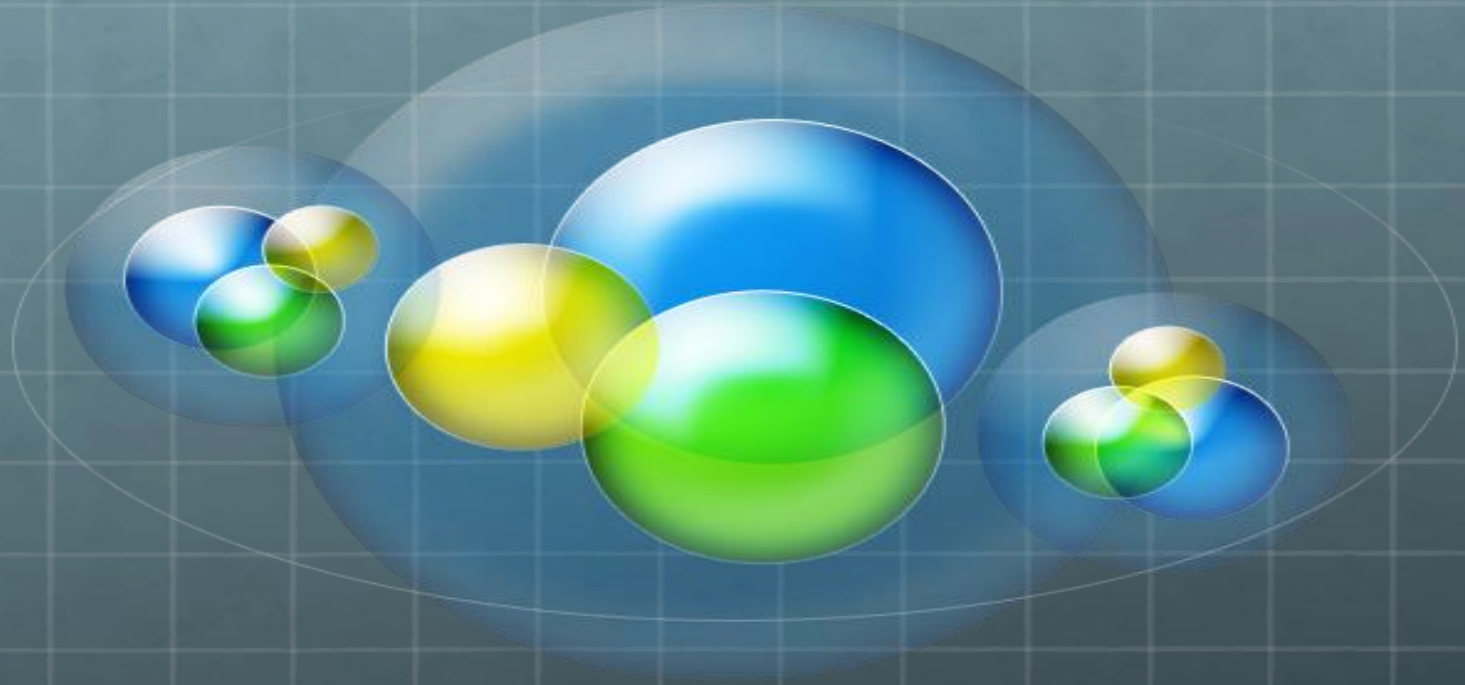

Remote Monitoring of Vital Signs of Elderly in the Community: a Feasibility Study

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MBBS FRCP FRCPE FRCPG FHKCP FHKAM MHA FHMISS
Chair, Hong Kong Society of Medical Informatics
Chair, HL7 Hong Kong
Founder, eHealth Consortium

Outline

- eHealth for the elderly
- Key success factors / barriers
- The Study Results
- Conclusion

Why GeronTech?

- Older Generation – baby boomers / Silver Tsunami
- Maximizing their independency
- Aging in Place, Enriching their lives
- Alleviate caregivers shortage
- Abundance of chronic diseases, Reducing health cost
  - 83% of HK Elderly above age of 80 have chronic diseases

Are they useful?

- Public Telesurveillance for 38 frail elderly: decreased LOS, decreased home care service, decreased 17-39% health cost (Vincent, 2006)
- Low Tech PERS 87 patients: reduced mortality 4x; reduced hospital utilization 59%; benefit : cost ratio 7:1 (Bernstein 2000)
- Trans European Network 426 Congestive Heart Failure patients: decrease 26% LOS, further 10% on top of call center service; 2.1 ROI (TEN-HMS 2005)
- NHS Sheffield 30 COPD patients reduce 50% of LOS and 80% of home visits (Sheffield 2008)

Figure 4: Outcomes: VHA Care Coordination/Home Telehealth 2004-2007[11]

Condition	# of Patients	% Decrease Utilization
Diabetes	8,954	20.4
Hypertension	7,447	30.3
CHF	4,089	25.9
COPD	1,963	20.7
PTSD	129	45.1
Depression	337	56.4
Other Mental Health	653	40.9
Single Condition	10,885	24.8
Multiple Conditions	6,140	26.0

Is it easy to adopt?

- Personal Emergency Response System (PERS) originated in Germany with Hormann's concept of "home alert" *(Hausnotruf)* in 1970.
- In 1989 LifeCall first launched in Canada; now 2014 still only 5% needy elderly use PERS (HK 10%)

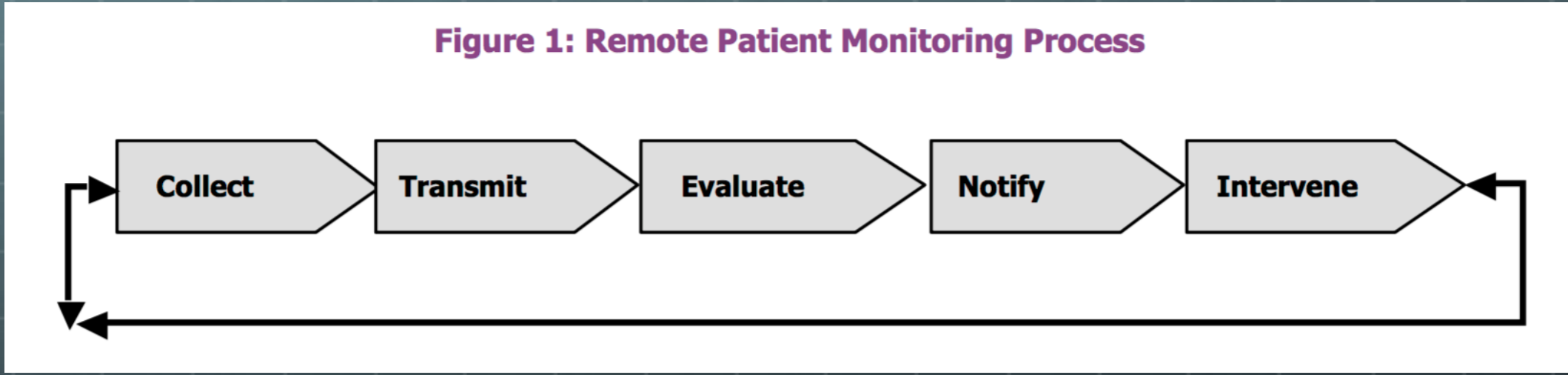
Barriers

- Some with impaired vision, hearing, dexterity 39%
- Phobias / skeptic on technology 35%
- Difficulty in learning new things 77%
- Afraid of being stigmatized
- Poor Awareness
- Too expensive
- No reimbursement

Key success factors

- Device must be SIMPLE to use !
- Feedbacks or Alerts must be SENSIBLE / NOISE FREE / VARIABLE
- Healthcare Service Background Support must be AVAILABLE
- It must be cost effective if not inexpensive

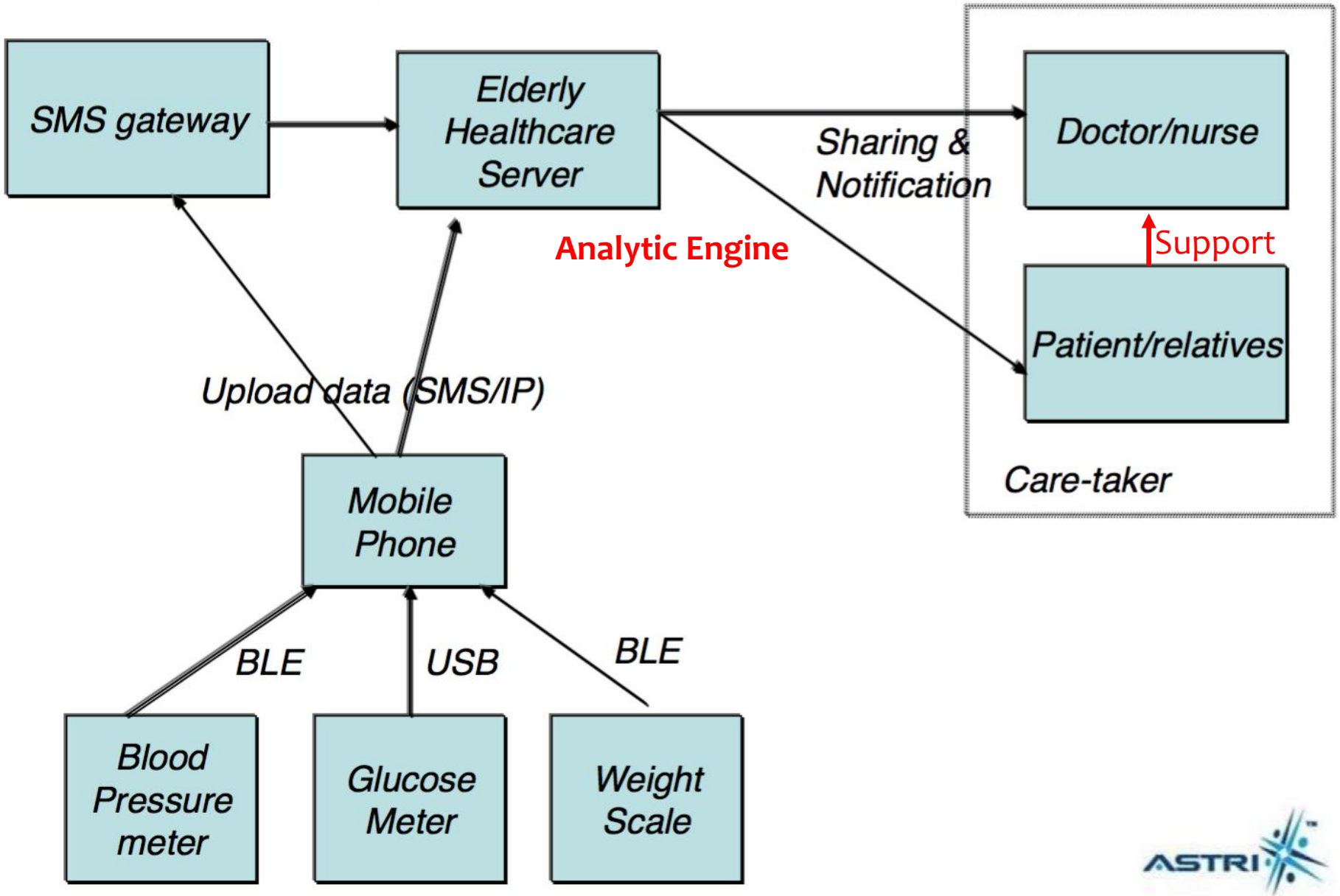
A closed ecosystem



Key Objective

- To design a platform for eHealth for elderly so that it is very user friendly
- To adopt medical professional analytic algorithm to increase accuracy
- To provide a network for healthcare provider background support
- To assess the usability, feasibility & acceptance of users

High Level Execution Plan – System Architecture



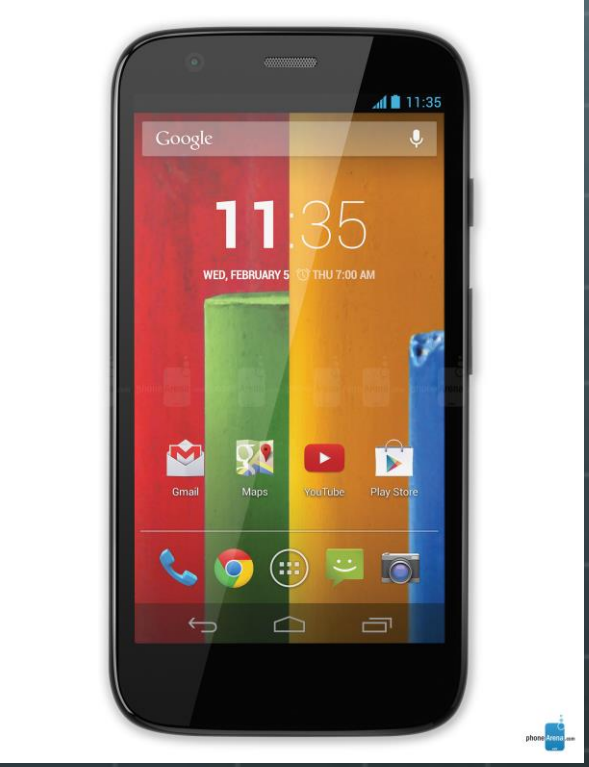
The System Design

- Seamless Data Collection
- ONE button turn-key
- No difference from usual use

No cumbersome clicks

Equipment

- Motorola Moto G 1st Gen 4.5” display 1G RAM
- 3G, Bluetooth 4.0 BLE, microUSB v2.0
- Android 4.4 KitKat
- As Receiving / Transmitting Console
- HK$1000

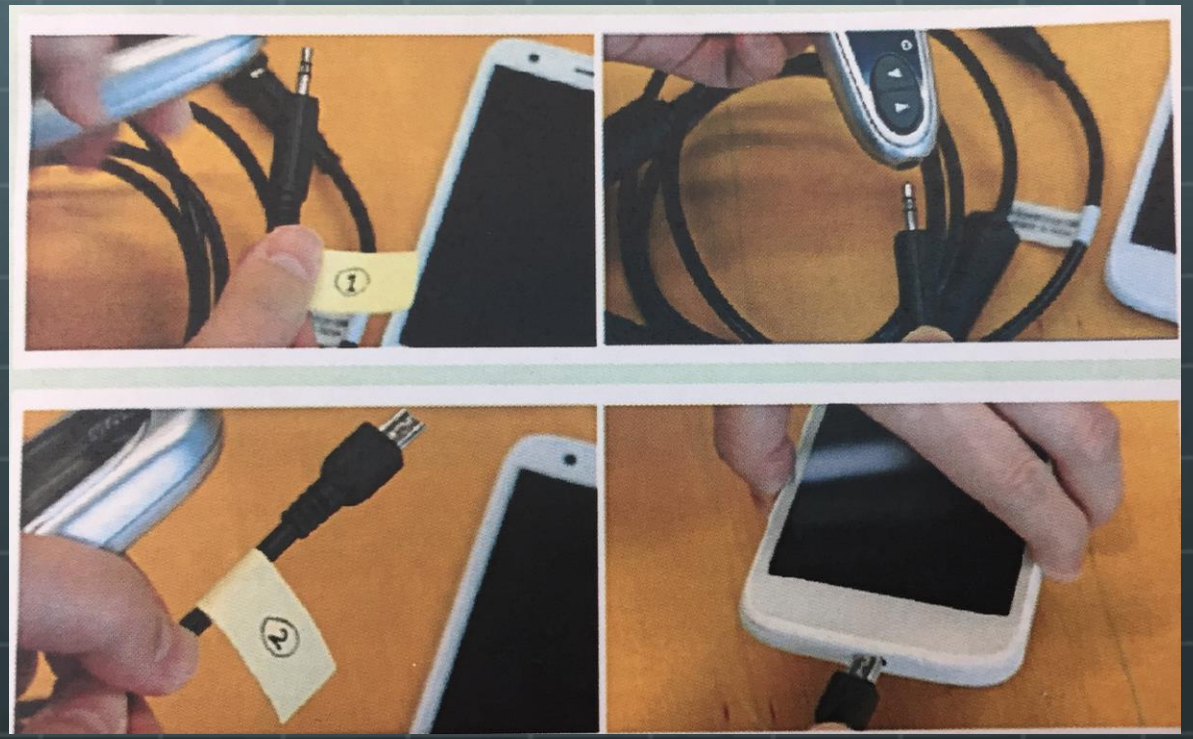


BP Monitor

- Oregon BPU 321OS
- 4.0 BLE
- HK$900
- Store 100 data
- Talking function in Cantonese

Blood Glucose Monitor

- Johnson & Johnson OneTouch UltraEasy



Weight Scale

- CURA XY-6073 with Bluetooth BLE
- No button to press
- Voice read your weight in 2 seconds
- Automatic sending of data

A simple user manual

Simple Instructions

血壓計使用及數據上傳

① 戴上血壓計

如圖所示方向戴好血壓計，將手臂平放於桌面，保持心情平靜和呼吸勻暢。

② 按兩次血壓計上的開關按鈕開始量度

兩次之間最好不要太快。

Intuitive

③ 血壓量度同時，電話會有語音及畫面提示血壓計連接成功

④ 等待血壓量度結果，及數據成功上傳至電話

量度血壓時，依照電話提示完成量度即可。無需在電話上作任何操作。

⑤ 除下血壓計, 完成。

Precision Analytics

- Personalized:
  - Sex
  - Age
  - Smoker
  - Diabetes
  - Kidney Disease
  - Symptomatic CVS Disease
  - Organic Damage
  - High Cholesterol
  - Family History
  - Obesity
- Professional:
  - 2013 European Society of Cardiology/Hypertension ESC/ESH Guidelines
  - 2013 American Diabetes Association ADA Guidelines
  - Expert Panel of cardiologists, endocrinologists, geriatricians & family physicians

Patient Specific Algorithm

Medical Information

Smoker (Current)	Y or N
Diabetes	Y or N
Hypertension	Y or N
Microalbuminuria	Y or N
Symptomatic CVD	Y or N
Organ Damage (eye/ kidney/ heart / brain)	Y or N
Lipid Problems	Y or N
Family History of Premature CVD (M<55,F<65)	Y or N
Obesity (BMI >= 27)	Y or N
High Blood Sugar (5.6 - 6.9 mmol/L)	Y or N

Alert Systems

- Highly Personalized
- Separately to the patient, caregiver & family physicians
- Alerts included: Out of bounds, critical Hi/Lo, rolling averages, rapid rising or falling trends, congratulatory messages with incentives
- All alerts levels can be configured by caregiver and doctors
- Finally endorsed by doctors

Rules Engine

```
SBP 130-139   AND OR        DBP 85-89
HT=HIGH NORMAL BLOOD PRESSURE
IF RF=0, RLVL=MINIMAL RISK(0)
IF RF=1,2, RLVL=LOW RISK(1)
IF RF=>3, RLVL=LOW TO MODERATE RISK(2)
IF OD OR CDK3 OR DM=T, RLVL=MODERATE TO HIGH RISK(3)
IF CKD4=T OR CV=T OR (DM=T AND RF>=1 OR OD=T), RLVL=VERY
```

- >140 rules
- Highly personalized
- Requires medical professional endorsement
- Highly stratified into risk levels
- Gives individualized congratulatory messages or warnings

Risks Levels

Other risk factors, asymptomatic organ damage or disease	Blood pressure (mmHg)			
	High normal SBP 130–139 or DBP 85–89	Grade 1 HT SBP 140–159 or DBP 90–99	Grade 2 HT SBP 160–179 or DBP 100–109	Grade 3 HT SBP ≥180 or DBP ≥110
No other RF		Low risk	Moderate risk	High risk
1–2 RF	Low risk	Moderate risk	Moderate to high risk	High risk
≥3 RF	Low to moderate risk	Moderate to high risk	High risk	High risk
OD, CKD stage 3 or diabetes	Moderate to high risk	High risk	High risk	High to very high risk
Symptomatic CVD, CKD stage ≥ 4 or diabetes with OD/RFs	Very high risk	Very high risk	Very high risk	Very high risk

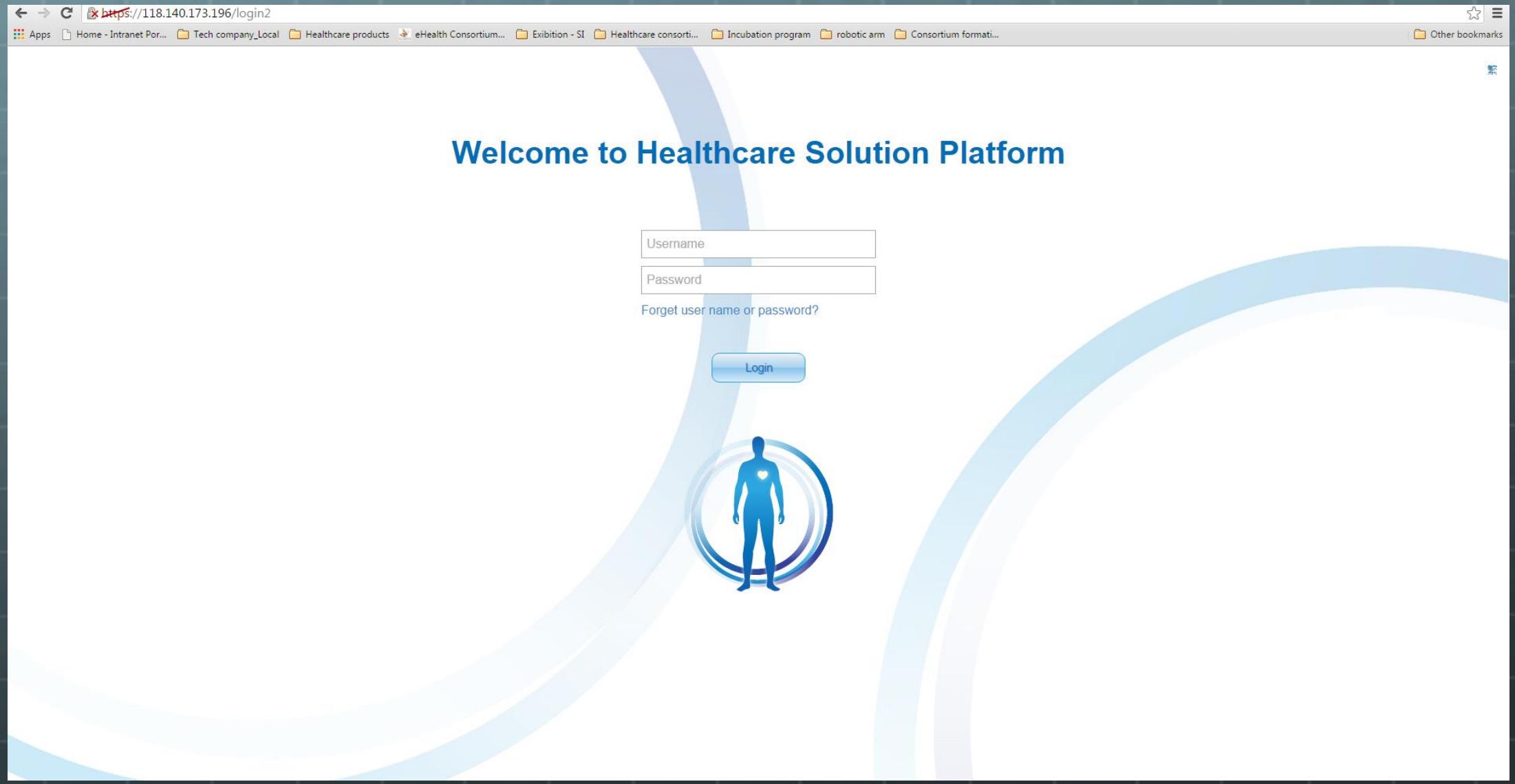
BP = blood pressure; CKD = chronic kidney disease; CV = cardiovascular; CVD = cardiovascular disease; DBP = diastolic blood pressure; HT = hypertension; OD = organ damage; RF = risk factor; SBP = systolic blood pressure.

FIGURE 1 Stratification of total CV risk in categories of low, moderate, high and very high risk according to SBP and DBP and prevalence of RFs, asymptomatic OD, diabetes, CKD stage or symptomatic CVD. Subjects with a high normal office but a raised out-of-office BP (masked hypertension) have a CV risk in the hypertension range. Subjects with a high office BP but normal out-of-office BP (white-coat hypertension), particularly if there is no diabetes, OD, CVD or CKD, have lower risk than sustained hypertension for the same office BP.

Risk Level	Possibility of Cardiovascular Events in 10 Years
Minimal	N/A
Low	< 1%
Moderate	2%
Moderate to High	3 – 4%
High	5 – 10%
High to Very High	> 10%
Very High	> 15%

Creative encouraging alerts

Web Portals


https://118.140.173.196/login2
Apps
Home - Intranet Por...
Tech company_Local
Healthcare products
eHealth Consortium...
Exibition - SI
Healthcare consorti...
Incubation program
robotic arm
Consortium formati...
Other bookmarks
Welcome to Healthcare Solution Platform
Username
Password
Forget user name or password?
Login

Web Portals

- **Web portal for Doctors**
  - Individualized alert setting
  - Full report (data record with statistical analysis, trend graph and charts, risk analysis, etc.)

- **Web portal for Patients/Family members**
  - simple report to show data record and trend graph

Web portal reports

Report Book

- Readings
- Averages
- Optimal control
- Cardiovascular Risk

Clinic a

2015年7月21日

姓名 (Name): a003　　起止日期 (Date Range): 03/21/2015 - 07/22/2015

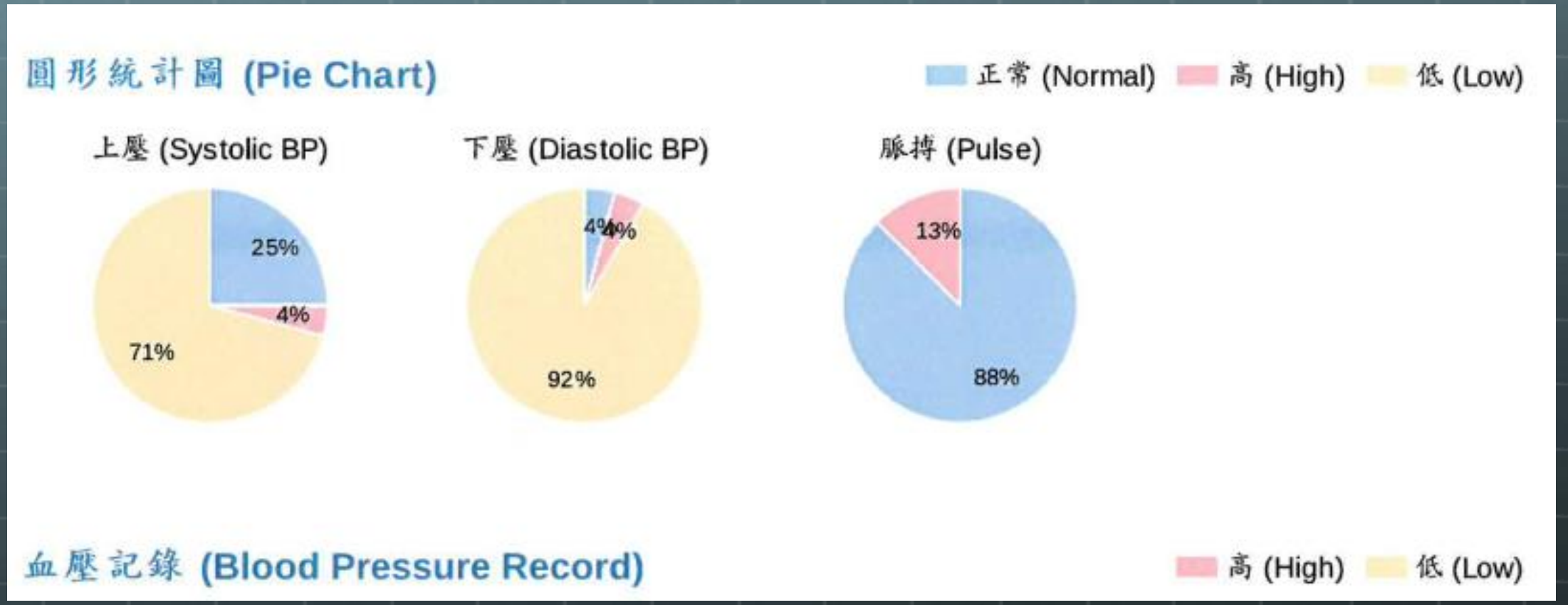
日期 (Date)	時間 (Time)	上壓 (SBP)	下壓 (DBP)	脈搏 (Pulse)
04/09/2015	06:59	114	71	74
03/29/2015	10:26	106	69	74
03/28/2015	22:49	122	69	74
03/28/2015	08:39	123	76	78
03/27/2015	22:14	124	74	82
平均值 (Average)		110.5	67.46	75.75
達標 (In Target)		6 (25%)	1 (4.17%)	21 (87.5%)
標準偏差 (SD)		13.95	11.04	5.08
記錄數量 (# Results)		24	24	24

評語 (Comments)

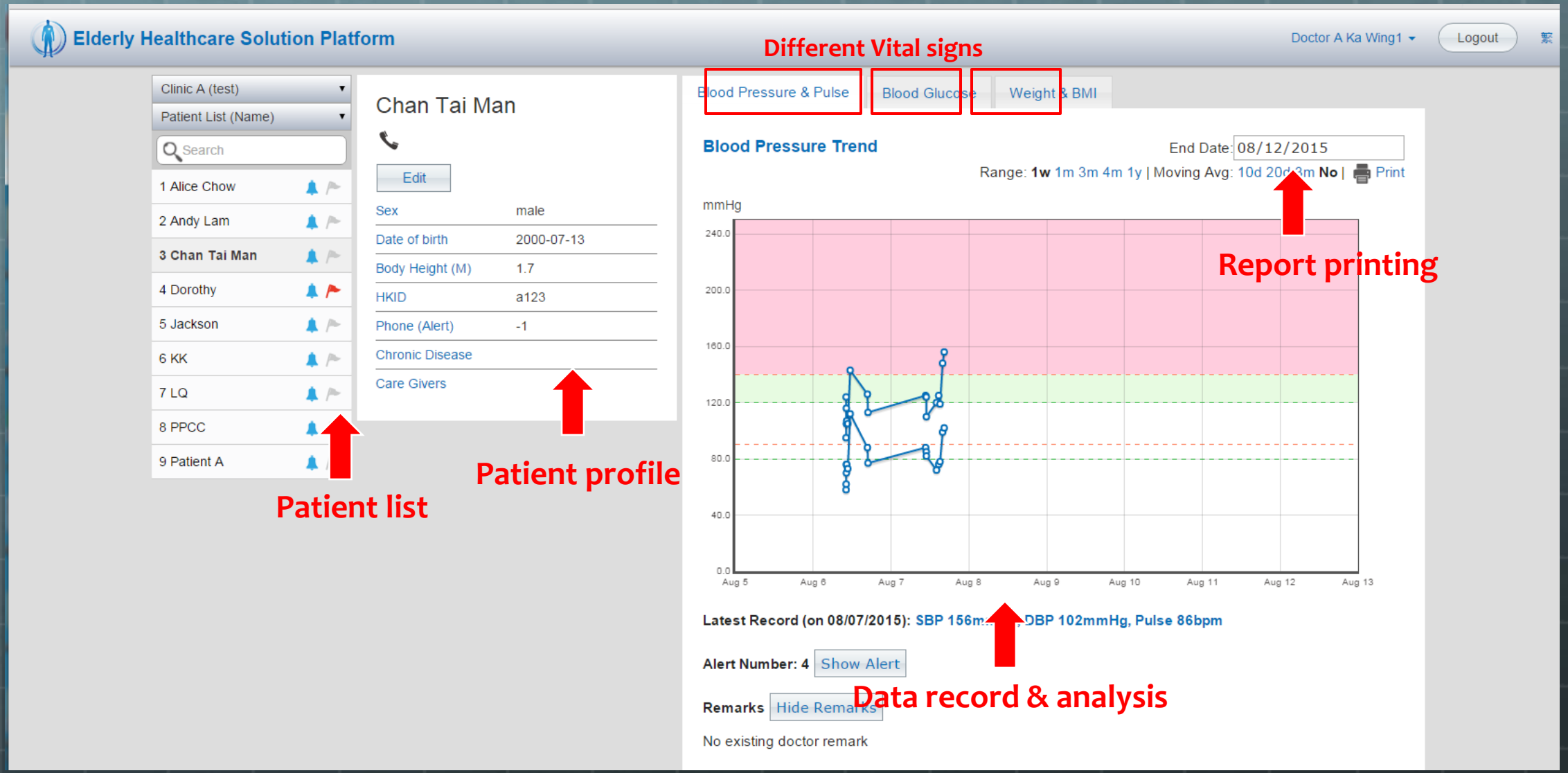
Systolic Blood Pressure: average 110.5 mm/Hg
Diastolic Blood Pressure: average 67.46 mm/Hg
Pulse: mean 75.75 beats/minute
Blood Pressure under Optimal Control in 14.58% of time
Cardiovascular Risk is Minimal.

上壓: 平均 110.5 mm/Hg
下壓: 平均 67.46 mm/Hg
心跳: 平均 75.75 下/分
14.58% 的時間裡血壓受到良好控制
心血管疾病風險指數是極低。

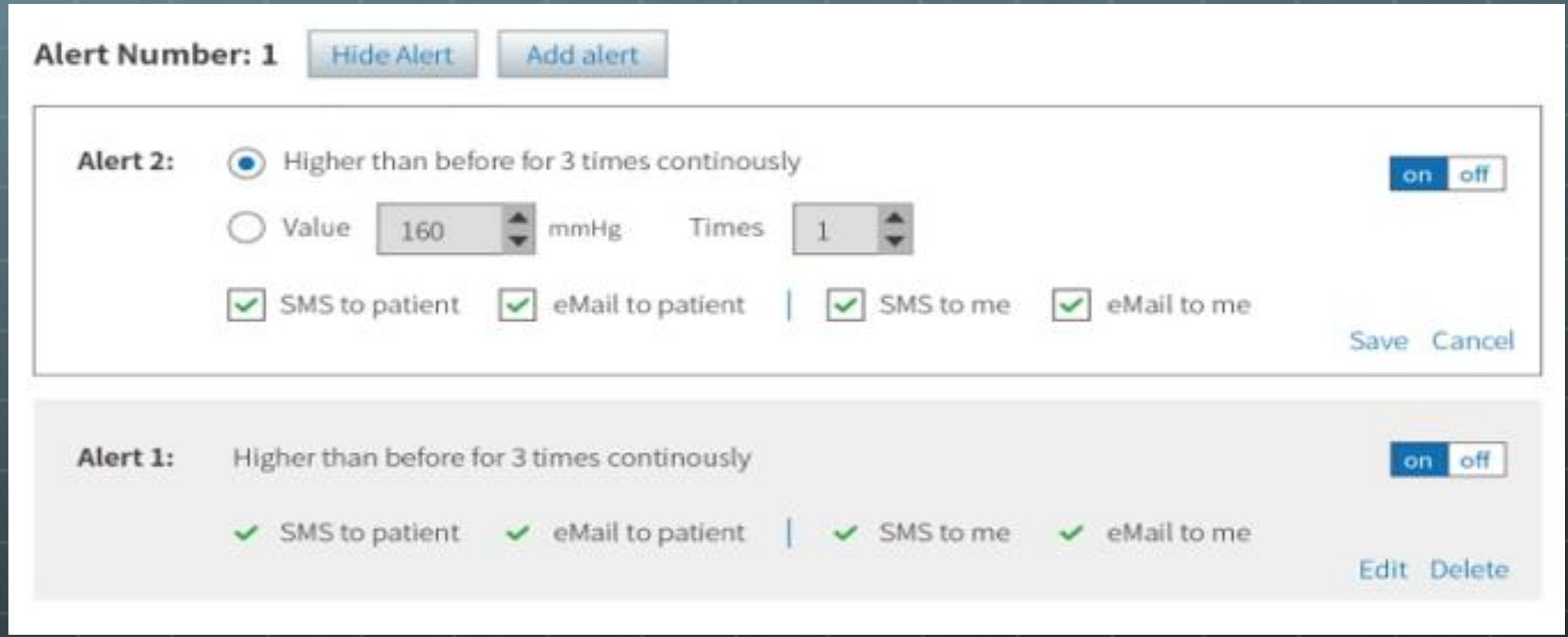
Optimal Control Pie Charts



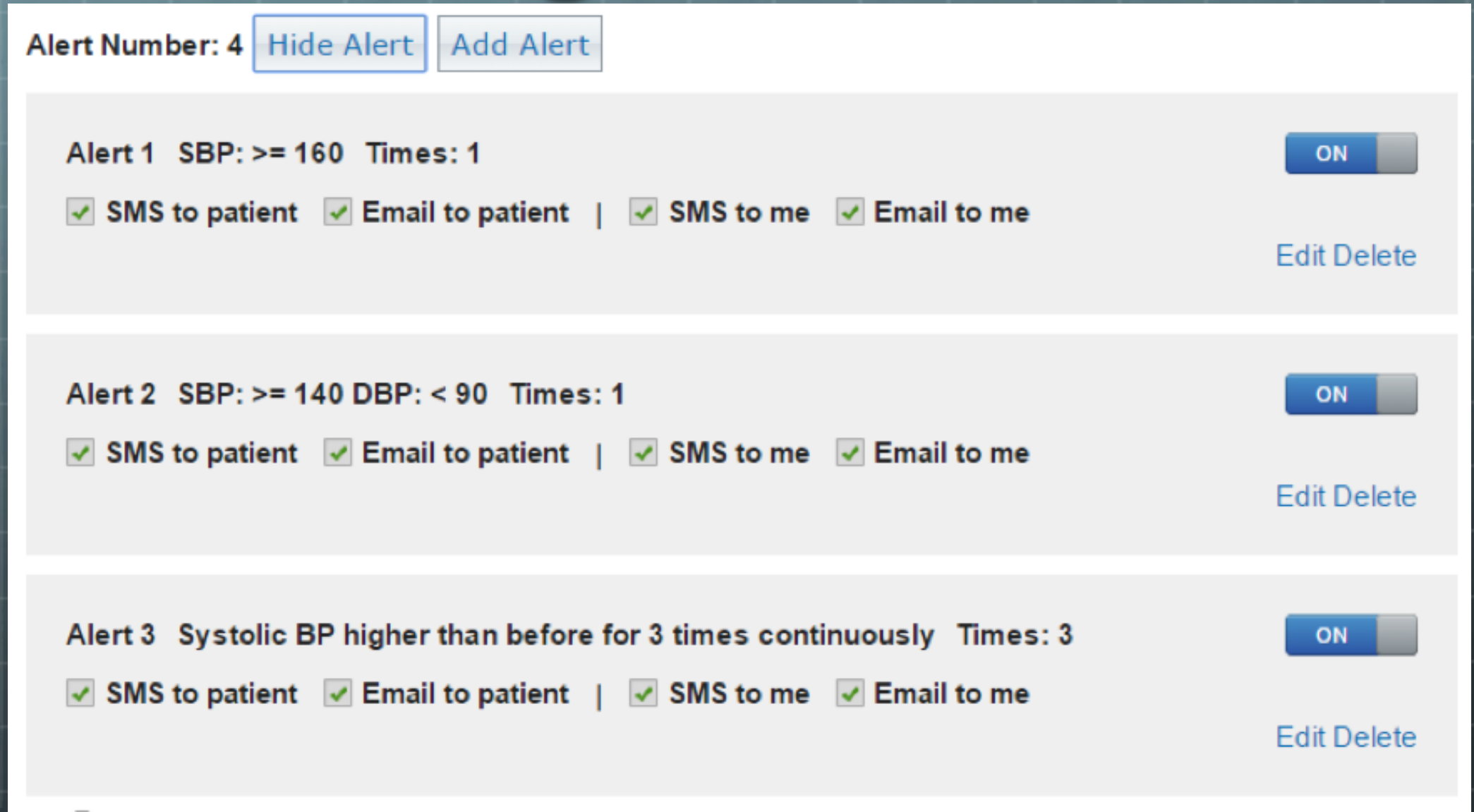
Web Portals


Elderly Healthcare Solution Platform
Doctor A Ka Wing1
Logout
Different Vital signs
Clinic A (test)
Patient List (Name)
Search
1 Alice Chow
2 Andy Lam
3 Chan Tai Man
4 Dorothy
5 Jackson
6 KK
7 LQ
8 PPCC
9 Patient A
Chan Tai Man
Edit
Sex male
Date of birth 2000-07-13
Body Height (M) 1.7
HKID a123
Phone (Alert) -1
Chronic Disease
Care Givers
Blood Pressure & Pulse
Blood Glucose
Weight & BMI
Blood Pressure Trend
End Date: 08/12/2015
Range: 1w 1m 3m 4m 1y | Moving Avg: 10d 20d 3m No | Print
mmHg
240.0
200.0
160.0
120.0
80.0
40.0
0.0
Aug 5
Aug 6
Aug 7
Aug 8
Aug 9
Aug 10
Aug 11
Aug 12
Aug 13
Latest Record (on 08/07/2015): SBP 156m... DBP 102mmHg, Pulse 86bpm
Alert Number: 4 Show Alert
Remarks Hide Remarks
No existing doctor remark
Report printing
Patient profile
Patient list
Data record & analysis

Configurable alerts



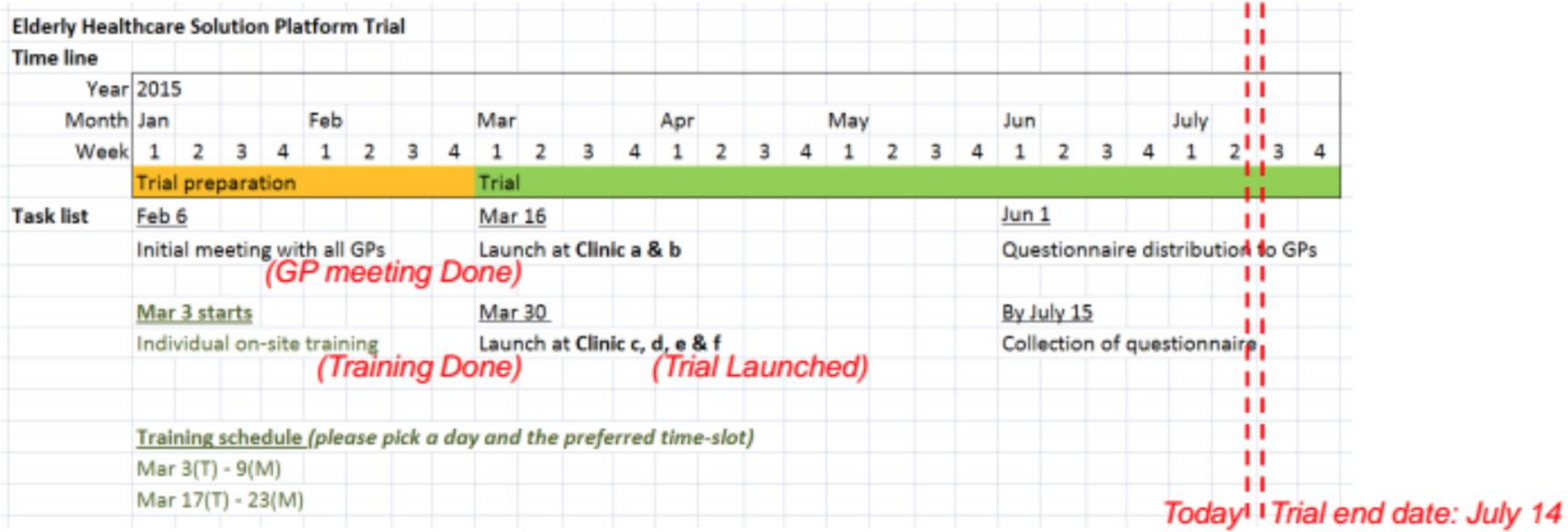
Configurable Alerts



Trial Period

- March 3 to July 14, 2015
- 6 Family Physicians
- Each recruit 5 patients with age >55
- Total 30 patients, 26 completed the trial, 23 active users
- Uploading vital signs automatically
- Alerts sent to caregivers and doctors via SMS/emails upon patient consent

Trial Schedule Overview



Age of patients

average 65.4

Age	Number
55-60	6
61-75	15
76-89	5

Results

- Usage rate is very good

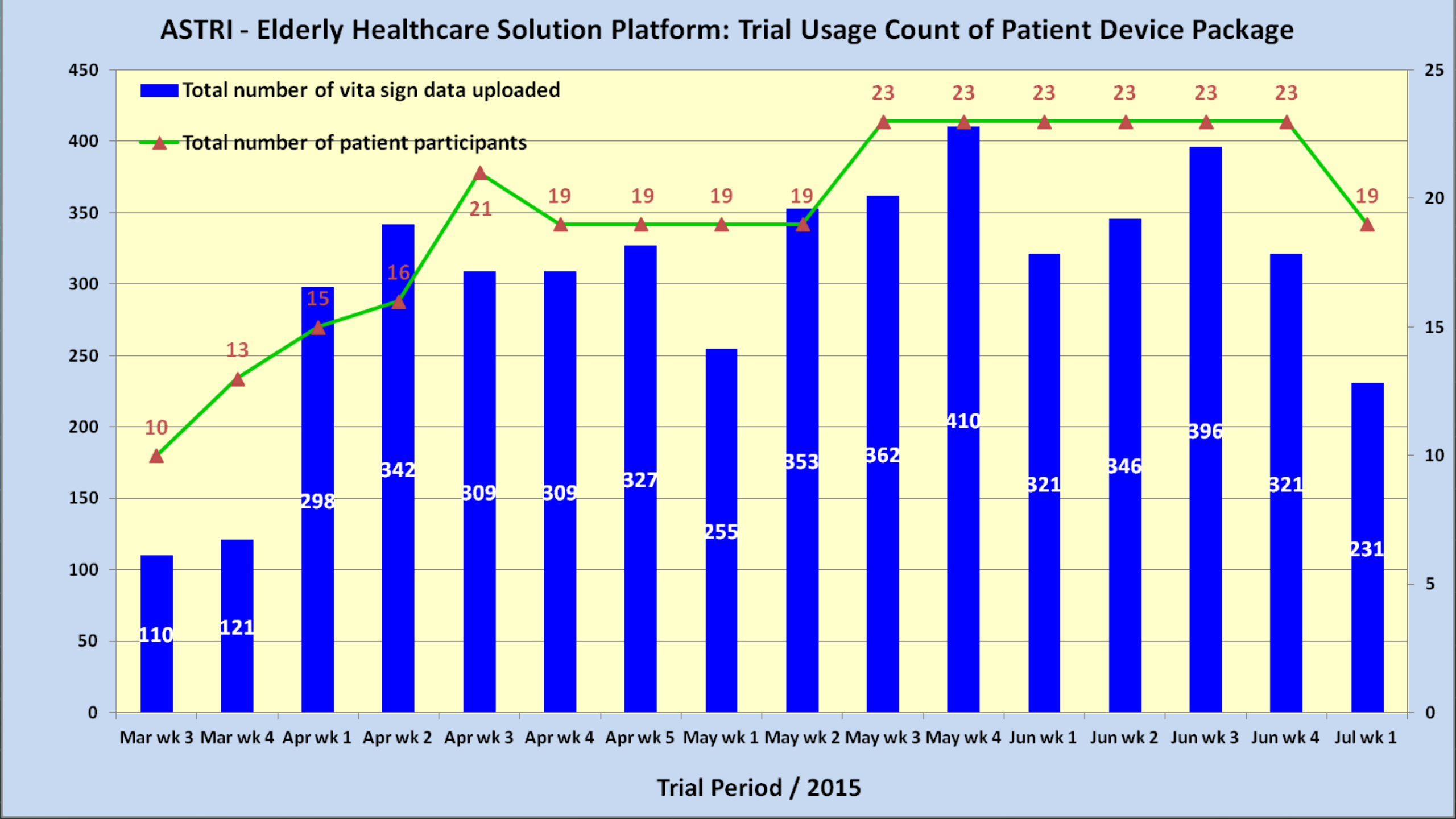
Total number of device packages disseminated	30
Total number of device packages put on trial	28
Total number of participating patients	***23***
Total number of participating patients in active usage status	***23***
Total number of withdrawn patients	***3***
Total number of patient enrollment	**26**

3 patients withdraw

- 1 F/86 finds it difficult to use especially the USB connected Blood Glucose Meter
- 2 patients M/56 M/67 idle after a week; no maid to help / maid on vacation / unable to be contacted
- Drop out rate 3/26 = 11.5%
- Completion rate 88.5%

Inactive cases

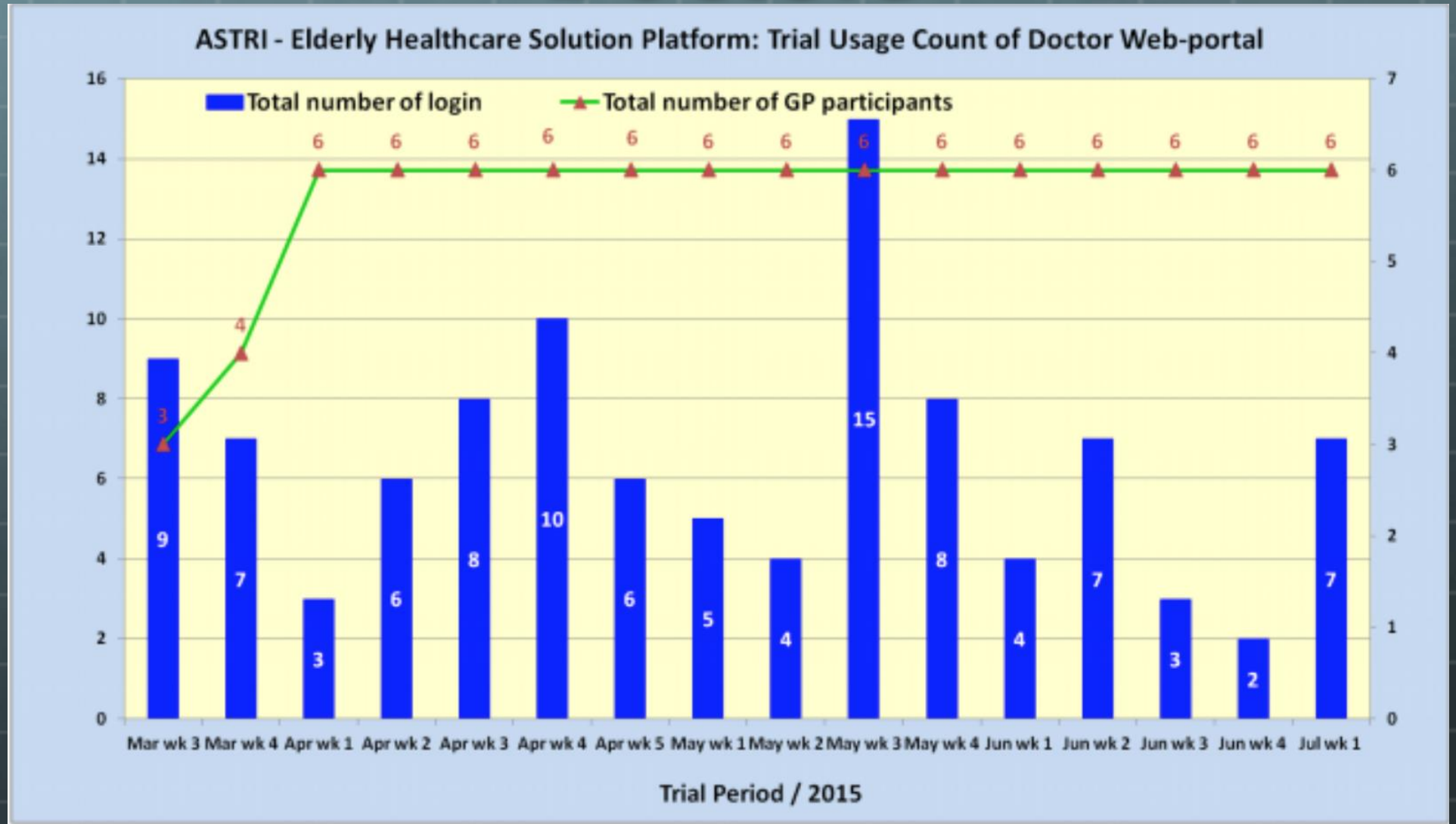
- 10-15% of the 26 cases were found to be inactively uploading data
- Follow up call by the research team called to encourage them
- 23 cases out of 26 cases actively upload data regularly


ASTRI - Elderly Healthcare Solution Platform: Trial Usage Count of Patient Device Package
Total number of vita sign data uploaded
Total number of patient participants
450
400
350
300
250
200
150
100
50
0
25
20
15
10
5
0
10
13
15
16
21
19
19
19
19
23
23
23
23
23
23
19
110
121
298
342
309
309
327
255
353
362
410
321
346
396
321
231
Mar wk 3
Mar wk 4
Apr wk 1
Apr wk 2
Apr wk 3
Apr wk 4
Apr wk 5
May wk 1
May wk 2
May wk 3
May wk 4
Jun wk 1
Jun wk 2
Jun wk 3
Jun wk 4
Jul wk 1
Trial Period / 2015

SMS Alerts Count

- Out of total of 4,903 data uploads (63 data / month / patient)
- Total of 452 Alerts fired in 3 months
- Alert rate = 9.2%
- Average alert rate 150 per month per 26 patients (5.8 / month / patient)
- 2 Alerts are being intervened, with drug adjustments (0.44%)

Web Portal Usage Rate by Doctors

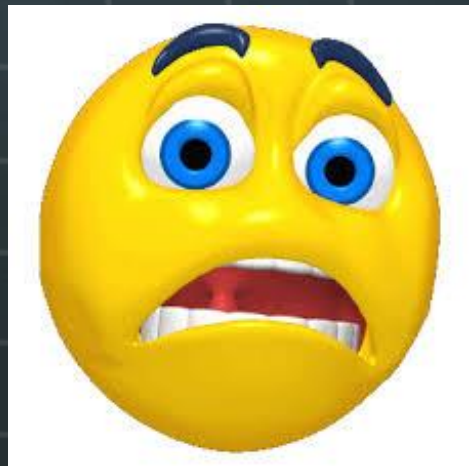


Web Portal Usage Rate by Patients & Caregivers

- Only 8 out of 26 patients / caregivers ever logged onto the web portal
- Login rate:
  - 7 of them logged in < 3 times
  - 1 of them logged in > 10 times

Overview of Alert Settings by GP

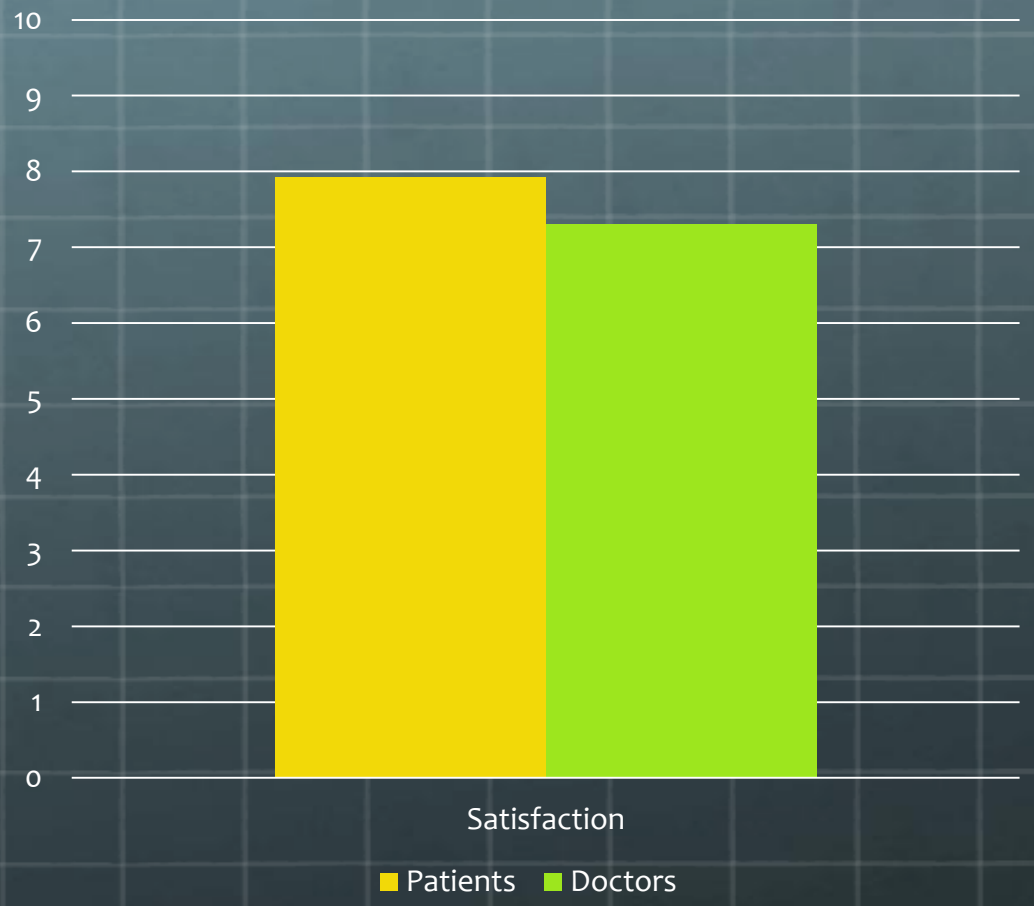
- Only 5 GP used the Alert Settings:
  - 4 used the default settings suggested by the literature
  - 1 used a modified setting by himself
- 1 GP DID NOT USE the alerts
  - His concern: Liability Issue & support logistics concern



Minor Hiccoughs

- 3 episodes of Hard Ware defects
- 1 data sync error: because of date settings, reversible
- 1 data upload error: operating issue
- 1 SMS SIM card error

Satisfaction Survey



Feedback by Doctors

- 6 out of 6 questionnaires returned
- 5 out of 6 agreed that the system is easy to use
- 5 out of 6 agreed that it assists in patient care
- 5 out of 6 agreed that the platform can make the patient doctor relationship closer

Feedback by patients

- 23 out of 26 questionnaires returned
- 21 (90%) elderly indicated that they use the system BY THEMSELVES
- 2 used the system with help of family members
- 21 elderly reported that they check the Apps for records
- 70% indicated that they are willing to pay for the service if the fees is <HK$100 per month

Observations from post-trial interview

- **Enhanced patients' healthcare awareness**

  "My patients measured Blood Pressure and Blood Glucose at least once per week after joining the Trial whereas they measured these vital signs only once per half a year before the Trial."

- **Promoted data sharing**

  "I found my patient acted on his own incentive to share his Blood Glucose data with another doctor , his own diabetes doctor."

- **Appreciated user-friendliness**

  "My father can do the measurement by himself completely. It's really a seamless system!"

  "During this Trial, my patients just brought the mobile phone to show the data record in the EHSP App, rather than carry his/her own Blood Glucometer previously."

Conclusions

- The devices have been configured to be extremely simple to be used
- The adoption rate is high at 90%
- Alert rate is 9.2%, with 0.44% intervention rate
- Web portal usage by doctors are average, Web portal usage by patients are poor
- 100% of patients and 90% of doctors found the system useful
- There is business opportunity using this service model

The Future

- Personal vital signs data should be uploaded and incorporated into the Electronic Health Record Sharing System
- To facilitate earlier diagnosis and intervention
- And to improve continuity of care of chronic diseases
- Apart from the community, those data from the ward and out patient settings should also be incorporated

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- Dr Chiu Kun Ming
- Dr Mak Kwong Leung, Dominic
- Dr Tang Kuen Yan, Alfred
- Dr Wong Nai Ming

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