Cost-Effectiveness Analysis of Tele-ophthalmology for screening for Diabetic Retinopathy in Remote Communities

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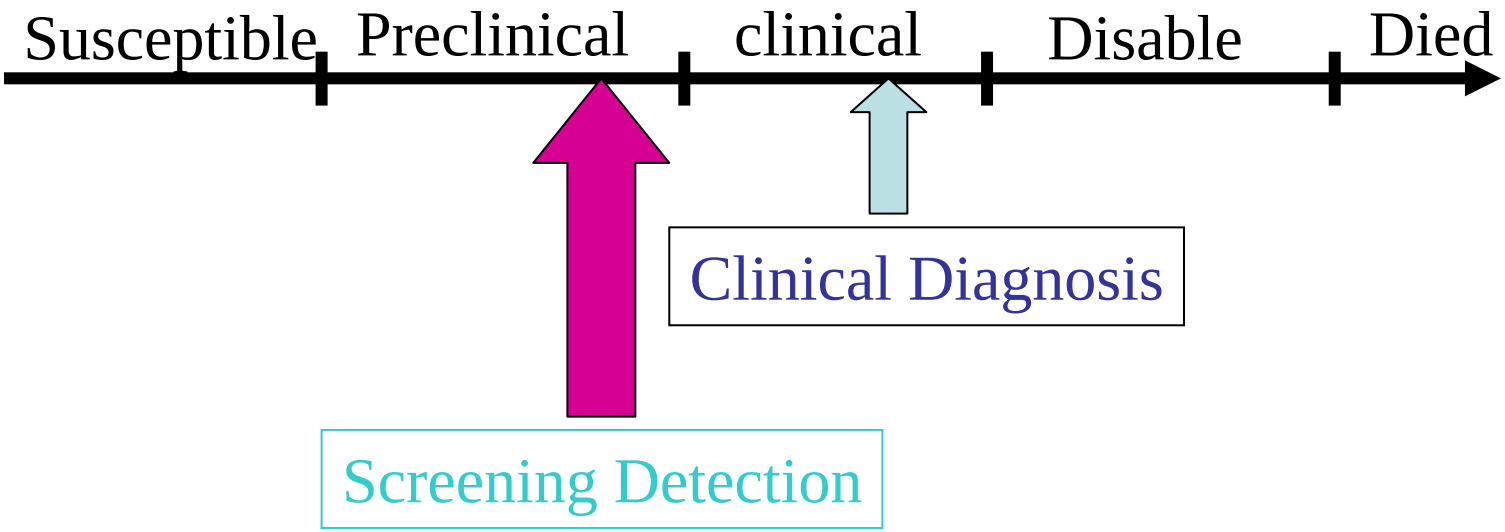
Why Tele-ophthalmology

- Scarce resource in Ophthalmologist in remote area
- Visual loss problem
  - Between 2000 and 2020, the prevalence of blindness is expected to double
  - Major causes of low vision and blindness
    - diabetic retinopathy, macular degeneration, cataracts, and glaucoma
- Diabetic retinopathy incidence increase
  - Diabetes is expected to increase worldwide from 135 million to 300 million people between 1995 and 2025(Mokdad ,2000)
- Tele-ophthalmology has been recognized as a tool in providing health care for rural community (Chen et al. 2004)



The disease natural history of diabetic retinopathy

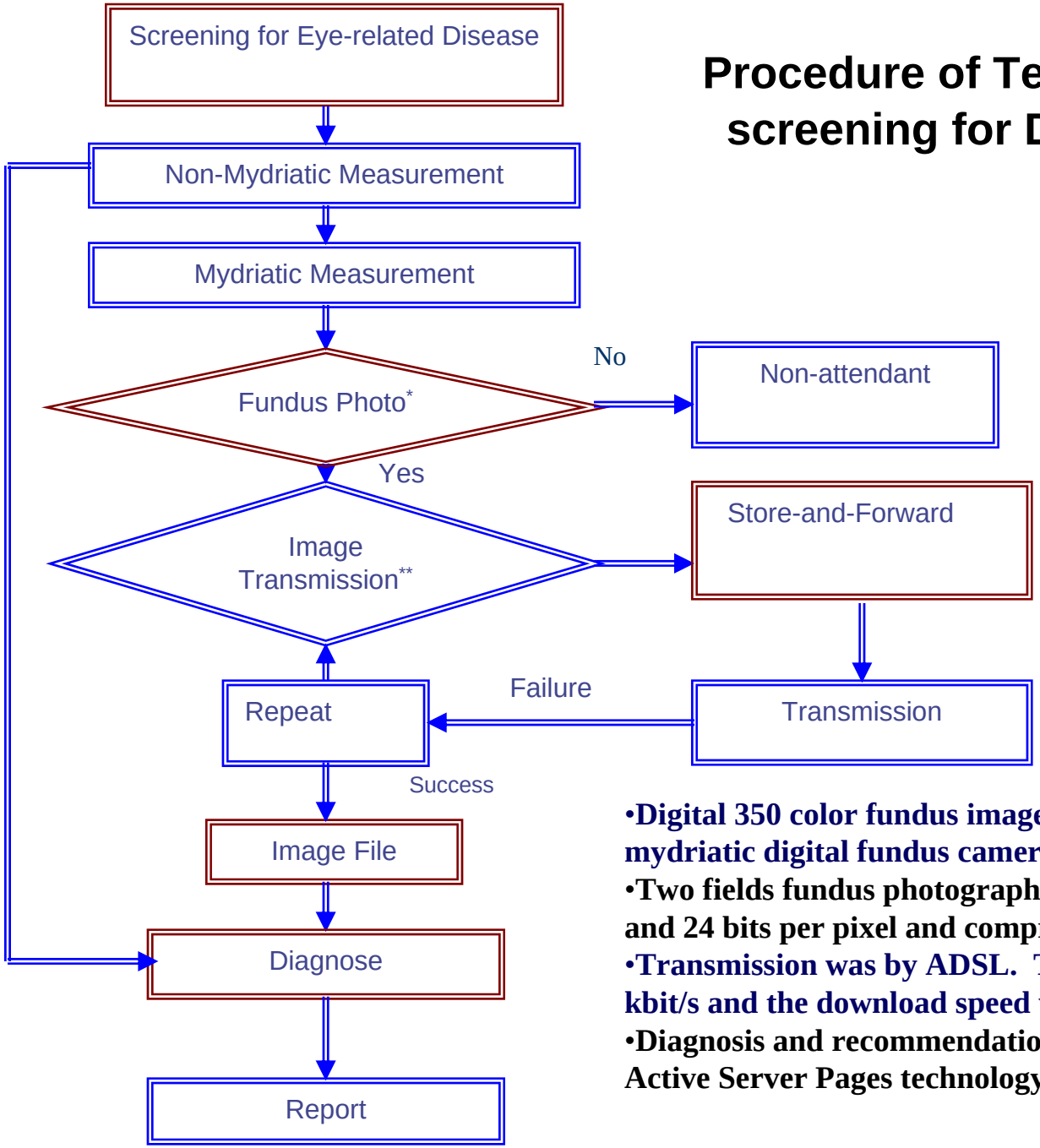
$$\text{NDR}\ (1) \xrightarrow{\lambda_1} \text{BDR}\ (2) \xrightarrow{\lambda_2} \text{PPDR}\ (3) \xrightarrow{\lambda_3} \text{PDR}\ (4) \xrightarrow{\lambda_4} \text{Blindness}\ (5)$$

Annual transition rates

λ_1 (NDR→BDR):	0.11	λ_2 (BDR→PPDR):	0.07
λ_3 (PPDR→PDR)	0.24	λ_4 (PDR→Blindness) :	0.20

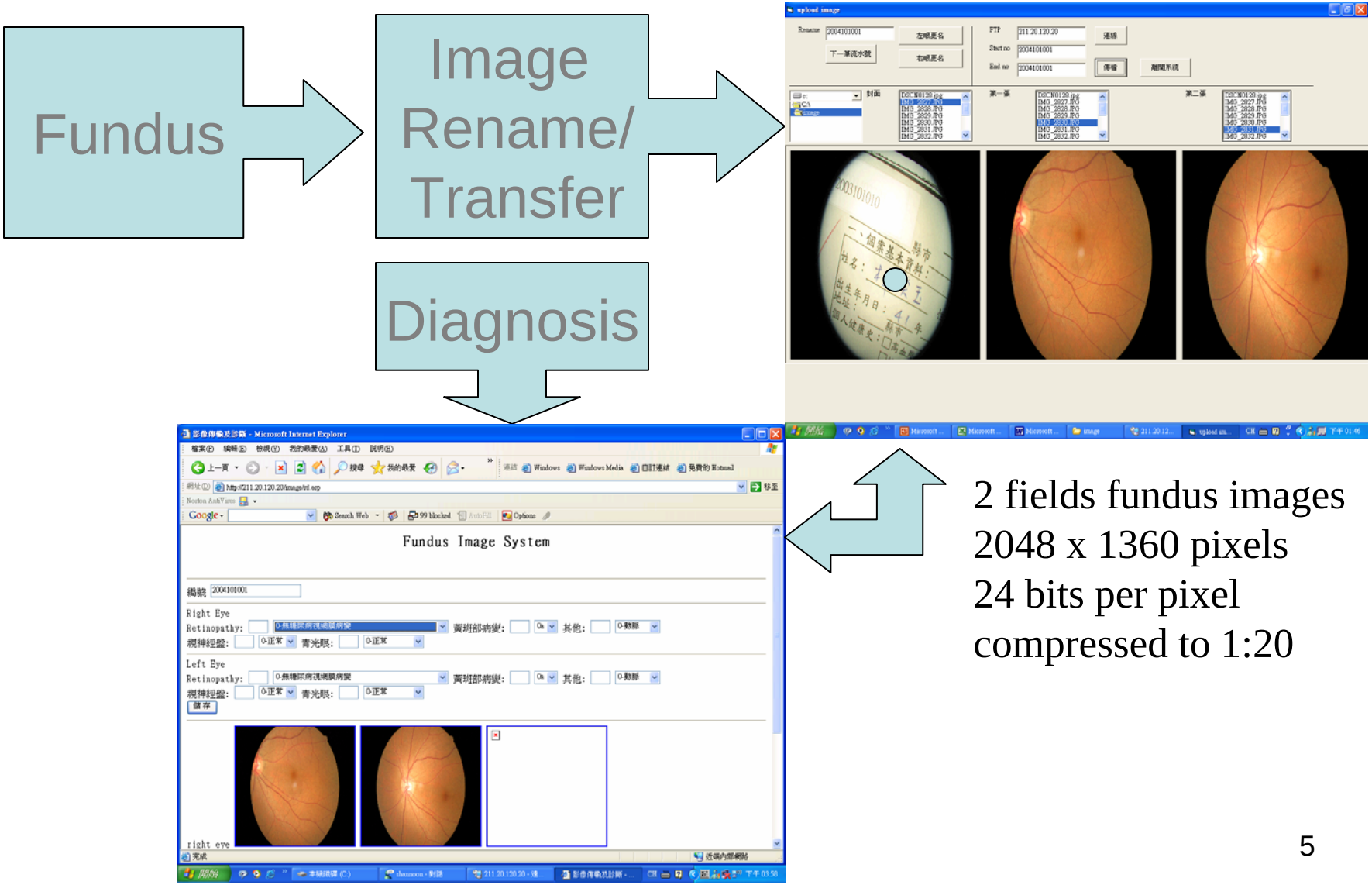
NDR: No diabetic retinopathy
BDR: Background diabetic retinopathy
PPDR: Preproliferative diabetic retinopathy
PDR: Proliferative diabetic retinopathy

Procedure of Tele-ophthalmology for screening for Diabetic Retinopathy

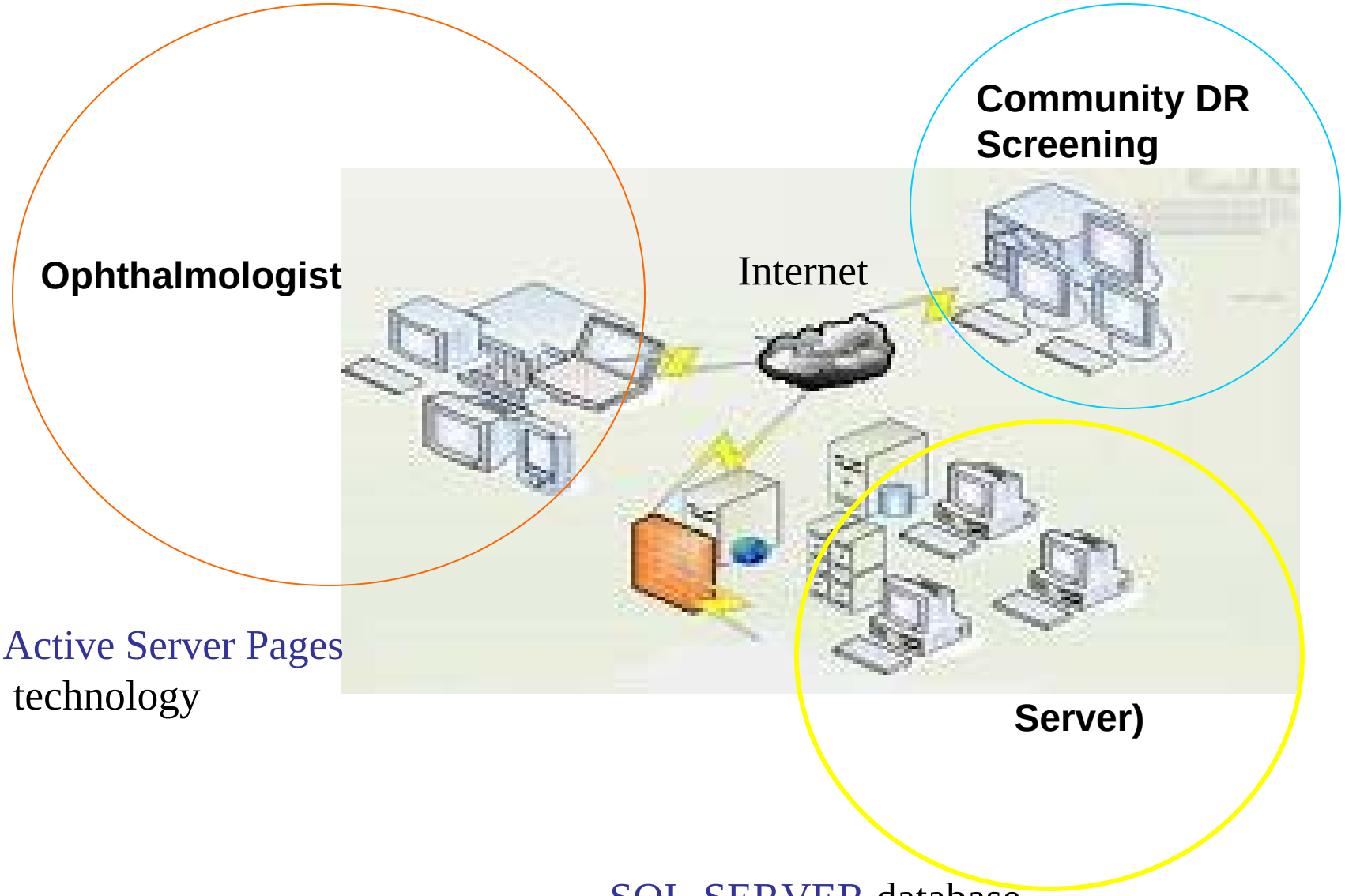


- **Digital 350 color fundus images were obtained with a non-mydriatic digital fundus camera**
- **Two fields fundus photographs consisted of 2048 x 1360 pixels and 24 bits per pixel and compressed to 1:20 before sending**
- **Transmission was by ADSL. The lowest upload speed was 64 kbit/s and the download speed was 512 kbit/s**
- **Diagnosis and recommendations in a server was based on the Active Server Pages technology and SQL-SERVER database**

Tele-ophthalmology in DR Diagnosis



2 fields fundus images
2048 x 1360 pixels
24 bits per pixel
compressed to 1:20



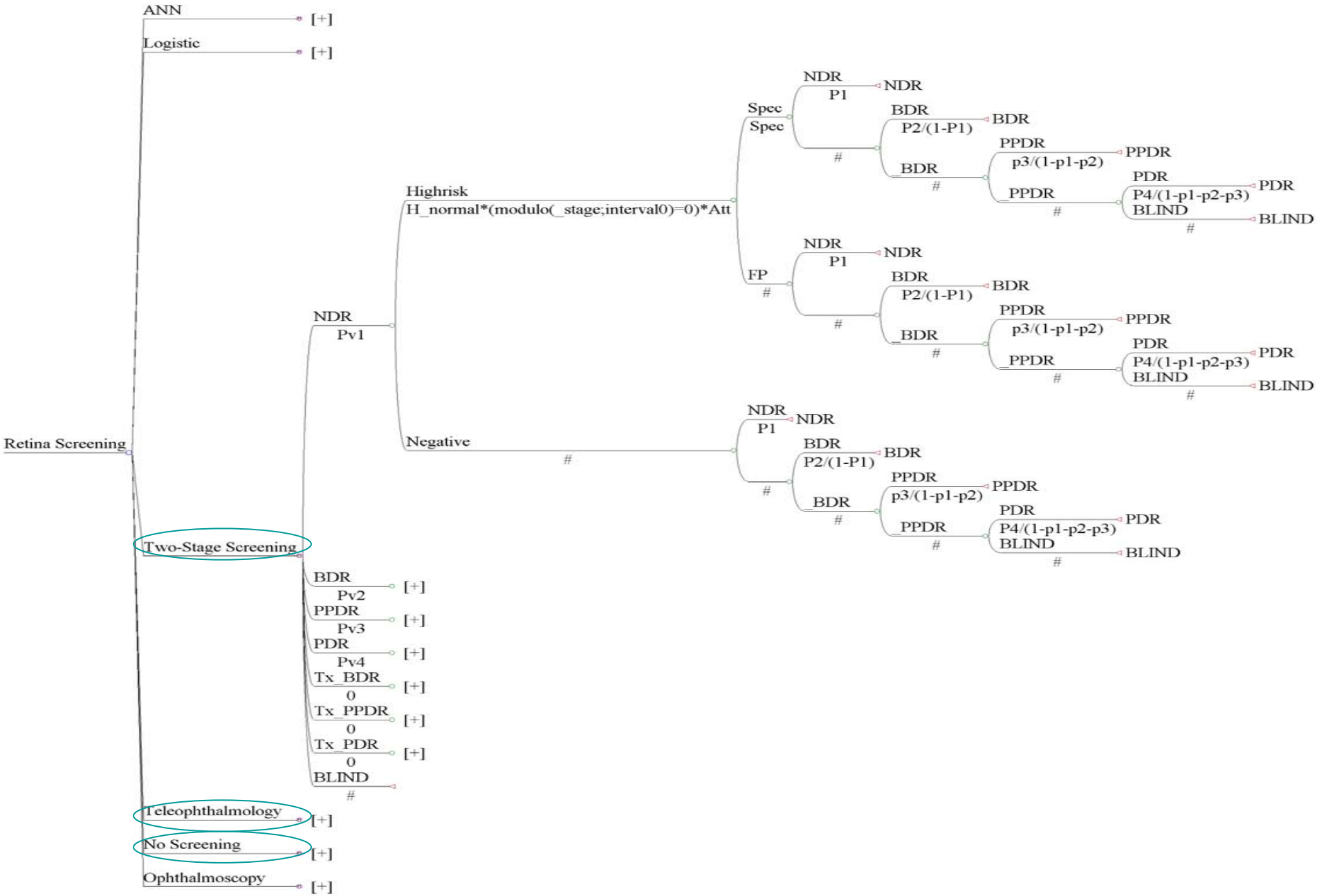
Active Server Pages technology

SQL-SERVER database

Rationale

- Natural History Model of Diabetic Retinopathy
- Markov Decision Analysis
- Data source and base-case probability
- Utility measurement
- Cost data
- Monte Carlo Computer Simulation
- Implementation of computer simulation
- TreeAge 4.0 used

Decision Tree for diabetic retinopathy screening



Base-Case Estimates

- Annual transition rates
  - NDR to BDR 0.11
  - BDR to PPDR 0.07
  - PPDR to PDR 0.24
  - PDR to Blindness 0.20

(Liu et al , Diabet Med, 2003)

- Screening test characteristics
  - Ophthalmoscopy
    - Sensitivity% 0.75(0.33-0.86)
    - Specificity% 0.86(0.75-0.99)
  - Teleophthalmology
    - Sensitivity% 0.88(0.72-0.98)
    - Specificity% 0.9(0.75-1)

Base-Case Estimates

- Attendance rate 0.5(0.25-0.7)
- Attendance rate on site 0.9(0.5-0.95)
- Utilization Value 0.92(0.91-0.93)
- Discount rate % 5%
- Year of repeat screening 4(2~8)

Cost Estimated

- Teleophthalmology
  - Fundus photograph evaluation US:5
  - Initial Cost US:20000
- Nonteleophthalmology
  - Examination Cost US:6
  - Transportation US:90
- Confirmatory Cost
  - Fluorescein angiography US:30
  - Transportation US:90
- Cost of treatment
  - Clinic visit US. 120
  - Transportation Fee US. 300
  - Operation Fee US. 400
  - Transportation Fee US. 160
- Cost of Blindness care
  - Age < 65 years US. 2000
  - Age ≥ 65 years US. 30

Blindness Incidence Case-55 years follow up

- No screening strategy : 265 blindness
- Teleophthalmology strategy: 218 blindness
  - Compare no screening: 15.7% blindness reduction
- Two-stage Design strategy: 236 blindness
  - Compare no screening: 9.5% blindness reduction

Cost-Utility for each screening regime

Two-stage Design v.s No Screening

ICUR: $$\frac{3{,}992 - 4{,}781}{18.350 - 18.276} = (10{,}658)$$ dominate

Tele-ophthalmology v.s No Screening

ICUR: $$\frac{4{,}051 - 4{,}781}{18.387 - 18.276} = (6{,}573)$$ dominate

Cost-Utility for each screening regime

Two-stage Design v.s Tele-ophthalmology

ICUR: $$\frac{3{,}992 - 4{,}051}{18.387 - 18.350} = 1{,}595$$

Screening interval for each screening regime

	Screening interval	Two-stage Design	Tele-ophthalmology
Cost		3,773	3,581
Qalys	2	18.43	18.51
C/E		204.7	193.4
Cost		3,992	4,051
Qalys	4	18.35	18.39
C/E		217.5	220.3
Cost		4,025	4,112
Qalys	6	18.32	18.35
C/E		219.6	224.1
Cost		4,032	4,125
Qalys	8	18.31	18.33
C/E		220.2	225.1

Economic Evaluation

- Tele-ophthalmology elicits more cost but also more effectiveness in reducing blindness
- Two-stage tele-ophthalmology may reduce cost but lead to smaller benefit because of false negative cases compared to tele-ophthalmology
- Cost per one Qalys gained was US 1,595
- Biennial screen regime dominates over other screening regimes because it elicits less cost but more benefit

Conclusion

- Tele-ophthalmology with or without two-stage design was demonstrated to be feasible in community-based screening for DR in remote area
- Cost per one Qalys gained was US 1,595