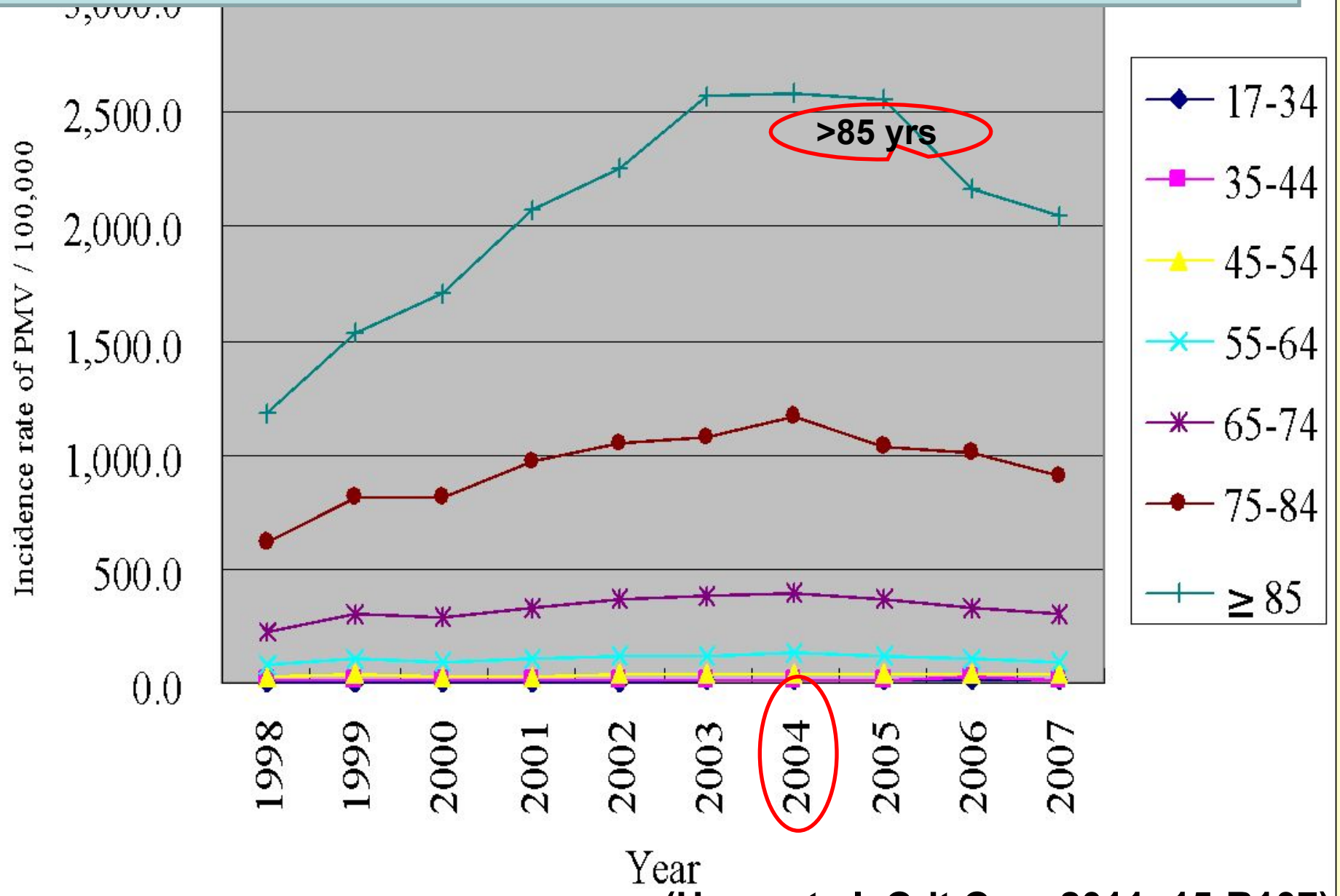
- **In Medicare patients received PMV**
  - Total charges: **3rd**
  - Charges per patient: **1st**

Carson SS. Current Opinion in Critical Care, 2006

Integrated delivery service to relieve traffic jams of hospitalization into ICU ward due to PMV



Old aged people are more likely to be ventilator dependent



(Hung et al. Crit Care 2011; 15:R107)

呼吸照護中心 (Respiratory Care Center)

Weaning of respirator

Respiratory Care Ward (ventilator dependent)

Cost per QALY (quality-adjusted life year) and lifetime cost of prolonged mechanical ventilation in Taiwan

Hung et al. PLoS One 2012; 7: e44043

& others

Quality of life (Qual Life Res 2010; 19:721-727)

Life expectancy (Crit Care 2011; 15:R107)

Improved survival (Respir Care 2013; 58:517-524)

Cancer (Crit Care 2013; 17(4):R144)

Summary(台灣醫界 2016年三月(59卷第3期) 40-43)

Specific diseases	No. of cases	Life expectancy (Years) (SE)	QALE (QALY)(SE)		Lifetime cost ($US) for treatment		Cost per QALY	
			partial cognition	poor cognition	NHI	Out of pocket	partial cognition	poor cognition
Cancer	5,367	1.49 (0.08)	0.46 (0.08)	0.20(0.03)	15,835	13,931	64,708	148,829
Chronic renal failure	2,032	1.32 (0.12)	0.40 (0.09)	0.18(0.04)	24,253	12,237	91,224	202,720
Liver cirrhosis	1,478	3.50 (0.37)	1.15 (0.22)	0.50(0.13)	19,652	32,568	45,409	104,440
Parkinson's disease	341	2.01 (0.27)	0.59 (0.14)	0.26(0.07)	44,708	17,461	105,371	239,110
Degenerative nervous disease	378	4.08 (0.60)	1.28 (0.25)	0.56(0.14)	78,622	36,898	90,250	206,286
Stroke	6,765	3.32 (0.13)	1.05 (0.20)	0.46(0.09)	42,452	29,932	68,938	157,358
Injury or poisoning	4,955	6.19 (0.17)	2.04 (0.39)	0.89(0.18)	43,090	56,806	48,969	112,242

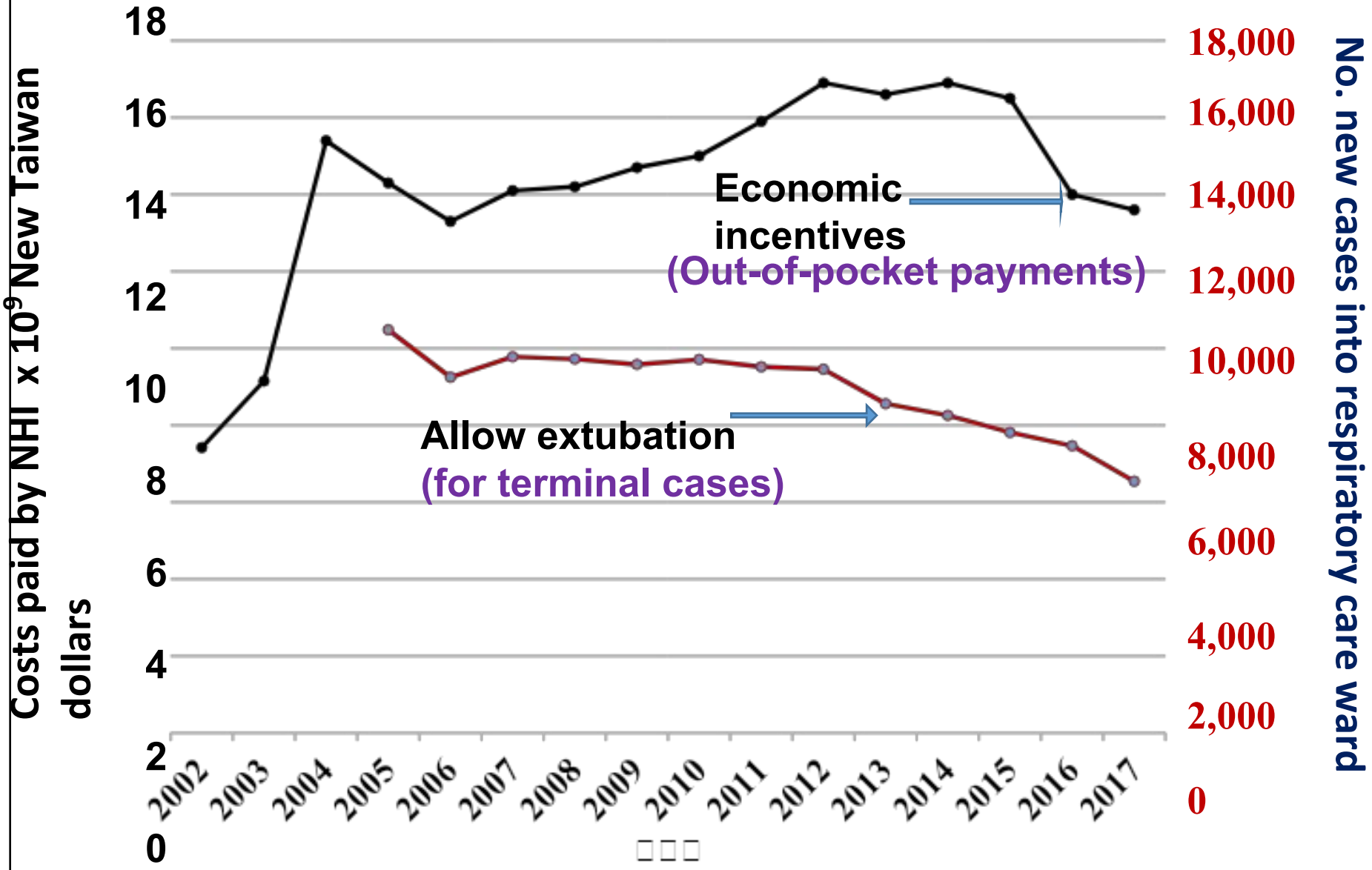
Hung et al. PLoS One 2012;(DOI: 10.1371/joumal.pone.0044043)

	No. of cases	Life expectancy (Years) (SE)	QALE (QALY) (SE)		Lifetime cost ($US) for treatment		Cost per QALY	
			partial cognition	poor cognition	NHI	Out of pocket	partial cognition	poor cognition
<65 yrs								
Heart diseases	616	4.97 (0.63)	1.61 (0.41)	0.70 (0.19)	47,230	45,463	57,574	132,419
Septicaemia/ Shock	919	4.42 (0.59)	1.22 (0.23)	0.64 (0.14)	27,797	40,663	56,115	106,969
Urinary tract infections / Shock	197	4.77 (0.98)	1.43 (0.35)	0.62 (0.18)	54,799	43,487	68,731	158,525
COPD	1788	5.18 (0.28)	1.66 (0.24)	0.72 (0.14)	59,284	46,875	63,951	147,444

Policy changes for PMV
(great efforts of Mr. Huang HS)

- Amendment of law, (January 26**, 2011**)
  "**Hospice Palliative Care Regulation**"
  allowing extubation under signatures of all family members
- Further amendment on article 7 (January 9, **2013**) to allow extubation under conditions of:
  1. diagnosed as terminal by 2 physicians
  2. signature of one closest relative if unconscious

Costs and No. prolonged mechanical ventilation



Take home messages

- For comatose & ventilator dependent patients (>3 weeks), determine:

  Is it a terminal case of the underlying diseases? (Ask two specialists)
- Inform patient's family about life expectancy & out-of-pocket payment associated with PMV
- Advance care planning

Opioid agonist treatment for heroin users

(Chang et al. Drug & alcohol dependence 2019:197-204)

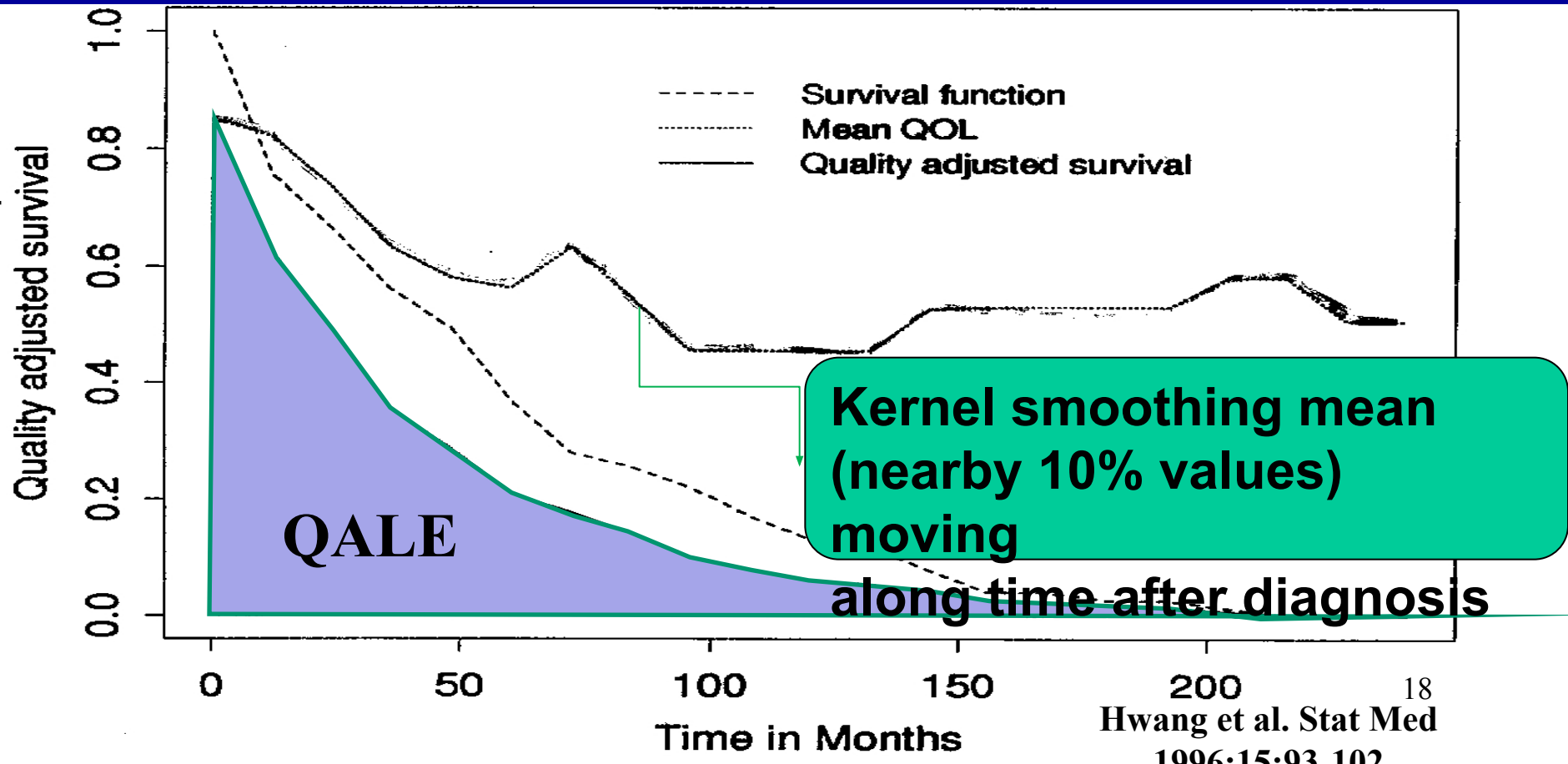
- 1283 heroin users (2006–2014)
- EQ-5D measured for quality of life (n=349)
- Utility of those receiving treatment **0.23** higher than no treatment
- Quality-adjusted life expectancy **9.7** **QALY** higher than those without treatment

Life expectancy for X_i= $\int_0^\infty S(t|x_i)\mathrm{d}t$

Life time utility= $\int_0^\infty E\left[U\left(t|x_i\right)\right]S(t|x_i)\mathrm{d}t$

QALE= $\int_0^\infty E\left[QOL\left(t|x_i\right)\right]S(t|x_i)\mathrm{d}t$

(Quality-adjusted life expectancy)

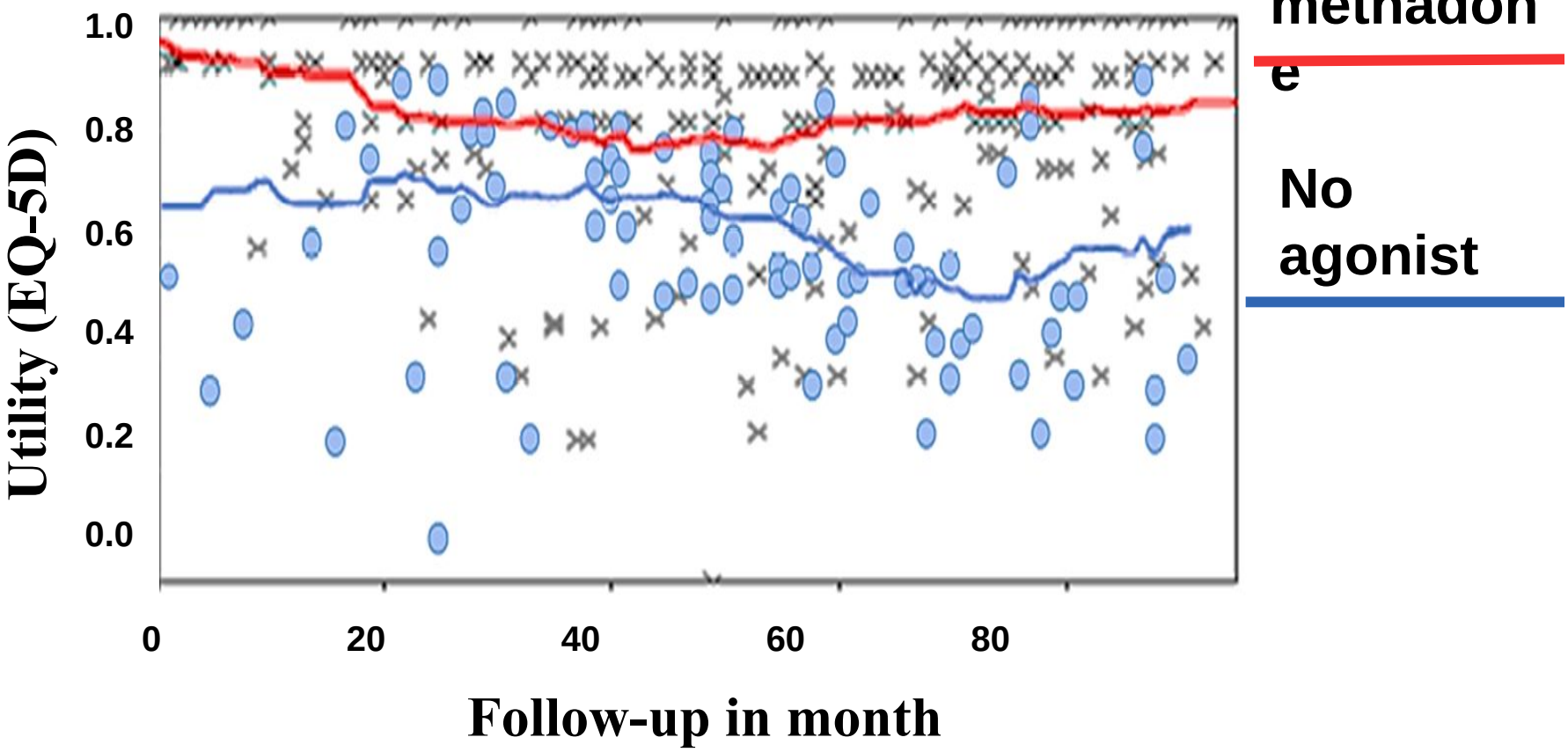


Hwang et al. Stat Med 1996;15:93-102

The transformation of the cross-sectional sampling to dynamic change of quality of life (QOL)

(ex: QOL of heroin users receiving methadone treatment)

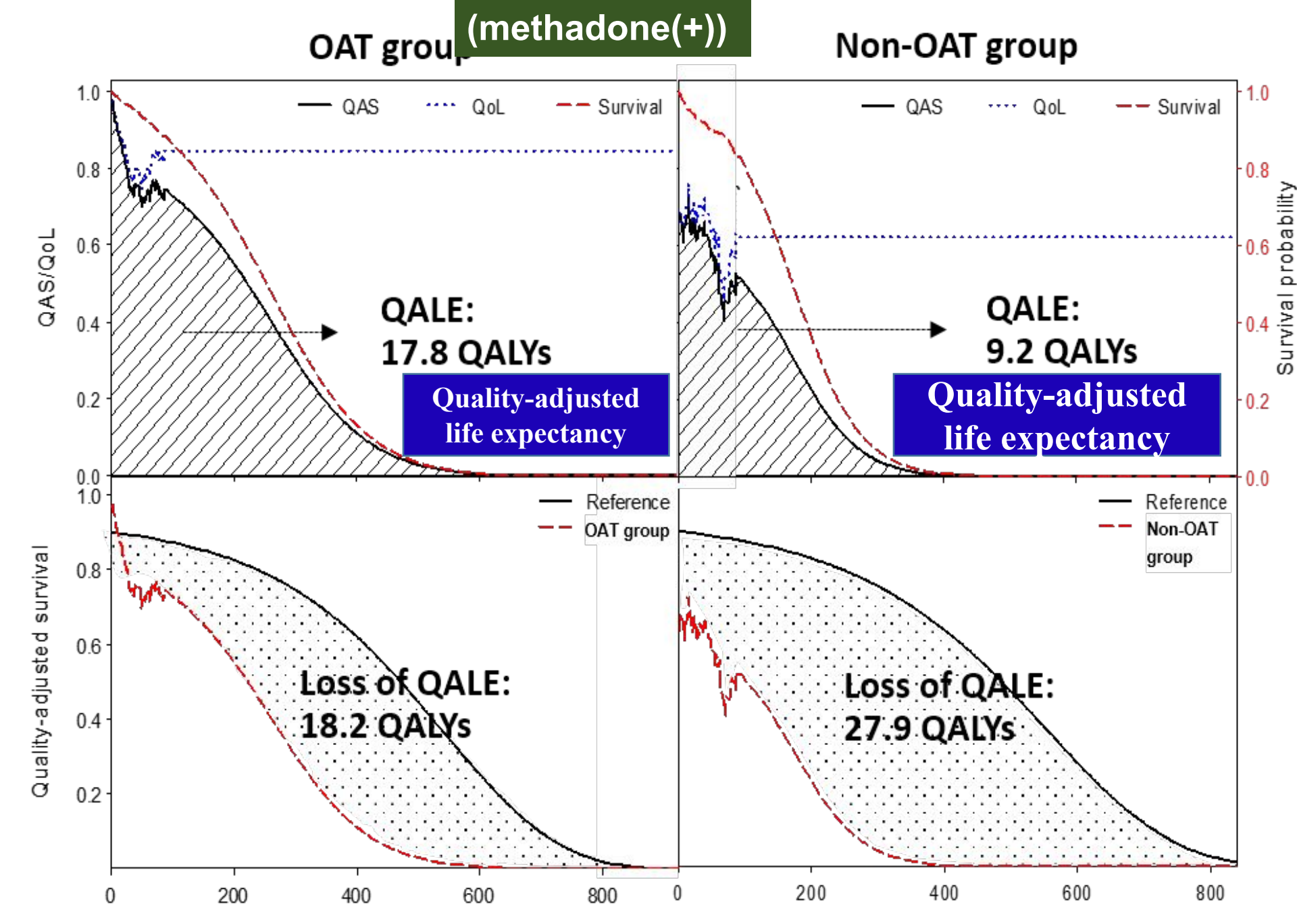
Chang et al. Drug and Alcohol Dependence 2019



利用生命表法, 估計終身調整生活品質後存活時間 (QAST, quality-adjusted survival time)

時間區間	失去追蹤人數	生存數	死亡數	時間區間內人數	風險暴露人數	條件化死亡比	條件化存活比	累積存活比	生活品質 QOL(ti)	QAST
$t_1 - t_2$	l_1	w_1	d_1	n'_1	n_1	$\hat{q}_1$	$\hat{p}_1$	$\hat{s}(t_1) = 1.00$	$qol(t_1)$	QS_1
$t_2 - t_3$	l_2	w_2	d_2	n'_2	n_2	$\hat{q}_2$	$\hat{p}_2$	$\hat{s}(t_2)$	$qol(t_2)$	QS_2
.			.	.	.	.	.	.	.	.
.			.	.	.	.	.	.	.	.
$t_i - t_{i+1}$	l_i	w_i	d_i	n'_i	n_i	$\hat{q}_i$	$\hat{p}_i$	$\hat{s}(t_i)$	$qol(t_i)$	QS_i
.			.	.	.	.	.	.	.	
.			.	.	.	.	.	.	.	.
$t_{s-1} - t_s$	l_{s-1}	w_{s-1}	d_{s-1}	n'_{s-1}	n_{s-1}	$\hat{q}_{s-1}$	$\hat{p}_{s-1}$	$\hat{s}(t_{s-1})$	$qol(t_{s-1})$	QS_{s-1}
$t_s - \infty$	l_s	w_s	d_s	n'_s	n_s	1	0	$\hat{s}(t_s)$	$qol(t_s)$	QS_s

QOL may be replaced by costs, proportion of funct. disability



Chang et al. Drug and Alcohol Dependence 2019

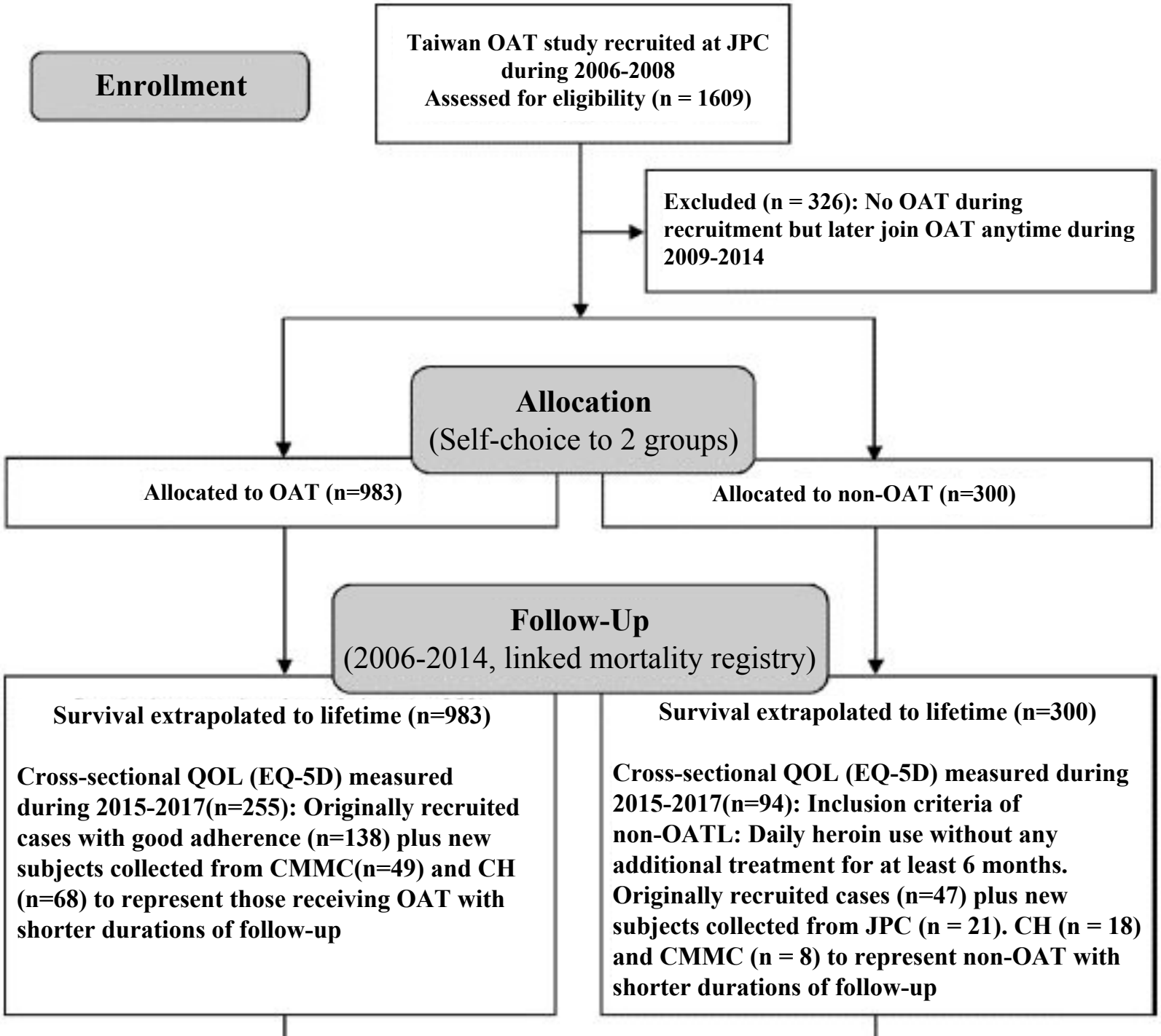
Take home messages

- **Consider both quality of life and lifetime survival function together, opioid agonists treatment would save 9.7 QALY compared with those without such treatments on loss-of-QALE (quality-adjusted life expectancy).**

Methadone & buprenorphine save lives.

THANK YOU FOR YOUR ATTENTION

email: jdwang121@gmail.com


Enrollment
Taiwan OAT study recruited at JPC during 2006-2008
Assessed for eligibility (n = 1609)
Excluded (n = 326): No OAT during recruitment but later join OAT anytime during 2009-2014
Allocation
(Self-choice to 2 groups)
Allocated to OAT (n=983)
Allocated to non-OAT (n=300)
Follow-Up
(2006-2014, linked mortality registry)
Survival extrapolated to lifetime (n=983)
Cross-sectional QOL (EQ-5D) measured during 2015-2017(n=255): Originally recruited cases with good adherence (n=138) plus new subjects collected from CMMC(n=49) and CH (n=68) to represent those receiving OAT with shorter durations of follow-up
Survival extrapolated to lifetime (n=300)
Cross-sectional QOL (EQ-5D) measured during 2015-2017(n=94): Inclusion criteria of non-OATL: Daily heroin use without any additional treatment for at least 6 months. Originally recruited cases (n=47) plus new subjects collected from JPC (n = 21). CH (n = 18) and CMMC (n = 8) to represent non-OAT with shorter durations of follow-up

Cost-effectiveness of healthcare

- **Lifetime survival function** ***(by extrapolation)***

  X QOL **(quality of life) (= QALE)**

  or, ***X cost*** **of health care (=lifetime costs)**

  or, ***X proportion*** **of disability(=long-term care)**

  or, ***X other variables of societal values (kernel smoothing means or modelling)***

- **Health benefits from successful prevention**

  (Age- & sex-matched referents simulated from national life tables – cohorts of specific illnesses)

  EYLL (expected years of life loss)

  Loss-of-QALE (quality-adjusted life expectancy)

  X change of incidence rates due to prevention

Hemodialysis
(血液透析)

Peritoneal dialysis
(腹膜透析)

(Nadal)

Strong

(Federer)

Elegant

Which one is better？

Cost-effectiveness ratio of HD and PD

(Chang et al. Sci Rep 2016; 6:30266)

(血液透析與腹膜透析之成本效果比較)

- No. of dollars spent per QALY (quality-adjusted life year) = (計算每健康人年要花多少錢？)

Lifetime cost/QALE

QALE (quality-adjusted life expectancy):

(終身透析相關總費用/健康餘命)(兩者均折現)

National dialysis cohort

Matched on: **(HD and PD: 1:1)**

Sex, age, time of initiation of dialysis, urbanization, major co-morbidities, including stroke, acute myocardial infarction, congestive heart failure, chronic liver disease etc.

+

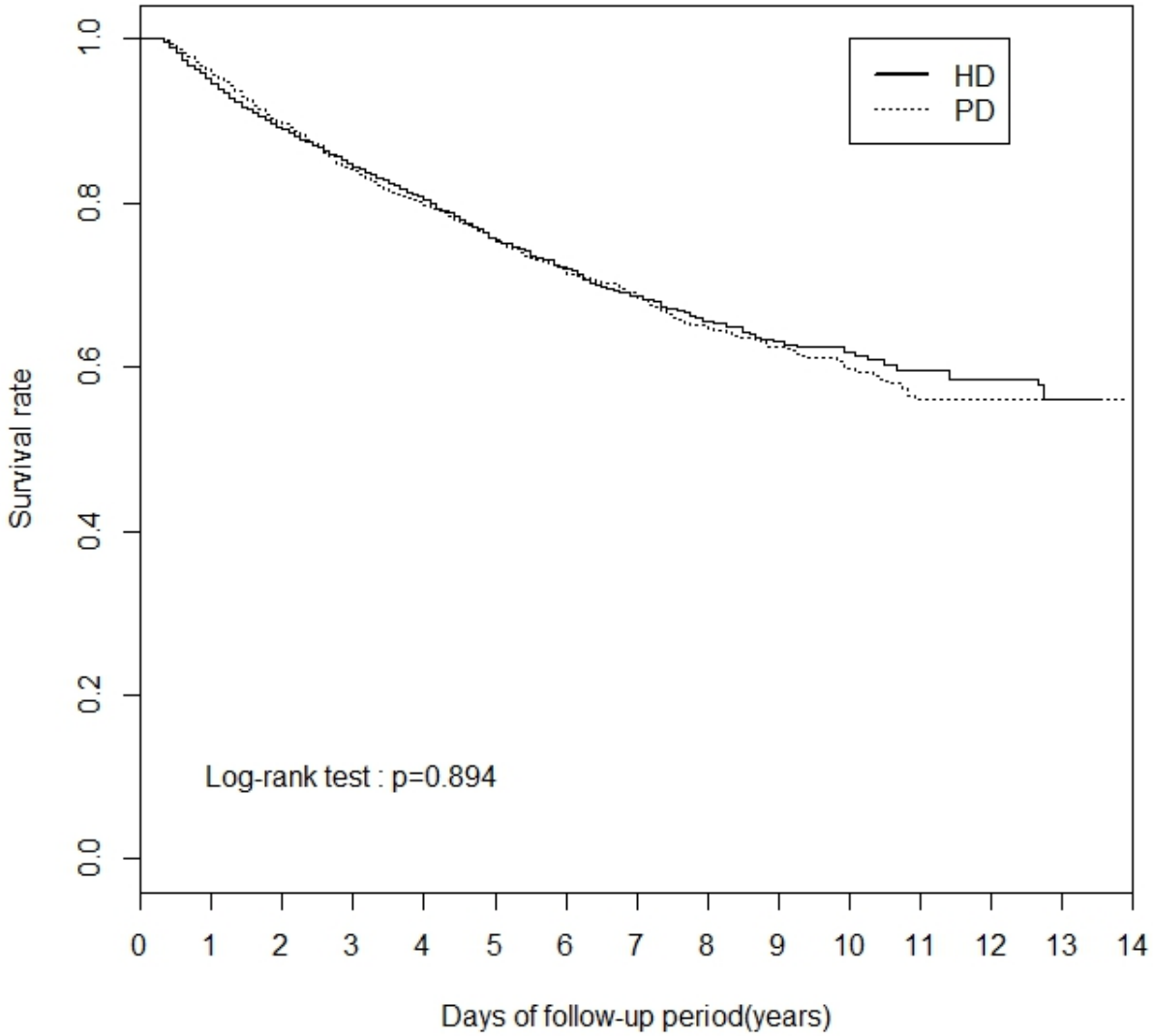
Propensity score for choosing matched-pairs

HD patients (n=66,996)
PD patients (n=4,800)

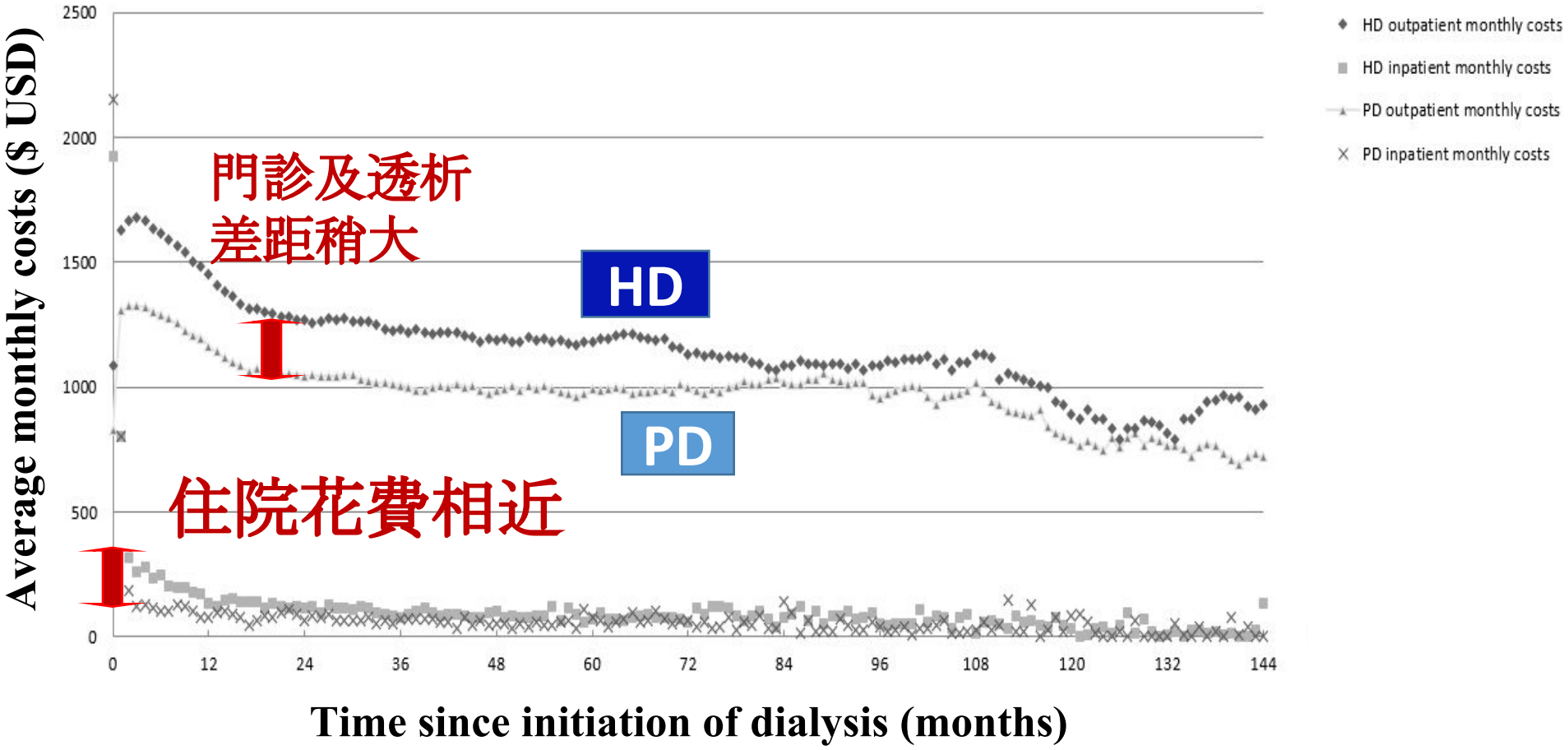
A 1:1 matching from the HD and PD patients; Matched pairs of HD (n=4,285) and PD (n=4,285) patients

Estimation of life expectancy and lifetime healthcare expenditure

Comparison of survival function between 1:1 matched HD and PD patients (4285 pairs)



血液透析(HD)與腹膜透析(PD)病人月平均花費 (1:1匹配共4285對):HD花較多

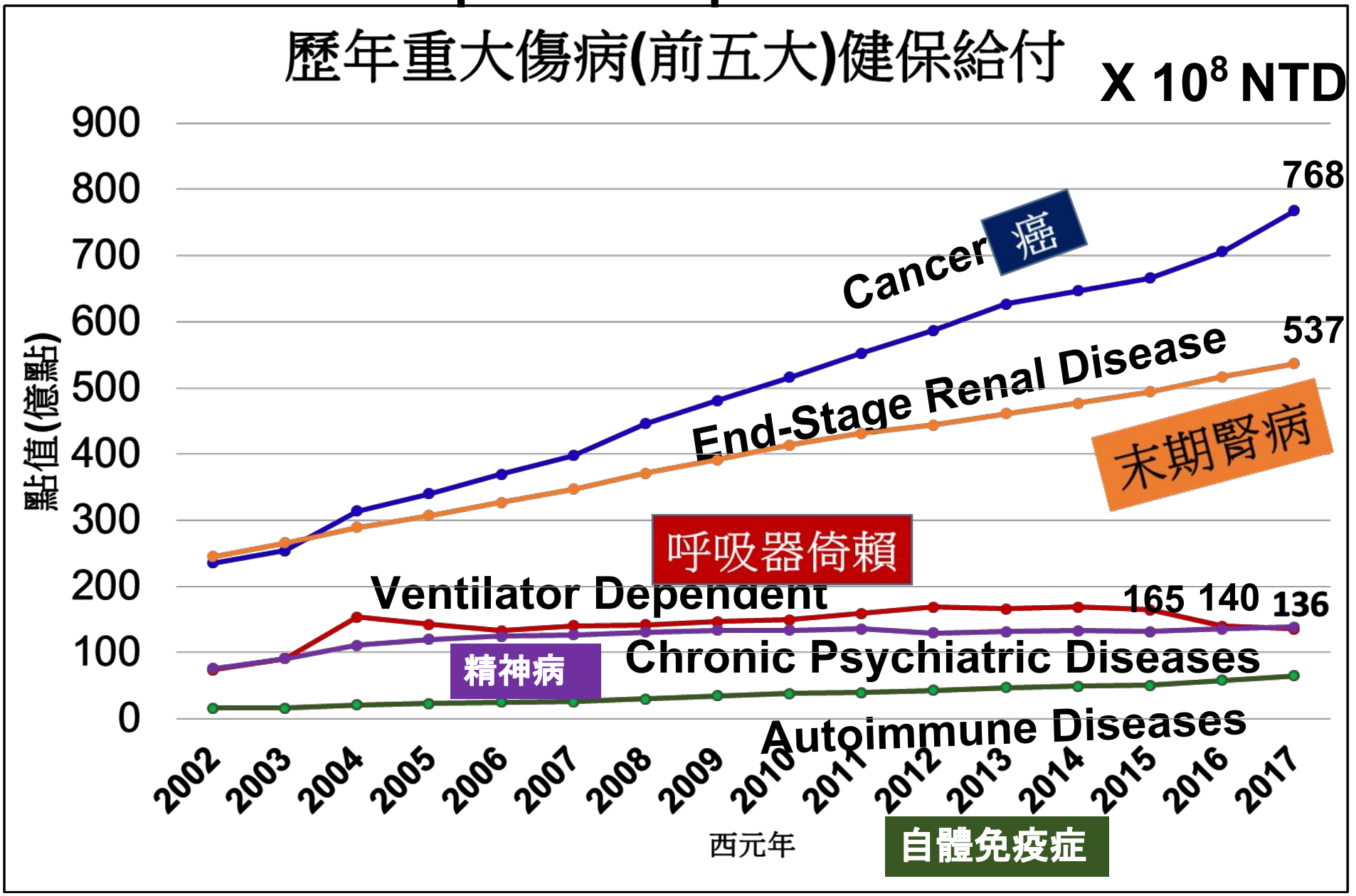


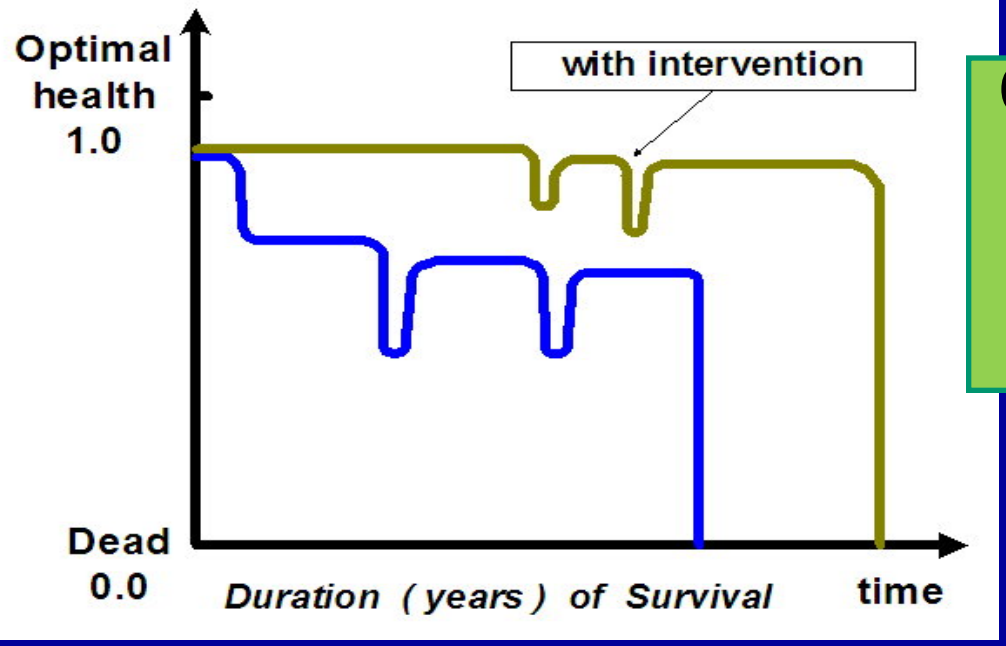
Chang YT, et al. Cost-effectiveness of HD and PD. Sci Rep 2016

HD(hemodialysis) vs. PD(peritoneal dialysis) 1:1 matched 4285 pairs followed 14 years & 179 pairs studied for quality of life (Sci Report 2016)

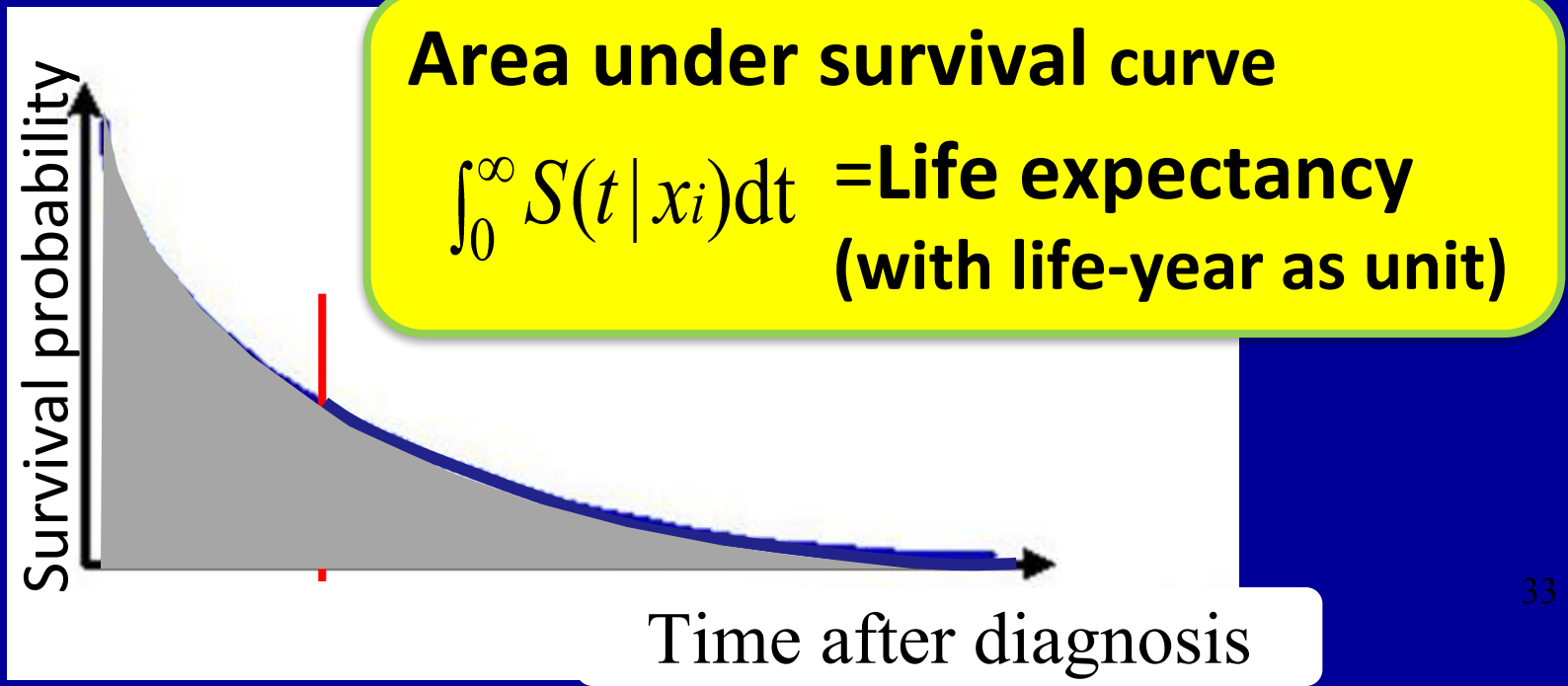
	HD	PD	p-value
Life expectancy(yr)	19.11	19.08	0.853
Lifetime cost (US dollars)	237,795± 6,161*	204,442± 4,888*	<0.001
QALE (in QALY)	16.42	17.41	0.072
QALE (3% discount)	14.29(0.39)	14.94(0.2)	0.149
Cost per QALY	16,643±659	13,681±354	<0.001
ICER (PD-HD)	-50,858*(PD dominant)		

Time trends of costs paid by National Health Insurance for 5 top catastrophic illnesses in Taiwan





QALY (quality-adjusted life year) – integrate survival and quality of life



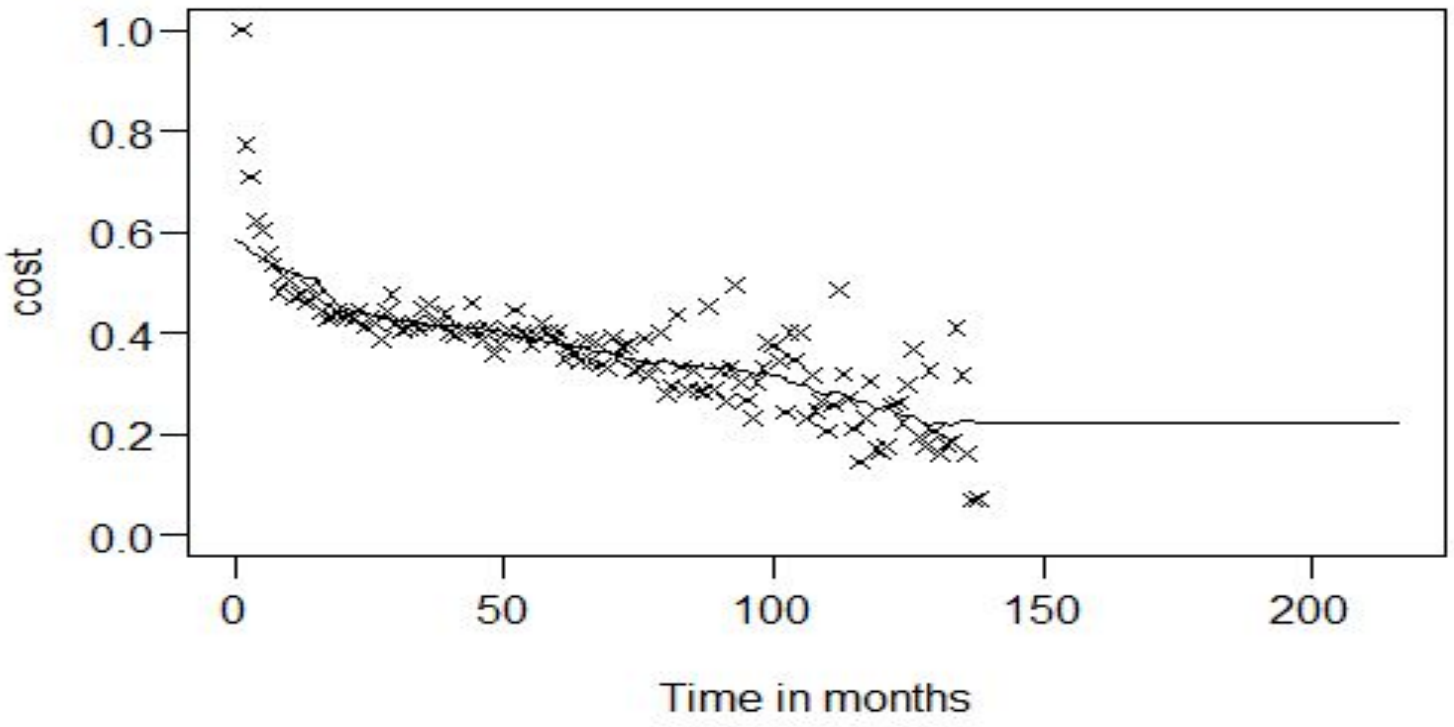
Area under survival curve

$\int_0^\infty S(t \mid x_i)\mathrm{dt}$ **=Life expectancy (with life-year as unit)**

Lifetime cost for liver cancer

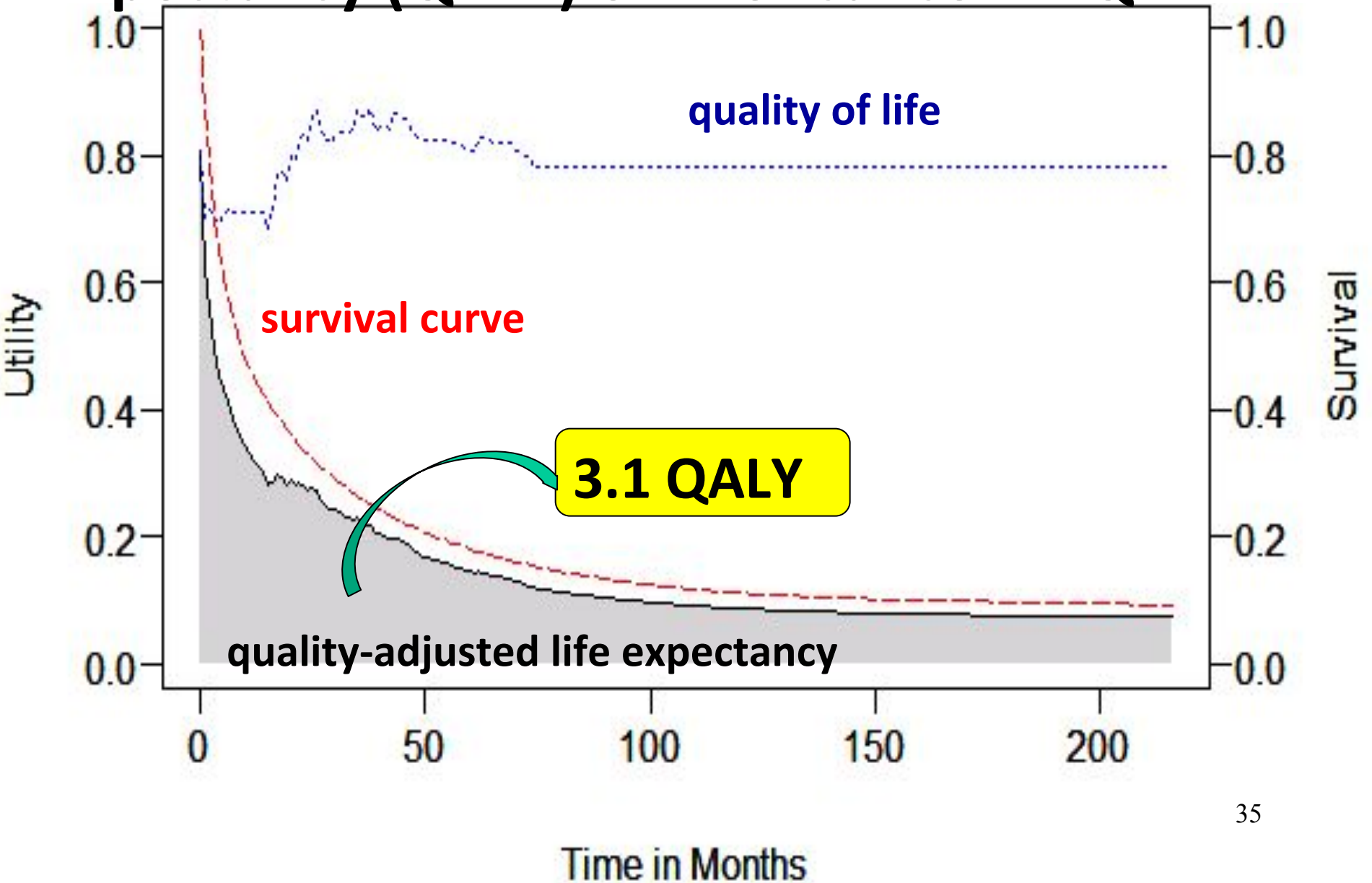
(Lee et al. Occup Environ Med 2012; 69: 582-6)

Monthly cost (healthcare expenditures spent along time after diagnosis)

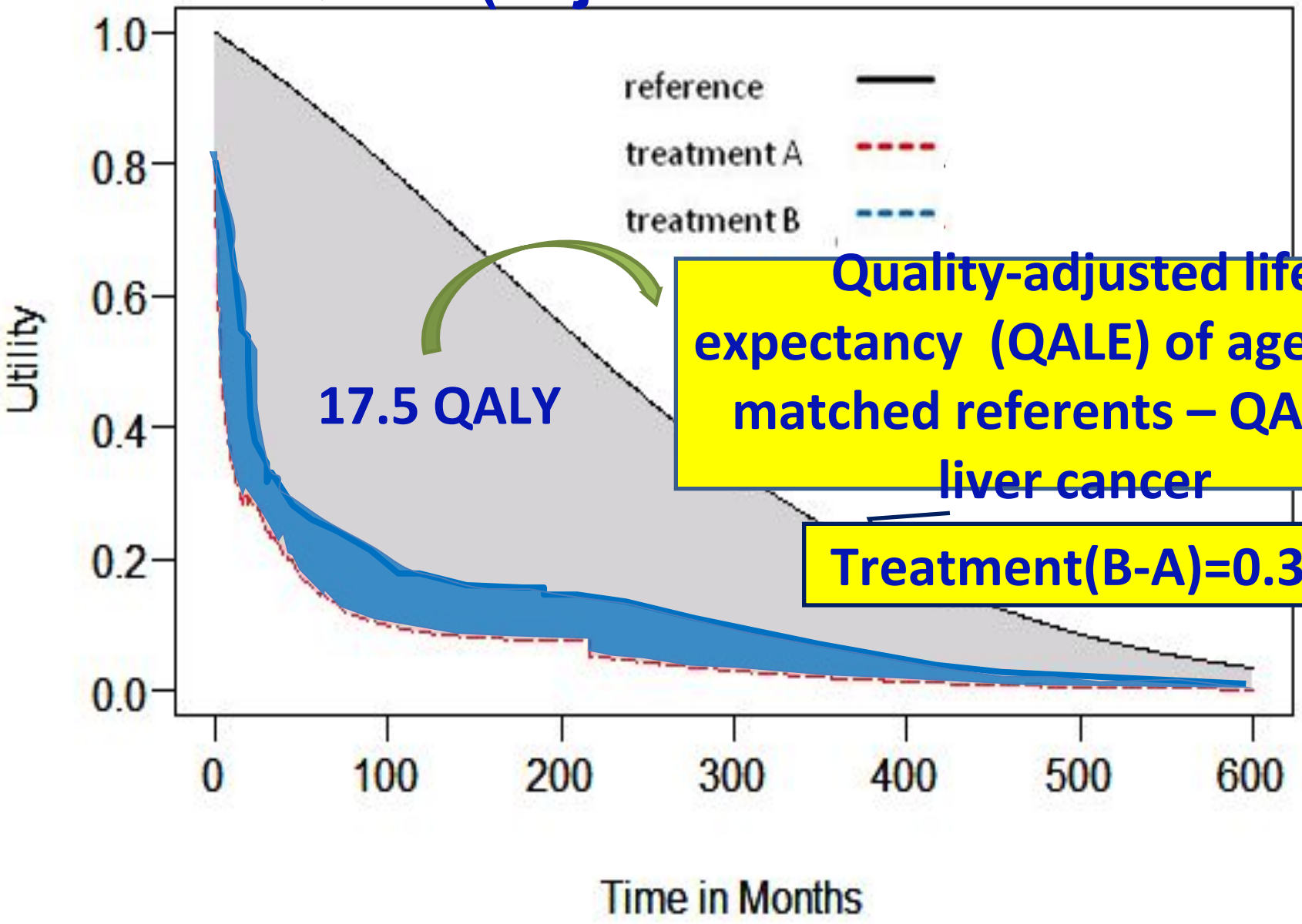


Maximum cost=USD $ 1,151/month

Estimating the quality-adjusted life Expectancy (QALE) of liver cancer in QALY



Health benefits of prevention vs. treatments: loss-of-QALE (adjustment for lead time bias)



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- Liu CT of NTU (劉錦添教授): economic analysis
- Yao KP of NTU(姚開屏教授): psychometry
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- Grants support from the Ministry of Science & Technology, Ministry of Health & welfare, etc.

Data requirements for estimating consequence of illness

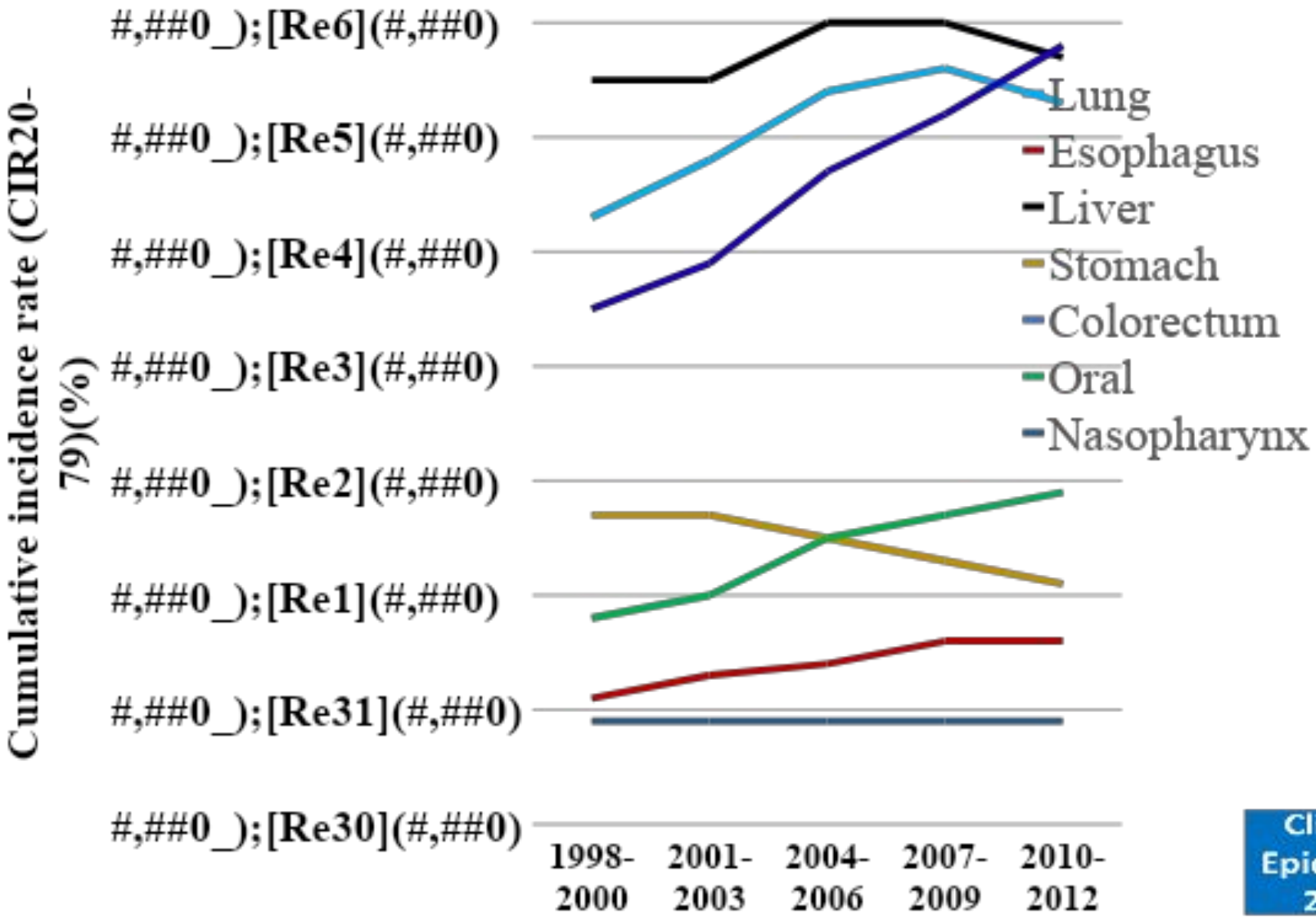
- National life tables (for comparison)
- A cohort with disease x_i followed for 5-10 years: survival can be extrapolated to lifetime if x_i causes premature death
- QOL (quality of life) measurements, or,

  proportions of functional disabilities,
  medical costs,

  personal wages,

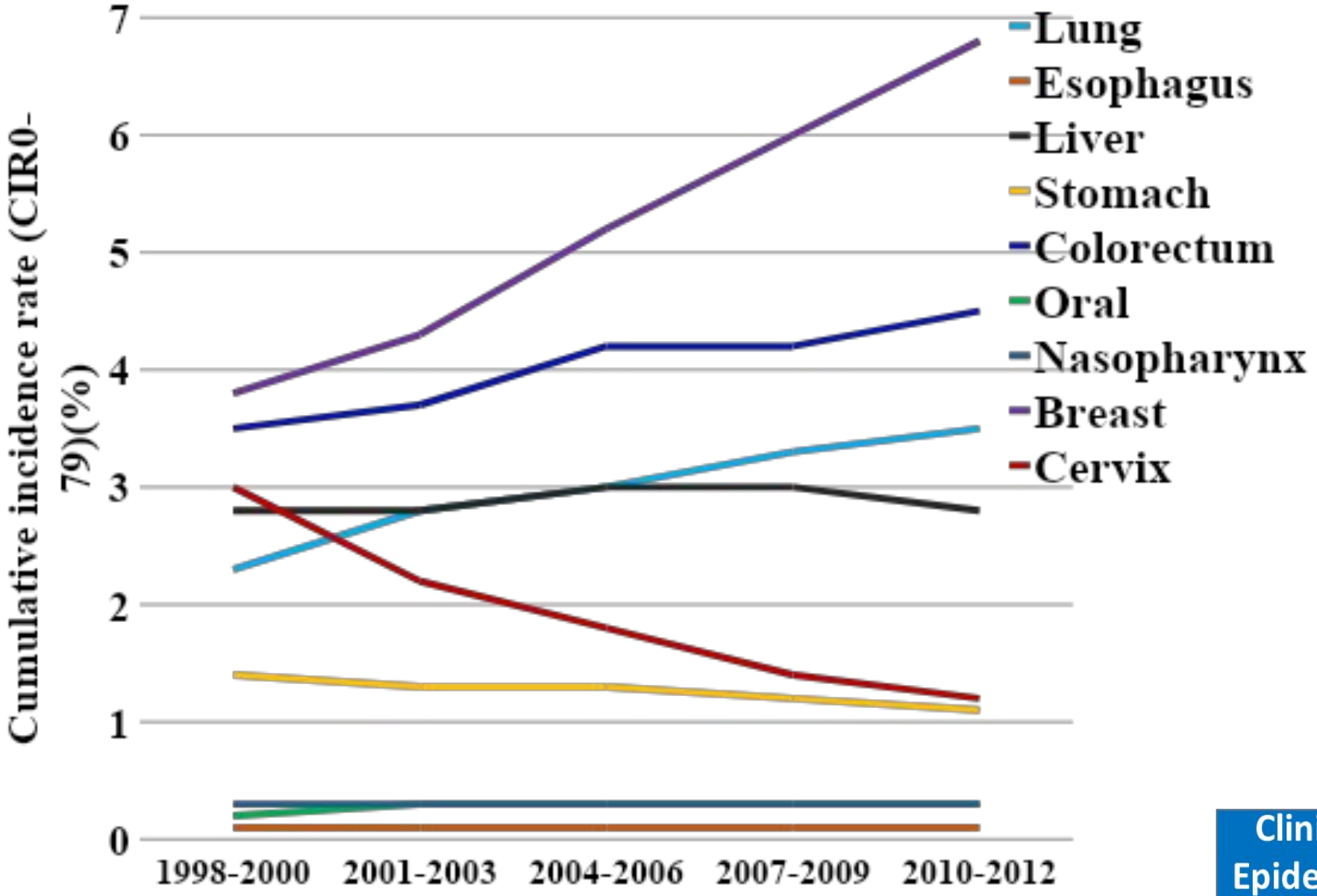
  no. of clinical visits or hospitalization days

Lifetime risks (age 0-79) of male cancer in Taiwan



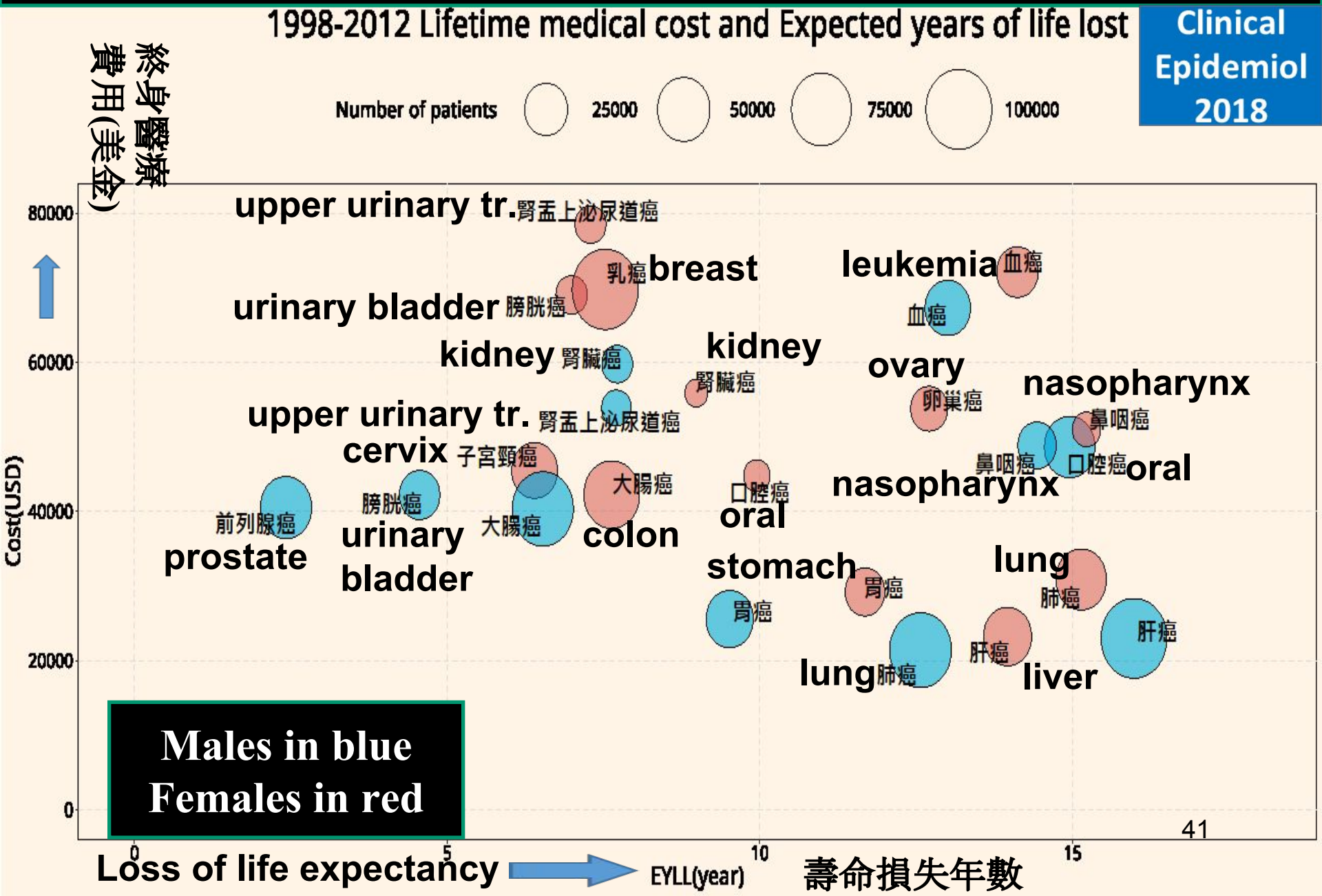
Clinical Epidemiol 2018

Lifetime risks (age 0-79) of female cancer in Taiwan



Clinical Epidemiol 2018

1998-2012台灣癌症病人終身醫療費用及壽命損失



Wu TY, Chung CH, Lin CN, Hwang JS, Wang JD*. Lifetime risks, loss of life expectancy, and healthcare expenditures for 19 cancers in Taiwan. Clin Epidemiol 2018; 10:581-591.

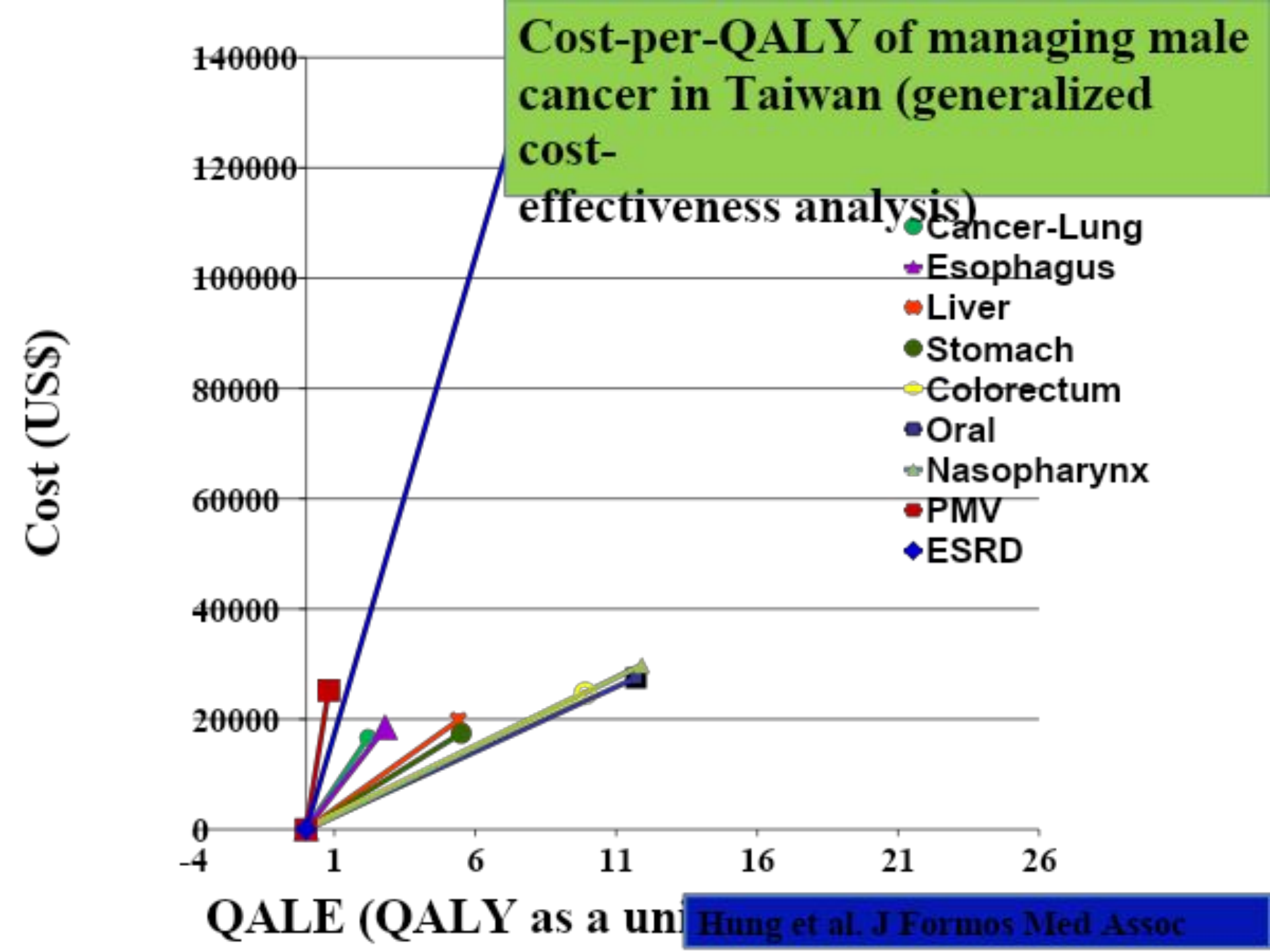
- https://www.dovepress.com/lifetime-risks-loss-of-life-expectancy-and-health-care-expenditures-fo-peer-reviewed-article-CLEP

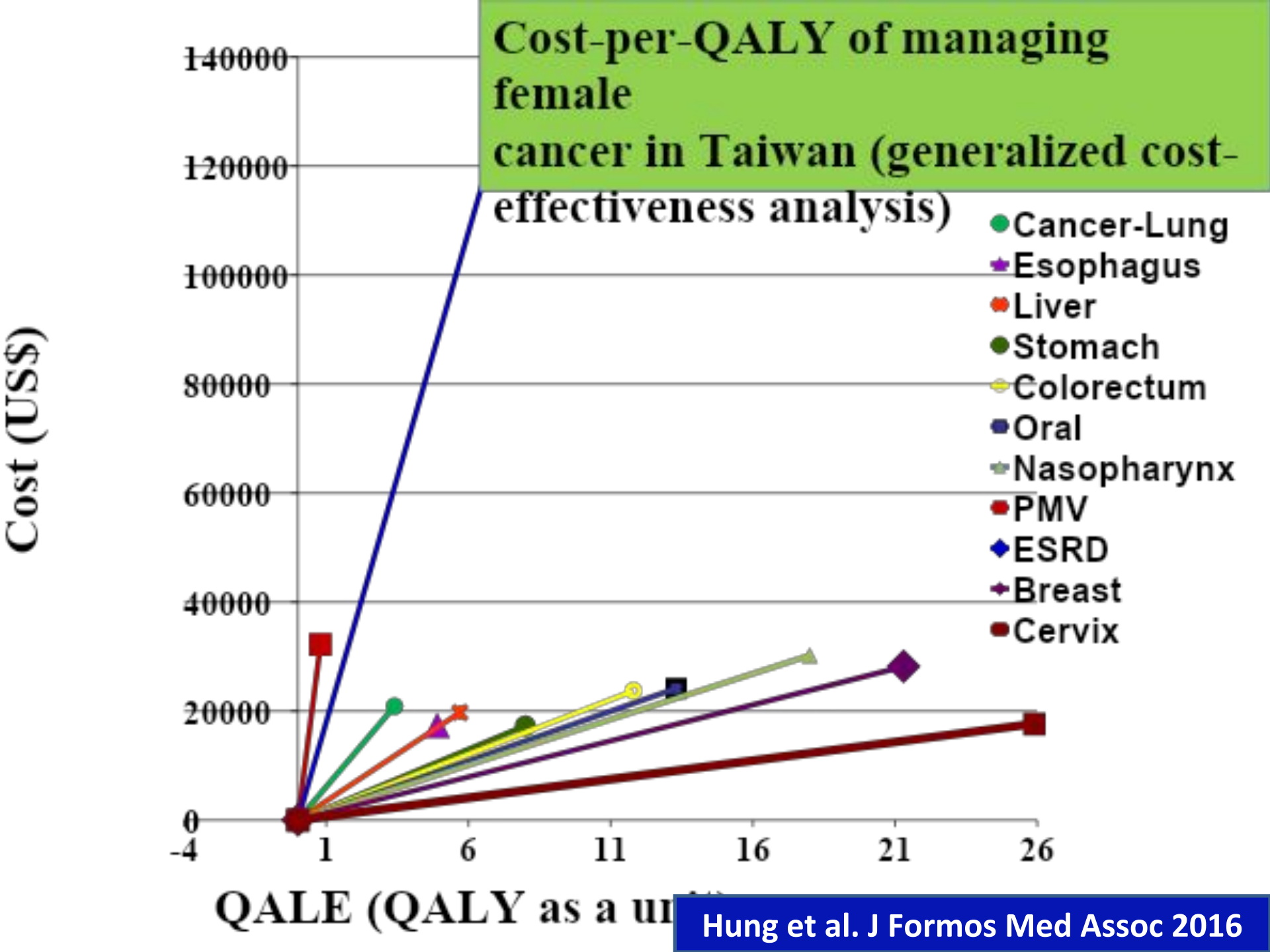
國際引用情形 (International citations):

- **Andersson TM**, et al. Estimating the loss in expectation of life due to cancer using flexible parametric survival models. Statistics in Medicine, 2013;32(30), 5286–5300
- **Jackson C**, et al. Extrapolating survival from randomized trials using external data: A review of methods. Med Decision Making 2017; 37(4):377-390
- **Cucchetti A**, et al. Years of life that could be saved from prevention of hepatocellular carcinoma. Aliment Pharmacol Ther 2016; 43: 814–824
- **Andersen PK**. Life years lost among patients with a given disease. Stat Med 2017; 36:3573-82 (doi: 10.1002/sim.7357)
- **Hwang JS**, Hu TH, Lee LJH, et al. Estimating lifetime medical costs from censored claims data. Health Economics 2017; 26(12):e332-e344 (DOI: 10.1002/hec.3512)

Patient reported outcomes collected from oncology patients

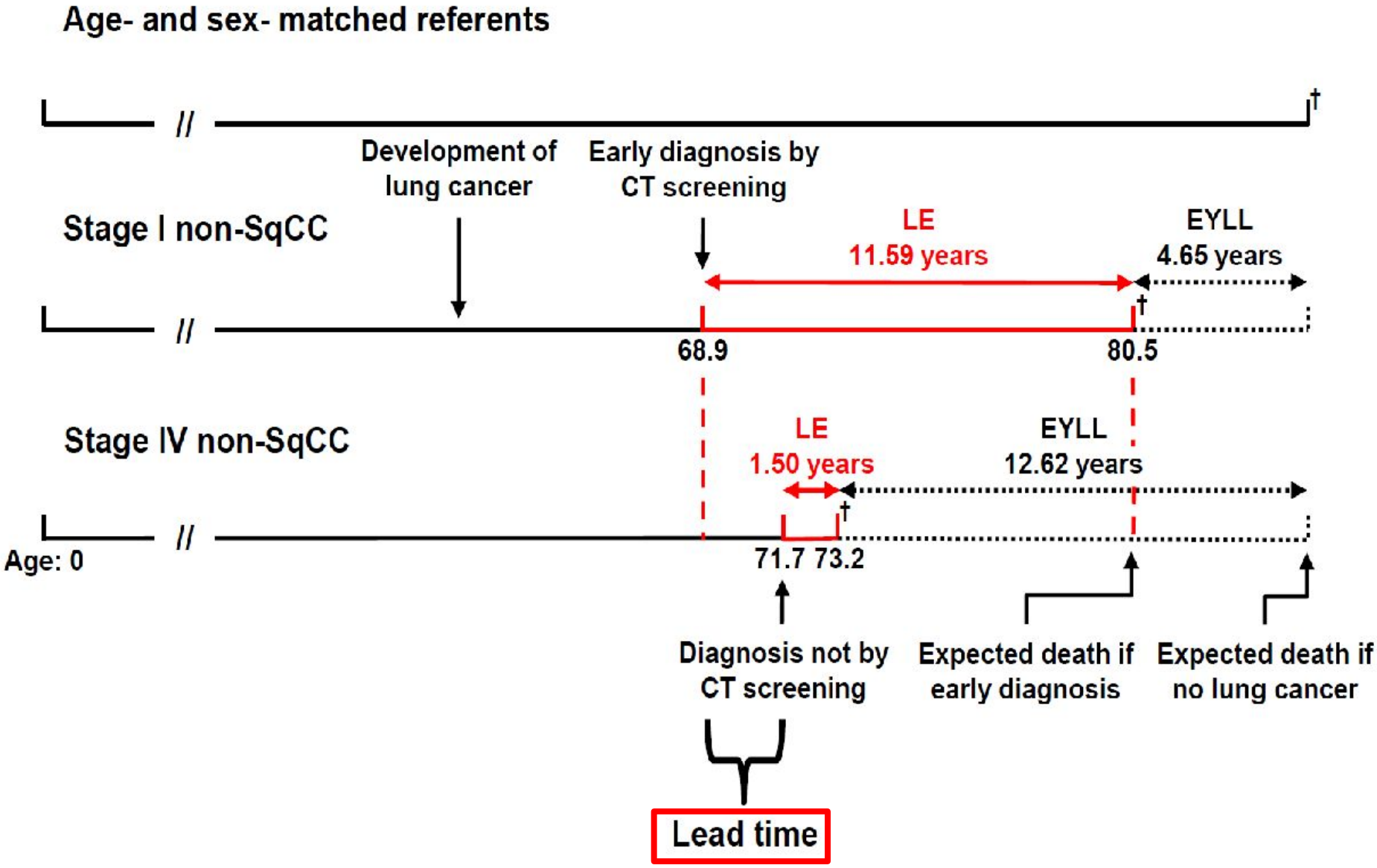
(up to 2019/07/05)	No. patients	Times of measurement
Lung cancer	1,941	8,013
Colorectal cancer	2,486	10,341
Liver cancer	1,468	6,264
Breast cancer	1,108	2,061
Cervical cancer	1,152	4,061
Endometrial cancer	629	2,542
Ovarian cancer	455	2,049
Oral cancer	1,406	5,611
Nasopharyngeal Ca.	478	1,726
Prostate cancer	581	1,721
Bladder cancer	458	1,663
Bed side (all cancers)		1,024
Total (plus others)	13,971	53,226


Cost-per-QALY of managing male cancer in Taiwan (generalized cost-
effectiveness analysis)
Cost (US$)
140000
120000
100000
80000
60000
40000
20000
0
-4
1
6
11
16
21
26
QALE (QALY as a uni
Cancer-Lung
Esophagus
Liver
Stomach
Colorectum
Oral
Nasopharynx
PMV
ESRD
Hung et al. J Formos Med Assoc



Hung et al. J Formos Med Assoc 2016

Our method for control of lead-time bias



EYLL = expected years of life lost; LE = life expectancy; SqCC = squamous-cell carcinoma.