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Rules for Normal and Abnormal Situations in the Elderly Person's Home

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Glossary of terms used

| Acronym/terms | Definition |
|-----------------------------------|--|
| ADL | Activities of Daily Living |
| AR | Assistive Robotics |
| COPD | Chronic Obstructive Pulmonary Disease |
| ER | Emergence Room |
| FEV1 | Forced expiratory volume in 1 second |
| FVC | Forced expiratory vital capacity |
| GOLD | The Global Initiative for Chronic Obstructive Lung Disease |
| HCI | Human Computer Interaction |
| HRI | Human Robot Interaction |
| iADL | Instrumental Activities of Daily Living |
| ICF | International Classification of Functioning |
| KSERA | Knowledgeable Service Robots for Aging |
| KSERA ubiquitous home environment | A smart home environment |
| KSERA-system | A smart home environment and a mobile platform, i.e. Nao |
| Nao | Humanoid Robot |
| PT | Prototype |
| Scenario | Usage narrative |
| UCD | User Centred Design |
| Use case | Describe the functional requirements |
| Users, primary | Older persons with COPD and Older persons in general |
| Users, secondary | Friends, family members, relatives, formal & informal carers, doctors, therapists, call centre personnel |
| Users, tertiary | Technicians for installation and maintenance, service providers, financing organisations, architects, social agencies, |
| WHO-ICF | See International Classification of Functioning |
| WP | Work package |
| Disease Management/Call Center | Centralized center staffed by health professionals with Personal Health Records for purpose of alert, reaction, and managing disease |

Executive summary

This report summarizes the rules for the users-normal and abnormal as relates to the KSERA project and specifically with regards to PT 2. The document is based on Deliverables 1.1(updated July 2011) as well as new rules in connection with PT2(see RC2 and updated Deliverable 5.1-Test Plan.

All rules relate to those people who have COPD and will be the subjects of the final trials-PT2 as well as potential users in the future of the KSERA system.

It is important to stress that this deliverable includes rules for COPD patients in the broadest sense and in no way indicates that all rules will be currently used and adapted in the KSERA system.

We feel it is important to provide the wide array so that the future development of the KSERA system will be able to adapt these rules and allow for them in the future. in the future.

All personas, as previously stated, are older people with different levels of COPD: GOLD 0 (no COPD, yet), GOLD I stage (undiagnosed), GOLD II (moderate COPD), GOLD III (severe COPD) and entering the GOLD IV stage of very severe COPD. User needs were identified and include the need to feel safe, the need for social contacts, the need for reminders and the need to exercise. Older people also need an easy way to call for help or alert, an easy way to communicate, help with banking, advice about their health and environment and to control different functions in the house remotely. The user needs created current scenarios, consisting of six main categories: monitor medical parameters, monitor environmental parameters, monitor activities of daily life, Nao interaction, communication & alarm and the category entertainment & domotics

Purpose of this deliverable

This document is limited to restating and adding rules for the KSERA system users (elderly people with COPD). Important to stress that the rules include those parameters that are not currently in the scope of the KSERA system but can be adapted for future use.

Suggested readers

This document is recommended to all KSERA partners and in particular to those involved in the KSERA trial plans and evaluation.

1 KSERA Rules

Sensors and rules (choices) to support ambitions and aspirations of older individual persons with GOLD 0-IV stages of COPD

Basic assumptions

1. Indoor air quality is defined by the EN 15421 and EN 15242 standards(EU Directorate for Energy and Building) COPD patients are more sensitive to changes and the rate of changes in air parameters levels
2. Outdoor air quality is monitored by environmental public services and will be used in KSERA system (external input)
3. The sensors sensitivity will be determined according to the minimal requirements as defined for the elderly COPD person.
4. In all cases measurements will be recorded and updated in the Personal Health Record and will serve the medical professionals in the disease management center.

2 Outdoor air sensors and calculations

Presently the environmental parameters are being monitored by local /national authorities. This data is collected with the best available sensors.

The relevant data from the outdoor sensors will be collected by the KSERA system (from public domain) and will be analyzed according to defined set of rules

The comfort range is smaller for the elderly and COPD person specially in moderate to severe illness (stages 3-4 of the disease)

A.1. CO₂-sensor (outdoors), ppm (parts per million)- not relevant

SENSOR: Nondispersive Infrared (NDIR) (but allow for sub-zero temperatures outdoors)

Sensitivity: At least 50 ppm

Accuracy: 40 ppm or 3% of measured value if this value is higher

Range: At least 0-5,000 ppm

Measurement frequency: Each 30 sec

Rules: **A.1.a.** Dynamic baseline to catch daily and seasonal changes in CO₂-level outside
A.1.b. Values will be used to calculate indoor-outdoor difference of CO₂ concentration of the inhaled air

A.2. Air temperature outdoors in the shade, and shielded from the wind, °C

SENSOR: Thermistor

Sensitivity: 1°C

Accuracy: 0.5°C

Range: At least -40 to +50°C

Measurement frequency: Each 30 minutes

Rules: **A.2.a.** Dynamic baseline to catch daily and seasonal changes in individual comfort range outdoors (in combination with relative humidity)
A.2.b. Inside current individual comfort range, and remains stable: no action
A.2.c. Still inside current individual comfort range, but the prediction is that it will soon be outside this range: warming to the person as to outdoor activities
A.2.d. Outside current individual comfort range: message not to venture outside
A.2.e. Information is also used for calculating (i) the outdoor experienced temperature (wind-chill index of Steadman in winter, heat index of Steadman in summer), (ii) the indoor-outdoor difference in absolute humidity (g water/m³ air), and (iii) ventilation efficiency in case of natural ventilation of a dwelling without mechanical exhaust

A.3. Relative humidity (RH) outdoors in the shade, and shielded from wind, %

SENSOR: Electronic hygrometer

Sensitivity: 3%

Accuracy: 5%

Range: at least 10-95% at temperatures of -20 to +45°C

Measurement frequency: each 30 minutes

- Rules:
- A.3.a.** Dynamic baseline to catch daily and seasonal changes in individual comfort range (in combination with temperature)
 - A.3.b.** Inside current individual comfort range (in combination with temperature), and remains stable: no action
 - A.3.c.** Still inside current individual comfort range, but the prediction is that it will within 60 minutes/hours be outside this range: warning to the person as to outdoor activities
 - A.3.d.** Outside current individual comfort range (in combination with temperature): message not to venture outside
 - A.3.e.** Information is also used for calculating (i) the outdoor experienced temperature in summer (heat index), and (ii) the indoor minus outdoor difference in absolute humidity (g water/m³ air)

A.4. Wind speed, m/s; and wind-chill index

- SENSOR: Anemometer
 Sensitivity: 1 m/s
 Accuracy: 1 m/s
 Range: 1-50 m/s (for -46 to +10°C)
 Measurement frequency: 30 minutes
 Rules:
- A.4.a.** wind speed over 40 Km/h the person is advised not to venture outdoor
 - A.4.b.** Information will be used for calculating the outdoor experienced temperature in winter (wind-chill index)
 - A.4.c.** If the indoor temperature minus the experienced (wind-chill) outdoor temperature <5°C and stable: no action
 - A.4.d.** If the indoor temperature minus the experienced outdoor temperature <5°C, but is predicted to reach 5°C today, the person is warned as to outdoor activities
 - A.4.e.** If the indoor temperature minus the experienced outdoor temperature >5°C, the person is advised not to venture outdoors

A.5. Heat index in summer

- Calculated from temperature and relative humidity
 Calculation frequency: Every 30 minutes
 Rules:
- A.5.a.** Heat index <25°C and stable: no action
 - A.5.b.** Heat index <25°C, but is predicted to reach 25°C today, the person is warned as to outdoor activities
 - A.5.c.** Heat index >25°C, the person is advised not to venture outdoors

A.6. Inhalable dust particle counts / m³ outdoor air**A6a PM10- Inhalable Particles smaller than 10µM**

Range: Current American standard for air quality is 150 µg/ m³ /24h & 50 µg/ m³ /year

Measurement frequency: Every 30 minutes

Rules: **A.6.a.1** Counts <50 µg/ m³ /24h air and stable: no action
A.6.b. Counts <50-100 µg/ m³ /24h, the person is warned as to outdoor activities
A.6.c. Counts >100 µg/ m³ /24h, the person is advised not to venture outdoors,

A6b PM2.5- Inhalable Particles smaller than 2.5µM

The standards are half of the PM10. All rules are adapted accordingly.

A7. CO

Range: Current American standard for air quality is 60000 µg/ m³ /8h & 10000 µg/ m³ /30 minutes

Measurement frequency: Every 30 minutes

Rules: **A7a.** Counts <5000 µg/ m³ /30 minutes: No action
A7b. Counts 5000-8000 µg/ m³ /30 minutes: the person is advised not to perform physical activities outdoor
A7c. Counts >8000 µg/ m³ /30 minutes: the person is advised to stay indoor
A7d. Counts >40000 µg/ m³ /8h: the person is advised to stay indoor

A8. So₂

Range: Current American standard for air quality is 350 µg/ m³ /1h & 125 µg/ m³ /24h

Measurement frequency: Every 30 minutes

Rules: **A8a:** Counts <300 µg/ m³ /1h: No action
A8b. : Counts 300-400 µg/ m³ /1h: the person is advised not to perform physical activities outdoor
A8c. : Counts >400 µg/ m³ /1h: the person is advised to stay indoor
A7d. Counts >100 µg/ m³ /24h: the person is advised to stay indoor

A9. NO₂

Range: Current American standard for air quality is 200 µg/ m³ /1h & 40 µg/ m³ /year

Measurement frequency: Every 30 minutes

Rules: **A9a:** Counts <200 µg/ m³ /1h: No action
A9b. : Counts 200-300 µg/ m³ /1h: the person is advised not to perform physical activities outdoor
A9c. : Counts >300 µg/ m³ /1h: the person is advised to stay indoor

A10 O₃

Range: Current American standard for air quality is 230 µg/ m³ /30 minutes & 160 µg/ m³ /8h

Measurement frequency: Every 30 minutes

Rules:

- A10a:** Counts <100 µg/ m³ /30 minutes: No action
- A10b.** : Counts 100-120 µg/ m³ /30 minutes the person is advised not to perform physical activities outdoor
- A10c.** : Counts >120 µg/ m³ /30 minutes: the person is advised to stay indoor
- A10d.** : Counts >140 µg/ m³ / in consecutive measurements within 8h: the person is advised to stay indoor

3 Indoor air sensors and calculations

The standard range for indoor is defined for healthy person according to European standard ref no. EN13779:2007:E .

For the elderly and COPD person we will define lower contamination levels . The suggested level are based on clinical recommendations and not validated (not existing in the literature)

There is a wide range of sensors in the market for the following parameters. The sensor type, sensitivity and accuracy of the sensor will be determined by local manufactures and price

B.1. CO₂-sensor (in each room of the dwelling), mg/m³

Range: Short term 10000 mg/m³ Long term 6300 mg/m³
 Measurement frequency: Every 30 minutes
 Rules: **B.1.a.** If <5000 mg/m³ and remains stable, : no action
B.1.b. If >5000 mg/m³, , adjust room ventilation, until a stable level of <5000 is reached

B.2. Air temperature indoors (in the living space of each room), °C

Range: According to standard EN15251 Summer tmp. 23 ±1.5 °C. Winter tmp 22 ±1.5 °C
 Measurement frequency: Every 30 minutes
 Rules: These standards are controlled by the programmed air condition system

B.3. Relative humidity (RH) indoors, % (in each room in the dwelling)

Range: The comfort humidity zone in-house suggested by the EN15251 standard is relative humidity 30% for Winter 60% for Summer. The air condition system will be programmed accordingly

B.4. Noise level

Range: Optimal noise levels suggested by the EN15251 standard is 20-35 DB for the air control system

B.5. Inhalable dust particle, Co, No₂, So₂ and O₃ are as for outdoor. The levels will be monitored and controlled by the air condition system.

4 Sensors worn by the person for continuous measurement

C.1. Mobility, steps / day

SENSOR: step meter

Sensitivity: 10 steps / day

Accuracy: 10 steps / day

Range: 0-20,000 steps / day

Measurement frequency: Each 15 minutes

Rules: **C.1.a.** Dynamic baseline to catch daily mobility fluctuation and changes from GOLD 0 to GOLD IV
C.1.b. If steps increase with 20%: congratulate the person and check FEV1
C.1.c. If (steps <20/day or steps decrease with 50%): check environmental measurements, and act accordingly
C.1.d. If (steps <20/day or steps decrease with 50%) and GOLD II-IV: perform an FEV1 measurement (and act accordingly)
C.1.e. If (steps <20/day or steps decrease with 50%) and GOLD II-IV: perform an FEV1 measurement (and act accordingly)
C.1.f. If (steps <20/day or steps decrease with 50%) and GOLD 0-I; complete SF12 questionnaire (and act accordingly)

C.2. Heart rate, +ECG beats / min

SENSOR: COMSOFT watch (EU approved)

Sensitivity: 1 beat / min

Accuracy: 3% of measured value

Range: 0 -240 beats / min

Measurement frequency: 1/h resting measurements

Normal range for elderly COPD person:

50-100 beats/minutes sinus rhythm and 40-120 for chronic arterial fibrillation

Rules: **C.2.a.** Dynamic baseline to catch daily heart rate fluctuation and changes from GOLD 0 to GOLD IV and COPD associated pathology
C.2.b. If (heart rate decreases below 50 b/m or increases above 120 b/m perform 1 lead ECG and send to the call center (and act accordingly)
C.2.c. If (heart rate decreases below 50 b/m or increases above 120 b/m and no ECG is taken, consult a medical professional within 15 min, and act according to the advice given
C.2.d. If (heart rate decreases below 50 b/m or increases above 120 b/m: and no ECG is taken, alert appears at disease management center and medical professional contacts patient for further review and consultation.

B.6. Coughing assessment, coughs/hour, total duration / hour (in each room in the dwelling)

SENSOR: Wearable sensor (for example Carmelsonix)

Range: No range is presently defined in the literature. The levels will be determined by our group and will be validated in clinical trial

Measurement frequency: Each min, and calculate the moving average over 12 hours of both coughs / hour, and total duration of coughing in min/hour

Rules:

- B.6.a.** Dynamic baseline to catch coughing pattern from GOLD 0 to GOLD IV stage
- B.6.b.** If the moving average of the number of cough / hour or duration/hour decreases by 30%: congratulate the person with his/her improved health
- B.6.c.** If the moving average of the number of coughs/hour or duration of coughing in min / hour increases by 30%: check the environmental measurements to find out if this caused the problem and act accordingly
- B.6.d.** If the moving average of the number of cough / hour or duration of coughing in min/hour increases by 30%: also offer an FEV1 measurement (and act accordingly)
- B.6.e.** If the moving average of the duration of coughing in min / hour or duration of coughing in min/hour increases by 30%, and no FEV1 measurement is done: alert is given to disease management center.
- B.6.f.** If the moving average of the duration of coughing in min / hour or duration of coughing in min/hour increases by 30%, and no FEV1 measurement is done , and GOLD III/IV: alarm to call center and contact made with patient.

5 Sensors continuously available for irregular or 2x/day use

D.1. FEV1 (Forced Expiratory Volume over 1 min), l

SENSOR: Digital FEV1 meter (EU approved)

Measurement/ frequency: Twice **daily**, after wake-up and before going to bed; additionally when called upon by the system

Rules: **D.1.a. Dynamic** baseline to catch daily FEV1 fluctuation and changes from GOLD 0 to GOLD IV
D.1.b. If FEV1 increases by 30%: congratulate the person with the increase of his/her health
D.1.c. If FEV1 decreases by 30%; check environmental measurements and measure O₂-saturation of the blood, HR, body tmp and advice the patient to perform a bronchodilator inhalation. Assess again in 30 minutes, if no improvement alert the call center

D.2. O₂-saturation of the blood, %

SENSOR: pulse oxymeter (EU approved)

Measurement frequency: Twice daily

Rules: **D.2.a.** GOLD I-II: If O₂-saturation of the blood is better than 95%: full exercise
D.2.b. GOLD I-II: If O₂-saturation of the blood is between 93-94 %: the person may perform mild exercises
D.2.c. GOLD I-II: If O₂-saturation of the is <92% system alerts call center/doctor to contact his/her treating physician, and act according to the advice given

D.3. Blood pressure, mmHg

SENSOR: (EU approved)

Measurement frequency: Irregular at the request of the professional care giver, or the system

Rules: **D.3.a.** Systolic dynamic baseline to catch daily, fluctuations and changes in systolic blood pressure from GOLD 0 to GOLD IV
D.3.b. If the systolic pressure drops below 90 mmHg, or above 180 mmHg HR should be assessed and 1 lead ECG performed and delivered to the call center
D.3.c. Diastolic dynamic baseline to catch daily, fluctuations and changes in diastolic blood pressure from GOLD 0 to GOLD IV
D.3.d. If the diastolic pressure drops below 50 mmHg or increases above 120, mmHg 180 mmHg HR should be assessed and 1 lead ECG performed and delivered to the call center.

D.4. Electrocardiogram (ECG)

SENSOR: 1 lead ECG wearable sensor (EU approved)

Measurement frequency: By demand and in response to changes in HR, blood pressure and O₂ saturation abnormalities

6 Behavioral sensors and Quality of Life (QoL) assessments

E.1. Perceived morning situation

SENSOR: NAO in dialogue

Measurement frequency: Each morning after waking-up

Question: How do you feel this morning?

Answer: If 'good': OK, have a nice day!

If 'bad': person is requested to take the SF12 test, and the environmental measurements are checked

E.2. Perceived medical quality of life assessment (SF12), score

SENSOR: SF12 questionnaire

Sensitivity: 2

Accuracy: 2

Range: 12-48

Measurement frequency: 1x / month, or on request of the system or the care professional

Rules: **E.2.a.** Dynamic baseline for GOLD 0 to GOLD IV

E.2.b. If the score is improved by 4 or more points: congratulate the person with its increase in health

E.2.c. If the score is increased or decreased by up to 3 points: give the person OK, no further action needed

E.2.d. If the score is decreased by 4 or more points: have environmental measurements checked and the O₂-saturation of the person's blood measurement taken, and schedule a visit to the treating physician.

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7 Rules in experiment flow

The following figure, taken from Deliverable 5.1 (updated) in preparation for PT2 demonstrates the use of the rules in the flow of one of the experiments.

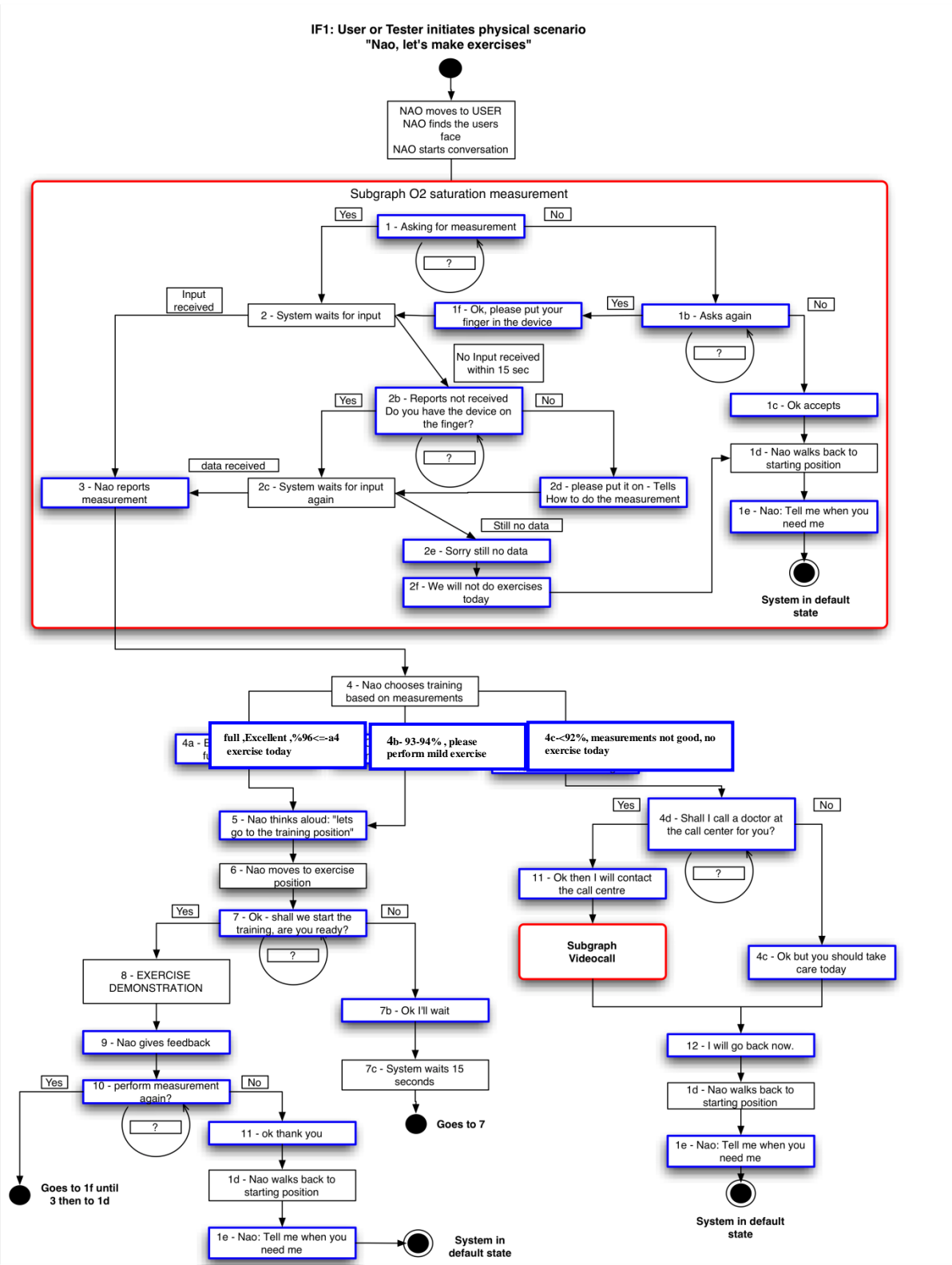


Figure 1: Rules in experiment flow

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