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## Deliverable D1.2

# Basic rules for ubiquitous monitoring

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## Glossary of terms used

Acronym/terms	Definition
ADL	Activities of Daily Living
carer	care person of older person
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-system	A smart home environment and a mobile platform, i.e. Nao
KSERA ubiquitous home environment	A smart home environment
Nao	Humanoid Robot
NR	Not Relevant
UCD	User Centred Design
Scenario	Usage narrative
Use case	Describe the functional requirements
User	Older Person, with or without COPD
WHO-ICF	See International Classification of Functioning
WP	Work package

## Executive summary

This deliverable presents the rules which define the parameters of the KSERA system—which indicators (health and otherwise) how are they measured , by whom and at what frequency. In addition we define the actions to be taken in the event of adverse or undesired events within each rule.

The rules were established based on the needs of the patients/users as defined in D1.1 with an understanding that not all the rules may be adhered to as they broaden the scope of the project and the resources available. As such this deliverable must be viewed as a "living document" in that it is an initial definition of rules for ubiquitous monitoring but will certainly go through additions, deletions, and amendments as the consortium, partners seek to reconcile the needs of persons with COPD together with the capabilities of the KSERA system as envisioned and projected in the DOW.

In this deliverable a basic set of rules was elaborated targeting at persons with COPD and older persons in general. The rules describe the sensor data relevant for judging the well being of older persons with COPD and the interpretation of these sensor data, when and how the Nao robot is involved when and how carers and family members are involved to support personal communication and to deliver reliable help if needed.

An extended version of the current set of rules will be delivered in D1.4 focusing on abnormal situations.

## Purpose of this deliverable

This deliverable serves as a blueprint for the partners involved in the technological aspects of KSERA to allow them to plan for the deployment of the system (NAO, sensors, communication to call centre, and involvement of the health professionals).

D1.2 is the initial deliverable in T1.4. It defines a first set of basic rules for ubiquitous monitoring derived from literature, pre-existing knowhow and identified by means of the KSERA scenarios. Work reported in D1.2 is input to WP2, WP3 and WP4.

## Suggested readers

This document is recommended to all KSERA partners and in particular to those involved in the KSERA system design, development and evaluation.

## Relationship to other documents

This document serves as input for WP4, in particular for D4.1 (Learning & decision making algorithms in pervasive environments). The work packages WP2, WP3 and WP4 use this document to design and develop the KSERA system components.

Complementary to D1.2 in month 28 a further deliverable (D1.4) will complete the work in Task T1.4. D1.4 (Rules for normal and abnormal situations in the home of older persons) will contain a final set of rules needed to develop the KSERA system.

## 1. Introduction

### 1.1 Approach

In preparing the rules there were many partners involved from medical, behavioral and technological areas. The approach is to anticipate the user's needs based on the accumulated clinical knowledge and the outlines of the literature on the subject together with European experiences and guidelines.

#### *Basic assumptions:*

Indoor air quality is defined by the EN 15421 and EN 15242 standards

COPD patients are more sensitive to changes and the rate of changes in air quality levels

Outdoor air quality is monitored by environmental public services and will be used in KSERA system as external input.

The sensors' sensitivity will be determined according to the minimal requirements as defined for older persons with COPD.

## 2. Rules for Older Persons with COPD

#### *KSERA RULES:*

In order to simplify the understanding of the KSERA rules tables the following definitions have been consistently applied for all the rule tables as follows:

User: Defines the intended subject of the rule (patient/caregiver).

Purpose: States the reason behind the rule.

Parameter: The measured physiological and/or environmental indicators and range of measurement

Action: What will happen as a result of rule enactment

Nao (yes/no)- Is Nao involved in this rule?

When: Time rule takes effect

Where: Place of Nao during rule effect

### A. Outdoor air sensors and calculations

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

Presently, the environmental parameters are being monitored by local /national authorities, using the best available sensors.

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

#### **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: every 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/m<sup>3</sup> air)

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Prevention of exposure to adverse outdoor temp, and relative humidity	Temperature 20-30°C. and stable, RH stable	none	No	24 hours	NR
Caregiver(s) -in addition to patient	Prevention of exposure to adverse outdoor temp, and relative humidity	Temperature <30°C and expected to rise to >30°C, RH > (High Humidity)	advised concerning outdoor activities	Yes	24 hours	In proximity to patient/caregiver in home
Caregiver(s) -in addition to patient	Prevention of exposure to adverse outdoor temp, and relative humidity	>30 Deg. C. + High RH	Warning not to venture outdoors	Yes	24 hours	In proximity to patient/caregiver at home

**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: every 30 minutes

**Rules:**

**A.4.a** At wind speeds over 40 Km/h the person is advice not to venture outdoors

**A.4.b** Information will be used for calculating the experienced outdoor temperature in winter (wind-chill index)

**A.4.c** If the indoor temperature minus the experienced (wind-chill) outdoor temperature is <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 or more on the same day, the person is warned as to outdoor activities

**A.4.e** If the indoor temperature minus the experiences outdoor temperature >5°C, the person is advised not to venture outdoors

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
<b>Patient/person</b>	Prevention of exposure to adverse wind speed and wind-chill index	Indoor temp.minus wind chill indexed temp. is >5°C	none	No	24 hours	NR
<b>Caregiver(s)-in addition to patient</b>	Prevention of exposure to adverse wind speed and wind-chill index	Indoor temp.minus wind chill outdoors is <5°C, predicted to reach >5°C.	Warning concerning outdoor activities	Yes	24 hours	In proximity to patient/caregiver in home
<b>Caregiver(s)-in addition to patient</b>	Prevention of exposure to adverse wind speed and wind-chill index	Indoor temp.minus wind chill outdoors is >5°C	Advised not to venture outdoors	Yes	24 hours	Inrproximity to patient/caregiver at home

#### A.5 Heat index in summer

Heat index is received from environmental authorities and calculated based on outdoor temperature and relative humidity

Calculation frequency: every 30 minutes

#### Rules:

**A.5.a** Heat index 20-30°C.and stable: no action

**A.5.b** Heat index <30°C, but is predicted to reach 30°C today, the person is warned as to outdoor activities

**A.5.c** Heat index >30, the person is advised not to venture outdoors

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
<b>Patient/patient</b>	Prevention of exposure to adverse outdoor temp.	20-30 Deg. C. and stable, RH stable	none	No	24 hours	NR
<b>Caregiver(s)-in addition to patient</b>	Prevention of exposure to adverse outdoor temp.	<30..and expected to rise to 30 with High Humidity	Warning concerning outdoor activities	Yes	24 hours	In proximity to patient/caregiver in home
<b>Caregiver(s)-in addition to patient</b>	Prevention of exposure to adverse outdoor temp.	>30 Deg. C. + High RH	Advised not to venture outdoors	Yes	24 hours	Inrproximity to patient/caregiver at home

#### A.6 Inhalable dust particle counts / m<sup>3</sup> outdoor air

##### A.6.a PM10- Inhalable Particles smaller than 10µm

Range: Current accepted standard for air quality is  $150 \mu\text{g}/\text{m}^3 / 24\text{h}$  &  $50 \mu\text{g}/\text{m}^3 / \text{year}$   
 Measurement frequency: every 30 minutes

**Rules:**

**A.6.a** Counts  $<50 \mu\text{g}/\text{m}^3 / 24\text{h}$  air and stable: no action

**A.6.b** Counts  $<50-100 \mu\text{g}/\text{m}^3 / 24\text{h}$ , the person is advised as to outdoor activities

**A.6.c** Counts  $>100 \mu\text{g}/\text{m}^3 / 24\text{h}$ , the person is warned not to venture outdoors,

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/Person	Measurement of inhalable dust particles to forewarn of adverse outdoor conditions	1 Counts $<50 \mu\text{g}/\text{m}^3 / 24\text{h}$ air and stable	none	No	24 hours	NR
Caregiver(s)-in addition to patient	Measurement of inhalable dust particles to forewarn of adverse outdoor conditions	Counts $<50-100 \mu\text{g}/\text{m}^3 / 24\text{h}$	advised concerning outdoor activities	Yes	24 hours	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient	Measurement of inhalable dust particles to forewarn of adverse outdoor conditions	Counts $>100 \mu\text{g}/\text{m}^3 / 24\text{h}$ /	warned not to venture outdoors	Yes	24 hours	In proximity to patient/caregiver at home

**A.7 CO**

Range: Current accepted standard for air quality is  $60000 \mu\text{g}/\text{m}^3 / 8\text{h}$  &  $10000 \mu\text{g}/\text{m}^3 / 30$  minutes

Measurement frequency: every 30 minutes

**Rules:**

**A.7.a** Counts  $<5000 \mu\text{g}/\text{m}^3 / 30$  minutes: No action

**A.7.b** Counts  $5000-8000 \mu\text{g}/\text{m}^3 / 30$  minutes: the person is advised not to perform physical activities outdoor

**A.7.c** Counts  $>8000 \mu\text{g}/\text{m}^3 / 30$  minutes: the person is advised to stay indoor

**A.7.d** Counts  $>40000 \mu\text{g}/\text{m}^3 / 8\text{h}$ : the person is advised to stay indoor

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/Person	Measurement of CO to forewarn of adverse	Counts $<5000 \mu\text{g}/\text{m}^3 / 30$ minutes	none	No	24 hours	NR

	outdoor conditions for performing physical activities					
<b>Caregiver(s)-in addition to patient</b>	Measurement of CO to forewarn of adverse outdoor conditions for performing physical activities	Counts 5000-8000 µg/ m <sup>3</sup> /30 minutes	a concerning performing phys.act. outdoors	Yes	24 hours	In proximity to patient/caregiver in home
<b>Caregiver(s)-in addition to patient</b>	Measurement of CO to forewarn of adverse outdoor conditions for performing physical activities	Counts >8000 µg/ m <sup>3</sup> /30 minutes	Advised to stay indoors	Yes	24 hours	In proximity to patient/caregiver at home
<b>Caregiver(s)-in addition to patient</b>	Measurement of CO to forewarn of adverse outdoor conditions for performing physical activities	Counts >40000 µg/ m <sup>3</sup> /8h	warned to stay indoors	Yes	24 hours	In proximity to patient/caregiver at home

**A.8 SO<sub>2</sub>**

Range: Current accepted standard for air quality is 350 µg/ m<sup>3</sup> /1h & 125 µg/ m<sup>3</sup> /24h  
 Measurement frequency: every 30 minutes

**Rules:**

- A.8.a** Counts <300 µg/ m<sup>3</sup> /1h: No action
- A.8.b** Counts 300-400 µg/ m<sup>3</sup> /1h: the person is advised not to perform physical activities outdoors
- A.8.c** Counts >400 µg/ m<sup>3</sup> /1h: the person is advised to stay indoors
- A.8.d**: Counts >100 µg/ m<sup>3</sup> /24h: the person is advised to stay indoors

User	Purpose	Parameter	Action	Na0 (yes/no)	When	Where
<b>Patient/person</b>	Measurement of SO <sub>2</sub> to forewarn of adverse	Counts <300 µg/ m <sup>3</sup>	none	No	24 hours	NR

	outdoor conditions for performing physical activities					
<b>Caregiver(s)-in addition to patient</b>	Measurement of SO <sub>2</sub> to forewarn of adverse outdoor conditions for performing physical activities	: Counts 300-400 µg/ m <sup>3</sup> /1h	advised not to perform phys.act. outdoors	Yes	24 hours	In proximity to patient/caregiver in home
<b>Caregiver(s)-in addition to patient</b>	Measurement of SO <sub>2</sub> to forewarn of adverse outdoor conditions for performing physical activities "	Counts >400 µg/ m <sup>3</sup> /1h	Advised to stay indoors	Yes	24 hours	Inrproximity to patient/caregiver at home
<b>Caregiver(s)-in addition to patient</b>	Measurement of SO <sub>2</sub> to forewarn of adverse outdoor conditions for performing physical activities	Counts >100 µg/ m <sup>3</sup> /24h	Advised to stay indoors	Yes	24 hours	Inrproximity to patient/caregiver at home

**A.9 NO<sub>2</sub>**

Range: Current American standard for air quality is 200 µg/ m<sup>3</sup> /1h & 40 µg/ m<sup>3</sup> /year  
 Measurement frequency: 30 minutes

**Rules:**

**A.9.a** Counts <200 µg/ m<sup>3</sup> /1h: No action

**A.9.b** Counts 200-300 µg/ m<sup>3</sup> /1h: the person is advised not to perform physical activities outdoors

**A.9.c** Counts >300 µg/ m<sup>3</sup> /1h: the person is advised to stay indoors

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Measuring air quality	Counts <200 µg/ m <sup>3</sup> /1h	None	NR	24 hours	NR
Caregiver(s)-in addition to patient		Counts 200-300 µg/ m <sup>3</sup> /1h	Advised not to perform phys.act.	Yes	24 hours	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient		Counts >300 µg/ m <sup>3</sup> /1h	Advised to stay indoors	Yes	24 hours	In proximity to patient/caregiver in home

**A.10 O<sub>3</sub>**

Range: Current American standard for air quality is 230 µg/ m<sup>3</sup> /30 minutes & 160 µg/ m<sup>3</sup> /8h  
 Measurement frequency: 30 minutes

**Rules:**

**A.10.a** Counts <100 µg/ m<sup>3</sup> /30 minutes: No action

**A.10.b** Counts 100-120 µg/ m<sup>3</sup> /30 minutes the person is advised not to perform physical activities outdoor

**A.10.c** Counts >120 µg/ m<sup>3</sup> /30 minutes: the person is advised to stay indoor

**A.10.d** Counts >140 µg/ m<sup>3</sup> / in consecutive measurements within 8h: the person is advised to stay indoor

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
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<b>Patient/Person</b>	Measurement of Oxygen (air quality)	Counts <100 $\mu\text{g}/\text{m}^3$ /30 minutes	None	NR	24 hours	NR
<b>Caregiver(s)-in addition to patient</b>		Counts 100-120 $\mu\text{g}/\text{m}^3$ /30 minutes	Advise patient not to perform phys.act.	Yes	24 hours	In proximity to patient/caregiver in home
<b>Caregiver(s)-in addition to patient</b>		Counts >120 $\mu\text{g}/\text{m}^3$ /30 minutes	Advised to stay indoors	Yes	24 hours	In proximity to patient/caregiver in home
<b>Caregiver(s)-in addition to patient</b>		Counts >140 $\mu\text{g}/\text{m}^3$ / in consecutive measurements within 8h	warned to stay indoors	Yes	24 hours	In proximity to patient/caregiver in home

## B. Indoor air sensors and calculations

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

For the elderly and COPD person we will define lower contamination levels. The suggested levels are based on clinical recommendations and not validated (not existing in the literature). Clinical efficacy of the suggested rules will require further studies

There is a wide range of sensors in the market for measuring indoor air quality. The actual sensor type, sensitivity and accuracy of the sensor, as it will be used in KSERA, will be determined based on the prices of local manufacturers.

### B.1 CO<sub>2</sub>-sensor (in each room of the dwelling), mg/m<sup>3</sup>

Range: short term 10000 mg/m<sup>3</sup> Long term 6300 mg/m<sup>3</sup>

Measurement frequency: every 30 minutes

#### Rules:

**B.1.a** If <5000 mg/m<sup>3</sup> and remains stable, : no action

**B.1.b** If >5000 mg/m<sup>3</sup>, adjust room ventilation, until a stable level of <5000 is reached

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Measure CO <sub>2</sub> inside the dwelling/room	<5000 mg/m <sup>3</sup> and remains stable	None	No	24 hours	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient		>5000 mg/m <sup>3</sup> ,	adjust room ventilation until <5000 mg/m <sup>3</sup> attained	Yes	24 hours	In proximity to patient/caregiver in home

### 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 conditioning system

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Measure indoor air temp.	Summer tmp. 23 ±1.5 °C	Controlled by programmed a/c system	No	24 hours	NR
Caregiver(s)-in addition to patient		Winter tmp 22 ±1.5 °C	Controlled by programmed a/c system	NO	24 hours	NR

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

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

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Measuring relative humidity indoors	30% for Winter	a/c system will be programmed accordingly	No	24 hours	NR
Caregiver(s)-in addition to patient		60% for Summer		No	24 hours	NR

**B.4 Noise level**

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

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Measure noise level	20-25 DB	Air control system	No	NR	NR

**B.5 Inhalable dust particles:** The criteria for particle size, CO, NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub> are the same as for outdoors. The levels will be monitored and controlled by the air condition system.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Measure inhalable dust particles in the home	Co, No <sub>2</sub> , So <sub>2</sub> and O <sub>3</sub> are as for outdoor	Monitored by a/c system	NR	NR	NR

**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: every 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 II to GOLD IV stage

**B.6.b** If the moving average of the number of coughs / hour or cough duration/hour decreases by 30%: Nao will congratulate him. -

**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

**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 clinical evaluation

**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: contact the treating care professional

**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, nor a care professional is contacted, and GOLD III/IV: alarm to call center  
**B.6.g** clinical evaluation=automated set of instruction presented by Nao to the User in order to assess his clinical status.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	To assess cough severity-set baseline per patient and measure changes in cough/ hours	Dynamic baseline to catch coughing pattern from GOLD II-GOLD IV	Measure average over 12 hours of coughs/hr and duration of coughing in min/hr	No	24 hours	By sensors
Patient/person		30% decrease of moving average of coughs/hr or	Congratulate the patient	No	24 hours	By sensors

		cough duration min/hr				
<b>Patient/person</b>		30% increase of coughs/hr and cough duration (min/hr)	Check environmental measures and act accordingly	No	24 hours	By sensors
<b>Patient/person</b>		30% increase also offer FEV1 measurement	Act accordingly	No	24 hours	By sensors
<b>Patient/person</b>		30% increase and no FEV done	Contact health professional	No	24 hours	By sensors
<b>Patient/person</b>		30% increase and no FEV done and no health care professional contacted	If Gold III-IV alarm to call center	No	24 hours	By sensors

### C. 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: ongoing measurements and a readout every 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

**C.1.c** If (steps <20/day or steps decrease with 50%): check environmental measurements,

**C.1.d** If (steps <20/day or steps decrease with 50%) and GOLD II-IV: perform an FEV1 measurement (and act accordingly)

User	Purpose	Parameter	Action	Na0 (yes/no)	When	Where
<b>Patient/person</b>	To monitor steps taken as indicator of increasing/decreasing function	Baseline to catch daily fluctuation and changes from GOLD 0-GOLD IV	Check steps with pedometer	No	24 hours	NR
<b>Patient/person</b>		20% increase of steps/day	congratulate person	No	24 hours	NR
<b>Patient/person</b>		<20	Check	No		NR"

		steps/day or 50% decrease	environmental measures and act accordingly			
<b>Patient/person</b>		(<20 steps/day or 50% decrease )AND gold II-IV	Perform FEV1 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 mesurments

Normal range for older 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 falls below 50 beats/min or rises above 120 beats/min perform 1 lead ECG and send results to the call center.

**C.2.c** If (heart rate decreases below 50 b/m or increases above 120 beats/min 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 beats/min or increases above 120 beats/min: and no ECG is taken, and no consultation of a medical professional took place within 15 min: call for an ambulance to the emergency room

User	Purpose	Parameter	Action	Naο (yes/no)	When	Where
<b>Patient/person</b>	To monitor heart rate of patient ( as an indicator of function change)	Dynamic baseline to catch daily heart rate fluctuation and changes from GOLD 0-GOLD IV and COPD associated pathology	Check heart rate	NO	24 hours	NR
<b>Patient/person</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	No	24 hours	NR
<b>Patient/person</b>		. If (heart rate decreases below 50 b/m or increases above 120 b/m and no	Consult medical professional within 15 min/ and act accordingly	No	24 hours	NR

		ECG taken				
<b>Patient/person</b>		If (heart rate decreases below 50 b/m or increases above 120 b/m and no ECG taken and no consultation within 15 min.	Call for ambulance to the emergency room	No	24 hours	NR

**D. Sensors continuously available for irregular or 2x/day use**

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

SENSOR: Digital FEV1 meter (EU approved)

Measurement frequency: 2x/day, 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 O<sub>2</sub>-saturation of the blood, HR, body tmp and advice the patient to perform a bronchodilator inhalation. Assess again in 30 minutes. If there is no improvement alert the call center

User	Purpose	Parameter	Action	Na0 (yes/no)	When	Where
<b>Patient/user</b>	To measure FEV in patient	Dynamic baseline to catch daily FEV1 and changes from GOLD 0- GOLD IV	Sensor will take initial measurement	Yes	0800,1900(after wake-up and before bed)	Near patient
<b>Patient</b>		If FEV1 increases by 30%	Congratulate person	Yes	0800,1900(after wake-up and before bed)	Near patient
<b>Caregiver(s)-in addition to patient</b>		If FEV1 deceases by 30%	Check environmental measurements, and O <sub>2</sub> saturation, HR, body temp+ advise to perform broncodilator inhalation. Assess in 30 min. If no change, contact call center	Yes (together with sensors)	0800,1900(after wake-up and before bed)	Near patient

**D.2 O<sub>2</sub>-saturation of the blood, %**

SENSOR: pulse oxymeter (EU approved)

Measurement frequency: 2x/day, in parallel to FEV1 assesment

**Rules:****D.2.a** GOLD II-IV: If O<sub>2</sub>-saturation of the blood is better than 88%: no further action**D.2.b** GOLD II-IV: If O<sub>2</sub>-saturation of the blood is <88%: the person is requested to contact his/her treating physician, and act according to the advice given**D.2.c** GOLD 0-I: If O<sub>2</sub>-saturation of the blood drops by <2%: no action**D.3.d** GOLD 0-I: If O<sub>2</sub>-saturation of the blood drops by >2%: complete the SF12, and act accordingly

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/user	To measure O <sub>2</sub> -saturation of the blood, %	Level of blood saturation, using pulse oxymeter	Perform baseline	Yes	0800,1900	In proximity to patient—presenting pulse oxymeter
Patient		GOLD II-IV: If O <sub>2</sub> -saturation of the blood is better than 88%-	no further action			
Patient		GOLD II-IV: If O <sub>2</sub> -saturation of the blood is <88 %	Patient requested to contact phys. And act according to advice	Yes	0800,1900	In proximity to patient—presenting pulse oxymeter
Patient		GOLD 0-I: If O <sub>2</sub> -saturation of the blood drops by <2 %	No action	Yes	0800,1900	
Patient		GOLD 0-I: If O <sub>2</sub> -saturation of the blood drops by >2%:	Complete SF 12 and act accordingly	(in combination with medical team)	0800,1900	In proximity to patient—presenting pulse oxymeter

**D.3 Blood pressure, mmHg**

SENSOR: (EU approved)

Measurement frequency: Irregularly at the request of the professional care giver, or the KSERA 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, HR should be assessed and 1 lead ECG performed and delivered to the call center

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/user	To measure the patient's BP	Systolic dynamic Baseline to catch daily fluctuations	Check BP (using cuff with signals to call center)	No	Irreg., by care plan	NR
Patient		If the systolic pressure drops below 90 mmHg, or above 180 mmHg	HR should be assessed and 1 lead ECG performed and sent to call center	No	Irreg., by care plan	NR
Patient		Diastolic dynamic baseline to catch daily, fluctuations	As above			
Caregiver(s)- in addition to patient		If the diastolic pressure drops below 50 mmHg or increases above 120 mmHg	HR should be assessed and 1 lead ECG performed and sent to call center	No	Irreg., by care plan	NR

**D.4 Electrocardiogram (ECG)**

SENSOR: 1 lead ECG wearable sensor (EU approved)

Measurement frequency: According to request by medical professional and in response to changes in HR, blood pressure and O2 saturation abnormalities

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/user	Check HR	1 lead ECG wearable sensor	By demand and in response to changes in HR, blood pressure and O2 saturation abnormalities	No	By demand of health professional	NR

## E. 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, glad to hear it!

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

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/user	To measure quality of life	Questions asked by NAO	Upon waking: NAO asks- "How do you feel today?"	Yes	Wake up	Next to patient
Patient			If good" NA says – "Have a good day."	Yes	Wake up	Next to patient
Caregiver(s)- in addition to patient			If "bad" patient takes SF-12 (gives to care team) and environmental measures checked	No	Wake up or during morning	NR

### 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 her/his 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 O<sub>2</sub>-saturation of the person's blood measurement taken, and schedule a visit to the treating physician

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/user	To measure perceived medical quality of life	SF 12 questionnaire	Administered by care team to establish baseline (first time) from GOLD 0-GOLD IV	No	1x a month	NR
Patient		Improved score by 4 points	Congratulate the person with health increase	No	1x a month	NR

<b>Patient</b>		. If the score is increased or decreased by up to 3 points	Patient gets OK no further action needed			
<b>Patient</b>		. If the score is decreased by 4 or more points	Check environmental measures, check O2 saturation and schedule phys. visit			

### 3. Rules for Older Persons in General

This section describes rules which are not specifically targeting persons with COPD but rather focus on older persons in general. The scenarios and use cases from D1.1 form the basis for defining these rules.

The rules are listed according to their function and the relevant scenarios (D1.1) are indicated similar to section on Nao’s autonomy in D3.1 (p.10).

If the rules in chapter 2 do not apply then KSERA/Nao ubiquitously monitors for abnormal behaviour patterns (to be defined in D1.4). If this occurs the KSERA system notifies/ alerts the care givers and facilitates, otherwise Nao can freely interact with the user (see D3.1). The latter may be due to externally triggered events like a phone call, user triggered events like a user calling for Nao, or time of day triggered events like fun and entertainment.

Scenario 1 (Healthy through indoor exercise) and scenario 2 (Disease self-management) were considered to be already fully covered by the rules in chapter 2 of this document.

#### 3.1 Rules for Appointments Outside home

For older persons in general it might be useful to check for good weather / bad weather and for extreme outdoor temperatures or snow and to warn if there might be slippery condition (ice on pathway). Weather conditions might be different between test sites (e.g. winter in Israel near coast differs from weather in Austria).

Corresponding Scenario: 3 – A safe environment

Proposed rules:

If there is an appointment to go outside in today’s calendar then one should remind the user well in advance, and inform him/her about weather conditions such as potentially dangerous environmental conditions (temperature - too hot, too low), precipitation (rainfall), snow, ice on road, pathway (possibly also hotness, ozone problem)

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Inform about weather condition some time ahead of appointment outside home	Appointment approaching; Temperature very high or very low; Wind very strong; Ice on road / pathways Ozone warning	Warning about outdoor conditions	yes	during day time, e.g. 0600 to 2200 *)	Nao in proximity to user

\*) this time should be adjustable to the individual user’s preferences and stored in the configuration file.

If appointment is in calendar but there was no user activity (i.e. movement) indicating that user is preparing to leave his/her home in time (e.g. 30 minutes before user has to leave his/her home) then it is assumed that the appointment might be forgotten and the user is reminded again.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
<b>Patient/person</b>	Remind user for a potentially forgotten appointment	Time of Appointment saved in calendar is approaching (0 < (appointment time – NOW) < 30 minutes) AND no significant user activity	Approach user and remind him / her regarding appointment	yes	0800-2000	Nao in proximity to user

If appointment is in calendar and system did not detect that user has left home in time then the user is informed that he/she should have left.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
<b>Patient/person</b>	Remind user for a forgotten appointment	Time of necessary leaving home to go to appointment has passed (appointment time – NOW < 0) AND No indication that user has left home (no entrance door event, still presence of user at home)	Approach user and remind him / her regarding appointment	yes	0800-2000	Nao in proximity to user
<b>Caregiver</b>	Inform carer that user has not left home	Time of necessary leaving home to go to appointment has passed (appointment time – NOW < 0) AND No indication that user has left home (no entrance door event, still presence of user at home)	Send email / SMS	no	0800-2000	NR

### 3.2 Rules to motivate for outdoor activity

If no appointment is in calendar and the weather is fine and preferred time for outdoor activity is in user profile and if activity is low then the system suggests to user to have a walk.

Corresponding Scenario: 3 – A safe environment

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Propose user to have a walk	Weather is fine (temperature, wind, precipitation in good range) AND Low activity at home AND Time is in-between preferred time for outdoor activity	Approach user and remind him / her regarding appointment	yes	0800-2000	Nao in proximity to user

### 3.3 Rules for Potential Risk Situations

#### 3.3.1 Unusual Activity Patterns

This is about unusual activity patterns which could be indicators for a potential risk situation. The system monitors activity patterns e.g. time of leaving bed in the morning, moving to different rooms (Nehmer et al., 2006) and draws conclusion on significant deviations from the usual patterns.

If abnormal activity patterns occur Nao approaches the user and asks if the user is fine. If no appropriate reaction of the user takes place then a phone / videophone connection to predefined receivers will be established. This will be done as an “alarm chain” making sure that the call will reach somebody who will care for triggering appropriate actions. If several numbers are in the list the last one need to be a number reachable 24/7 (e.g. an emergency call centre).

Abnormal activity pattern to trigger rules (Storf et al., 2009)

User does not leave bed in the morning at normal time

User is at home but is not using toilet / not moving to toilet during the whole day

User is at home but is not using kitchen facility (neither fridge door nor stove sensor)

If Nao is approaching user and asks him/her if s/he is fine an appropriate reaction would be that user says ‘I am fine’. A non-appropriate reaction would be if user says ‘I do not feel well’, or if user does not react at all. Note, that due to limitation in Nao’s speech recognition performance it might be more efficient to design the user dialogue between Nao and the older person in a way which let the user answer with Yes or No rather than free sentences. If for some reason NAO does not understand the answer the user has given, the “alarm chain” is triggered in any case.

The above scenarios and abnormal activities will be further defined and identified in D1.4 Rules for normal and abnormal situations in the home.

## Corresponding Scenario: 4 – Medical Alarm

Please note that medical emergency is clearly about when ubiquitous monitoring is no longer within safe bounds and KSERA must abort ongoing actions and initiate appropriate actions.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	If abnormal / missing activity data in home, ask user if s/he is fine and call for help if user is in need	User is present at home AND Activity rate is below threshold	Approach user and ask if s/he is fine.	yes	24 hours	Nao in proximity to user
Patient/person	Call for help if no appropriate reaction	User says "I am not fine" OR User does not react at all OR system does not understand verbal answer	Establish phone / videophone connection to predefined receivers	Yes	24 hours	Nao in proximity to user

### 3.3.2 Possible Fall Recognised

When a potential fall of the older person is detected Nao approaches the user and asks if the user needs help. If no appropriate reaction of user then establishing a phone / videophone connection to predefined receivers Using "alarm chain" as described in 3.3.1.

Note: Fall detection is done by 3<sup>rd</sup> party system, e.g. Adamo watch. In principle there are different approaches available for fall detection (Rajendran et al., 2008): wearable devices and distributed devices in the environment. Wearable devices are around the users neck, on the chest, belt or on the wrist (Doughty 2000) Possible falls are detected by means of integrated sensors, measuring acceleration, impact and quiet phase after impact (Degen et al., 2003, Noury et al, 2007). Distributed approaches measure the mechanical vibration of floor (Doughty 2000). The KSERA consortium will consider different methods and decide among the most effective, safe and cost-beneficial mode of detection.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	React on reported fall alarm	User is present at home AND Fall is detected by fall detector	Approach user and ask if s/he needs help. Signal call center	yes	24 hours	Nao in proximity to user
Patient/person	Call for help if no appropriate reaction	User says "Yes" OR User does not react at all OR system does not understand verbal answer	Establish phone / videophone connection to predefined receivers	Yes	24 hours	Nao in proximity to user

### 3.4 Rules for active & passive phone calls

General: If phone call /message is arriving, then Nao transfers it to the user.

Corresponding Scenario: 5 – Socializing and entertainment

*Proposed rules:*

If an external event (door bell rings or phone call comes or sms/email arrives) occurs and no reaction of the user is detected, then Nao approaches user and transfers the information to the user. An incoming phone call could be answered by Nao directly using an automated response like 'please hold the line'.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	React on incoming phone call, door bell...	User is present at home AND (Door bell is ringing OR phone call is coming OR message is received) AND No user activity recognised	Approach user and inform about incoming phone call, door bell, ...	yes	24 hours	Nao in proximity to user
Patient/person	Executing user's decision	User says "Take up call"	Take up incoming call	Yes	24 hours	Nao in proximity to user

If no activity for a longer period of time and now is the preferred time then Nao can approach user and propose to call up somebody in his friend list. Preferred time for initiating phone calls is time interval saved in the individual user's configuration setting file.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Support social contacts	User is present at home AND NOW is preferred time for calls AND No calls during last 48 hours	Approach user and propose him to have a phone call with one of his friends	yes	24 hours	Nao in proximity to user
caregiver	Support social contacts	No phone calls during last 48 hours	Send SMS / Email proposing to have a call	No	1500 1900	NR

Additionally, Nao could call up somebody of the friend / carer list and propose to them to call up the user.

### 3.5 Rules for Morning Procedure

General rule: Nao must not come too near to old person when s/he is moving in order to avoid dangerous situations.

Corresponding Scenario: 6 – Smart home & navigation

Proposed rules:

If system recognises that user is waking up in bed, then Nao approaches the user and wishes a good morning.

Optionally some users might appreciate if Nao would play some music after that.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Morning procedure	User is present at home AND Just has woken up in bed	Approach user and say to him/her a warm "Good morning"  (Optionally) Play an item from favourite music list	yes	0600 – 0900 (usual time for waking up)	Bed room  Nao in proximity to user

### 3.6 Rules for Nightly Visits of Toilet

Corresponding Scenario: 6 – Smart home & navigation

If it is night and user is waking up and leaving bed to go to toilet then the light in the hallway will be switched on.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Switch on light when user is going to toilet during night	User is present at home AND Just has left his/her bed AND It is night / dark	Gently switch on light on the way towards toilet	No	2300 – 0600 (usual sleep time)	Bed room  Nao in proximity to user

Corresponding Scenario: 6 – Smart home & navigation

If user is returning to bed during night after having been at the toilet then the system will switch off the light in the hallway automatically.

User	Purpose	Parameter	Action	Nao (yes/no)	When	Where
Patient/person	Switch off light after user has returned to bed	User was on toilet AND Has returned to bed	Gentle switch off light on the way towards toilet	No	2300 - 0600	Bed room  Nao in proximity to user

## 4. Outlook

In this deliverable a basic set of rules was elaborated by applying an interdisciplinary approach involving expertise from medical, behavioural, user related and technological areas.

The current rules target at persons with COPD and older persons in general. They describe the sensor data which are relevant for judging the well being of older persons with COPD how they are to be collected and the interpretation of these sensor data including also vital parameter and their normal range.

The rules also describe when and how the Nao robot is involved when certain rules are firing. A particular importance do have rules dedicated to support older persons social connectedness and their capability to communicate and to ask for help if needed.

The elaborated rules cover general behaviour of system, implicitly built on lower level functions like HRI (cf. D3.1) and mobile robot behaviour (D2.1).

The D1.2 material serves as input for WP2, WP3 and in particular for WP4 where the technical implementation of the needed KSERA rules and decision taking algorithm will be prepared and realised taking into account also feasibility and technological issues.

An extended version of the rules will be delivered in D1.4 focusing on abnormal situations.

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