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D.6.3 Personalized services for the medical expert

T. Smagurauskas, D. Stundys, N. Bileisiene, G. Juozalenaite,
L. Rimsevicius, R. Kizlaitis

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CARRE Contacts

Project Coordinator:	Eleni Kaldoudi	kaldoudi@med.duth.gr
Project Manager:	George Drosatos	gdrosato@ee.duth.gr

DUTH Democritus University of Thrace	Eleni Kaldoudi	kaldoudi@med.duth.gr
OU The Open University	John Domingue	john.domingue@open.ac.uk
BED Bedfordshire University	Enjie Liu	Enjie.Liu@beds.ac.uk
VULSK Vilnius University Hospital Santariškių Klinikos	Domantas Stundys	Domantas.Stundys@santa.lt
KTU Kaunas University of Technology	Arunas Lukosevicius	arunas.lukosevicius@ktu.lt
PIAP Industrial Research Institute for Automation & Measurements	Roman Szewczyk	rszewczyk@piap.pl

Disclaimer

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Executive Summary

Medical expert empowerment and decision support services (DSS) is a personalized service for disease progression management. This CARRE component is an event driven service, which supports and enables real-time decision support for medical experts. The DSS in CARRE requires the risk assessment of comorbidities probability occurrence based on input from risk association model. It suggests treatment guidance by providing alarms (based on a particular patient's observables) and new evidence based medical findings that are based on medical expert's selection, provides identification of important changes and advices for medical expert about the relevant frequency of patient's medical data measurements and suggests possible patient's lifestyle changes that would assist in stopping progression of disease.

The 6.3 task "Development of personalized services for medical expert" involves the development of personalized decision support and empowerment services for the patient within the DSS framework developed in task 6.1. Such services are detailed in the domain analysis and functional requirements of WP2 and include: risk assessment for cardio renal disease comorbidities (and/or for cardio renal disease based on comorbidities), medication compliance alerts and management, lifestyle management, medication/treatment adverse events and interactions with comorbidities, planning for medical check-ups and monitoring, patient education and alerts related to cardio renal disease and potential comorbidities, and patient social empowerment services.

This document is a report of Task 6.3 "Personalized services for the medical expert" of WP6 in CARRE project. It includes the description and implementation (within the DSS) of personalized empowerment and decision support services for medical expert.

About CARRE

CARRE is an EU FP7-ICT funded project with the goal to provide innovative means for the management of comorbidities (multiple co-occurring medical conditions), especially in the case of chronic cardiac and renal disease patients or persons with increased risk of such conditions.

Sources of medical and other knowledge will be semantically linked with sensor outputs to provide clinical information personalised to the individual patient, so as to be able to track the progression and interactions of comorbid conditions. Visual analytics will be employed so that patients and clinicians will be able to visualise, understand and interact with this linked knowledge and also take advantage of personalised empowerment services supported by a dedicated decision support system.

The ultimate goal is to provide the means for patients with comorbidities to take an active role in care processes, including self-care and shared decision-making, and also to support medical professionals in understanding and treating comorbidities via an integrative approach.

Terms and Definitions

The following are definitions of terms, abbreviations and acronyms used in this document.

Term	Definition
BMI	Body mass index
BP	Blood pressure
CHF	Chronic heart failure
CKD	Chronic kidney disease
DBS	Diastolic blood pressure
DSS	Decision support system
EMS	Emergency Medical Service
HBPM	Home blood pressure monitoring
SBS	Systolic blood pressure
SMS	Short Message Service

1. Introduction

This document is a report of Task 6.3 and describes the implementation of personalized Decision support system (DSS) for medical expert. This task consists of developing the concept of DSS functionality for providing medical experts with alerts about patient's health status and new evidence based medical literature in related medical fields. The alerts on patient's condition should assist medical expert in providing quality health care. Updates on medical literature are also aimed to empower medical expert in following updated content within sources of evidence-based medical literature.

Algorithms used to analyse patient's health parameters allow DSS to determine when medical expert should be informed by an alert about important changes in patient's condition. The aim of these alerts is not to substitute the medical expert but empower him/her to get updates more timely on patient's health status and take appropriate decisions based on patient's condition.

DSS for updates on new evidence based medical literature is designed to help medical expert keep his knowledge up to date with the latest findings. Medical expert is updated by the latest information based on the field of interest he/she chose. By automatically performing these tasks it is expected to reduce the risk of medical expert not noticing new evidence based literature.

2. DSS algorithms for medical expert

DSS algorithms created for medical experts aim to inform them on three main topics about their patient's activity (monitoring vital parameters) and health status changes on CARRE DSS. The designed DSS algorithms can be organized into three different categories:

- Notification of medical experts about the initiating of vital parameters monitoring
- Notification of medical experts of patient adherence to a self-monitoring regime
- Notification of medical experts about patient's health status change

These DSS algorithms work by examining data which consists of patient's observable measurements. Since these observables hold the measurements of various patient's vital parameters, they can be used to calculate patient's medical condition. If the calculated condition/risk is determined which is worth to be notified about, an email or SMS message is sent to medical expert describing the condition. An example would be, patient measures blood pressure and systolic blood pressure has a value of 180 mmHg; since this might be the case of medical emergency, the medical expert is notified about patient's condition.

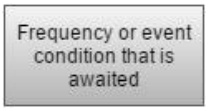
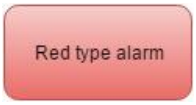
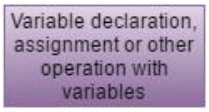
2.1. Interpreting the diagrams

The algorithm descriptions are based on flowcharts, which all use a common shape and colour set, as summarized in Table 1. Note the messages indicated in the DSS algorithm flowcharts are meant to convey only the logic (the actual messages are described in Annex 1 of this report). The actual phrasing of the message is based on common practices for conveying information to the layman in two different languages of the CARRE pilot demonstration.

The flowcharts can be interpreted by following these rules:

- Interpretation should start at the initial node. Initial node is a node that has no logical flow lines leading to it. For convenience it is always placed at the top left.
- Activity movement is performed by moving between nodes connected with lines.
- If it is a frequency or event condition node, flow is resumed from it every time the condition described in it occurs. The state of variables is preserved.
- If flow reaches a dead end, it should be resumed from initial node.

Table 1. The principles of diagram interpretation.

	Event or frequency condition is awaited until it is satisfied, then logical flow is continued from this.
	Logical flow is continued from here depending on the outcome of comparison.
	Green type alarm is being sent with message that is specified inside.
	Yellow type alarm is being sent with message that is specified inside.
	Red type alarm is being sent with message that is specified inside.
	Existing set of data is introduced into logical flow.
	Algorithm specified inside is being invoked.
	Operation with variable which can be: new variable declaration, assignment of value for variable or other kind of operation.
[Email]	Alarm is carried out via e-mail.
[Sms]	Alarm is carried out via sms.

3. Notifications about the beginning of vital parameters monitoring

DSS algorithms described in this section intend to inform medical expert that patient has started self-monitoring. DSS algorithms which define the initiating of a new self-monitoring regime refer to four different types of sensors that were selected to be included in CARRE pilot demonstration, namely blood pressure (BP) device, scales, blood glucose monitor and physical activity tracker. These vital parameters from the listed devices are analysed by the system: (1) systolic and diastolic blood pressure values; (2) body weight, (3) blood glucose, (4) counted number of steps.

3.1. Blood pressure monitoring

Home blood pressure monitoring (HBPM) is considered to be beneficial for all patients with cardiorenal disease or who have a high risk of developing this condition. HBPM is described in detail in D6.2.

The algorithm is created for medical expert to inform him/her that patient has started HBPM. After the first blood pressure measurement patient's predefined physician will be notified with a message (Figure 1).

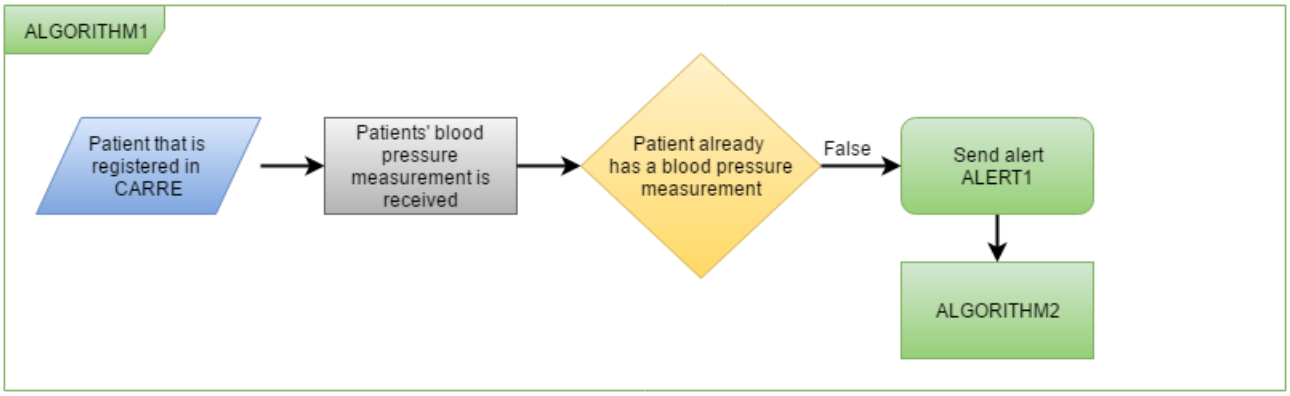


Figure 1. Starting monitoring blood pressure.

Algorithm 2 considers that every new CARRE user who wishes to monitor blood pressure systematically should monitor his/her blood pressure twice per week for one week and then according to his/her average blood pressure values further monitoring regime should be individually recommended[1]. Alarms for medical expert on preselected time intervals are created based on patient's adherence to the initial regime, incoming monitoring data and adherence to the following monitoring regimes (Figure 2).

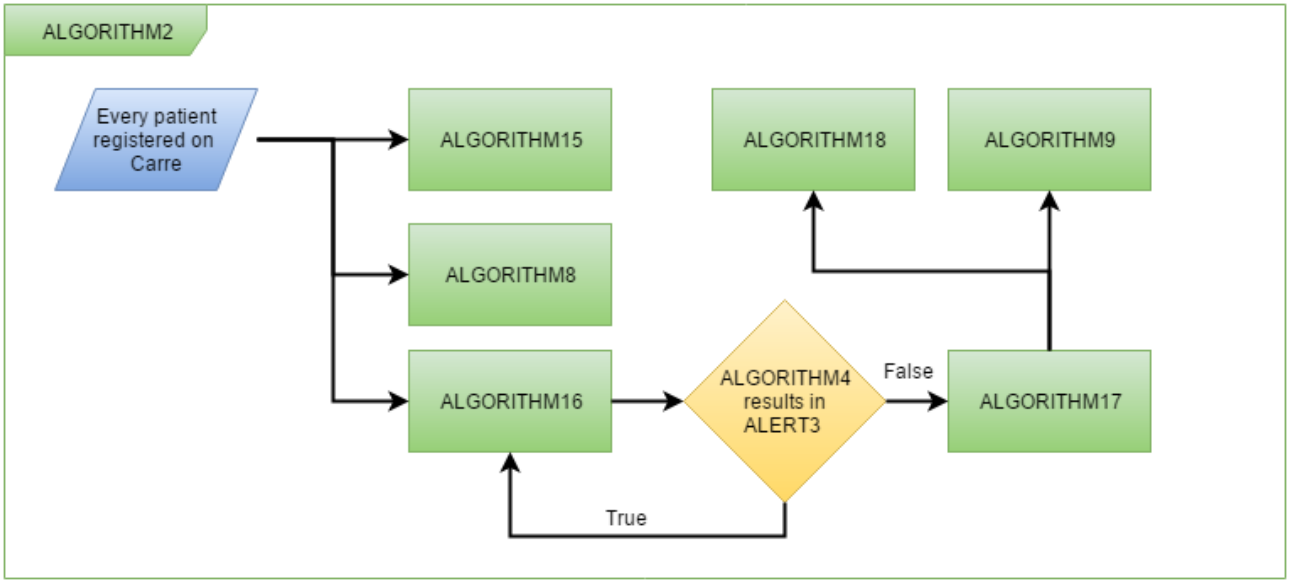


Figure 2. Blood pressure monitoring regime according to initial data.

3.2. Body weight monitoring

CARRE service suggests for patients with cardiorenal disease or who have a high risk of developing it to monitor body weight. The algorithm is created for medical expert to inform him/her that patient has started

[1] 2013 ESH/ESC Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC).

body weight monitoring. After the first time the patient has measured his/hers weight patient's predefined physician will be notified with a message (Figure 3).

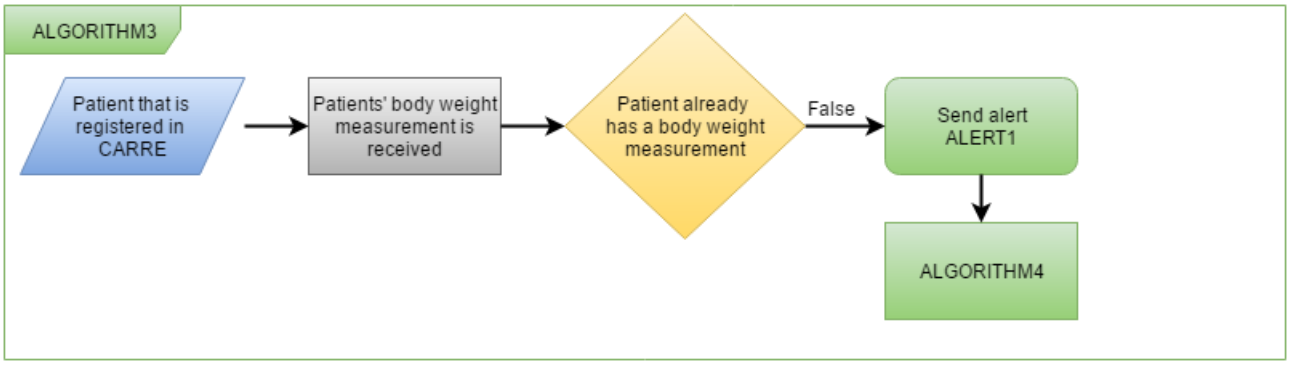


Figure 3. Starting monitoring of body weight.

Algorithm 11 represents three initial patient's health conditions according which they follow preselected monitoring regime. Based on their compliance to these regimes and incoming monitoring data alarms are created for medical expert on preselected time intervals[2,3,4] (Figure 4).

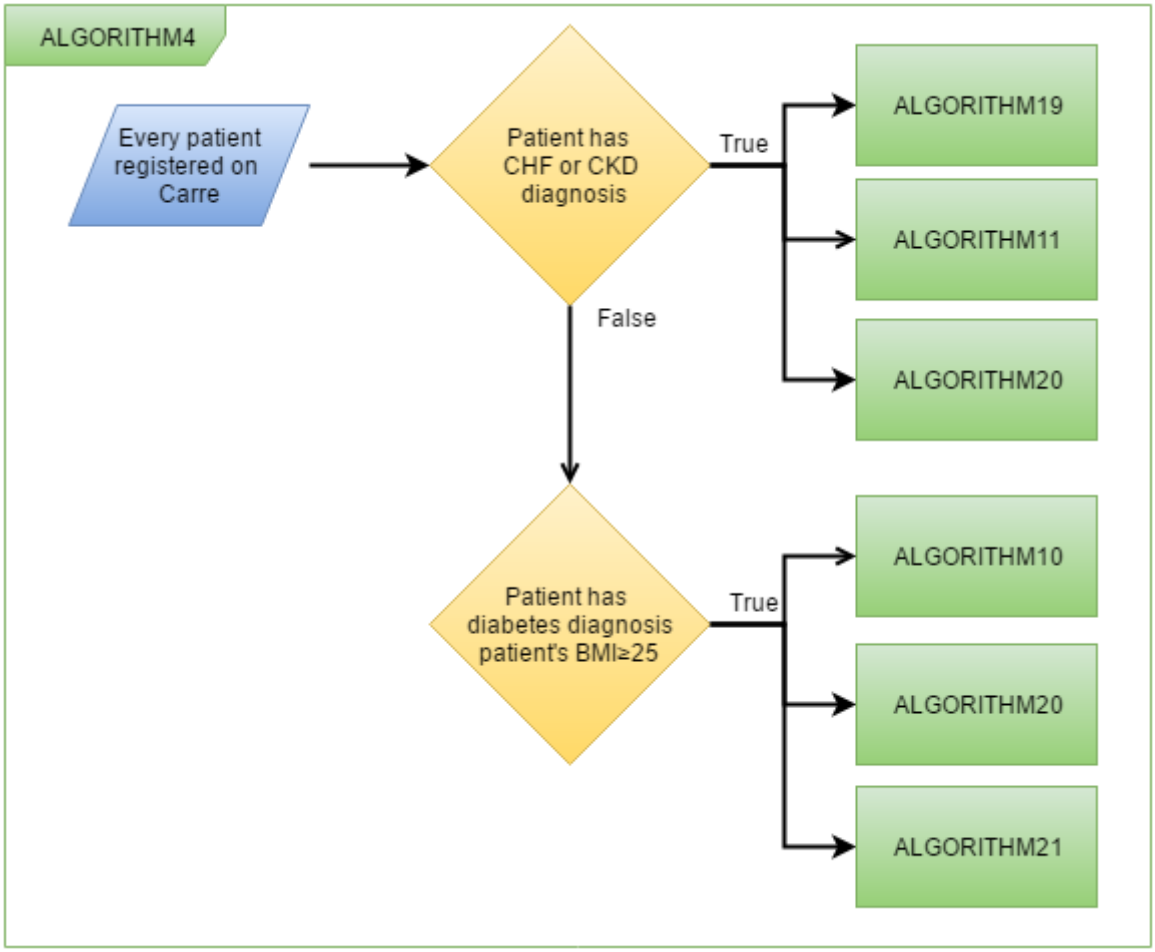


Figure 4. Body weight monitoring according to patient's initial status.

[2] 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure.

[3] American Diabetes Association. Standards of medical care in diabetes—2015. Diabetes Care. 2015;38:S1-S93.

[4] 2015 American Diabetes Association (ADA) Diabetes Guidelines Summary Recommendations from NDEI.

3.3. Blood glucose monitoring

CARRE service has established home blood glucose monitoring for diabetic patients and also supports the possibility for the patients with cardiorenal disease or who are at risk of developing it to check blood glucose occasionally. The algorithm is created for medical expert to inform him/her that patient has started blood glucose monitoring. After the first time the patient measures his/her blood glucose patient's selected physician will be notified with a message (Figure 5).

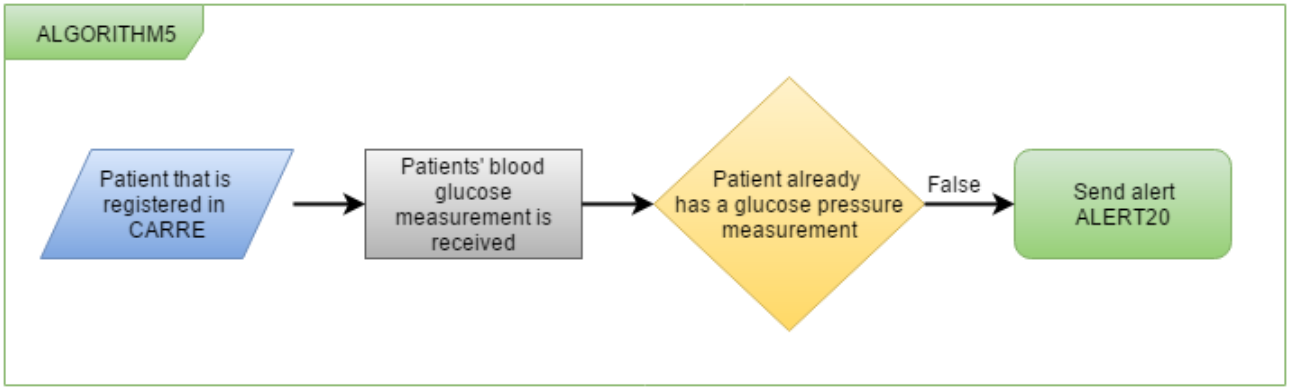


Figure 5. Starting monitoring of blood glucose.

Different measurement regimes are defined for patients with diabetes and for those who have higher risk of developing diabetes (Figure 6)[5].

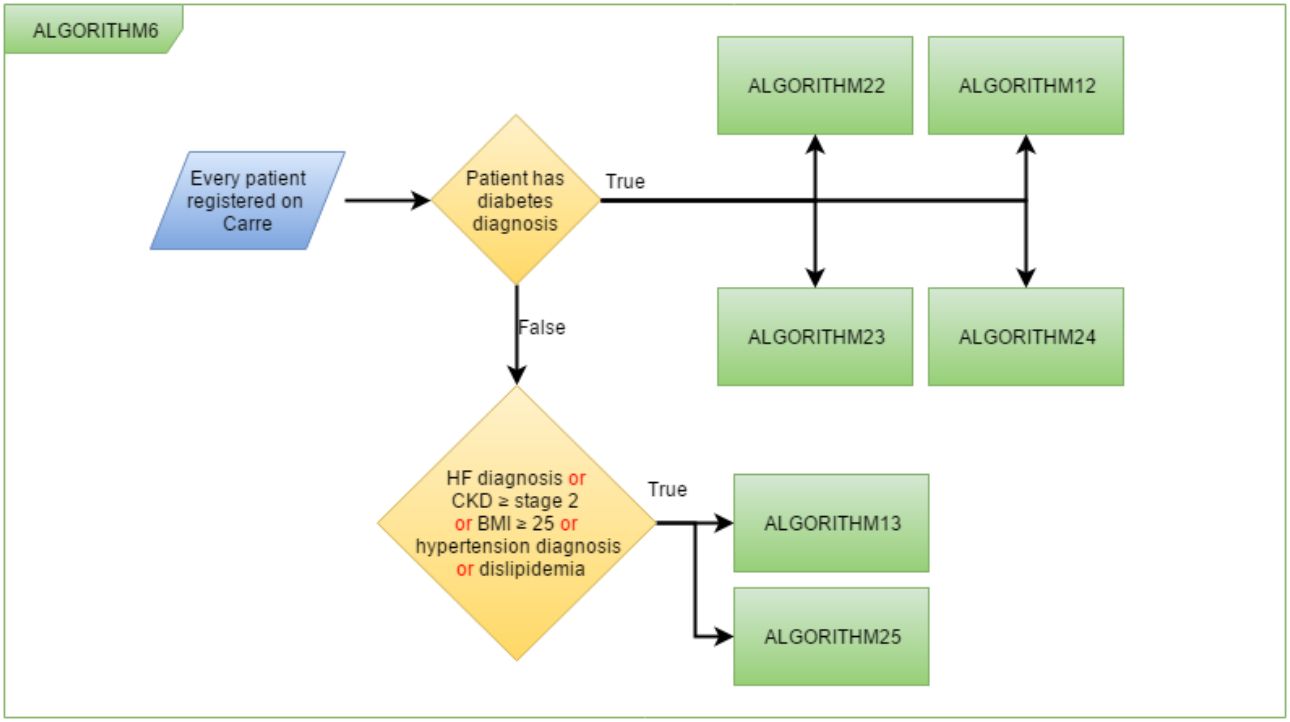


Figure 6. Blood glucose monitoring according to patient's initial status.

[5] 2015 American Diabetes Association (ADA) Diabetes Guidelines Summary Recommendations from NDEI.

3.4. Physical activity monitoring

CARRE service promotes exercising and suggests monitoring physical activity for long term health benefits. The algorithm is created for medical expert to inform him/her that patient has started physical activity monitoring. When the patient does so, selected physician will be notified with a message (Figure 7).

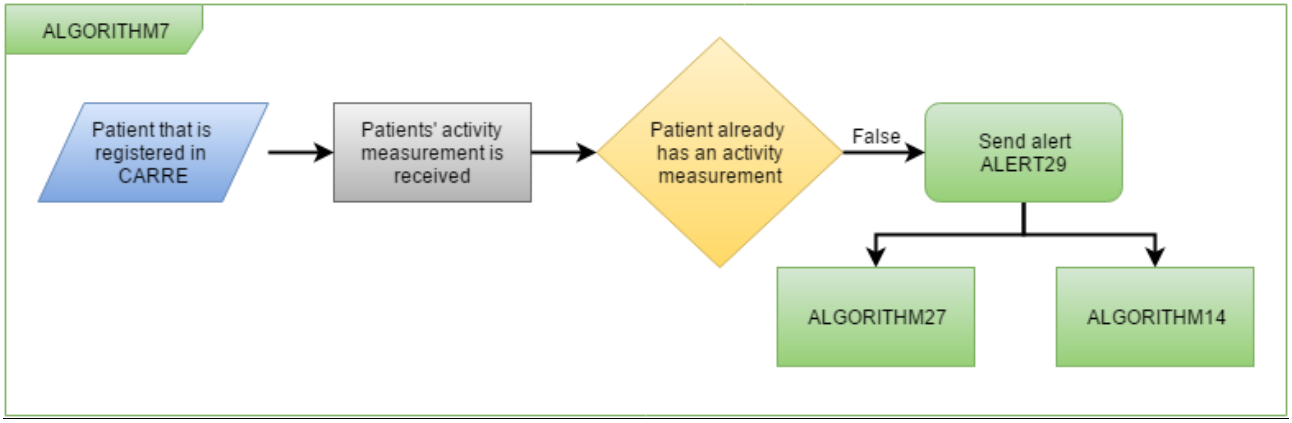


Figure 7. Starting monitoring of patient's activity.

After the initial algorithm which notifies medical expert about the beginning of physical activity monitoring, subsequential algorithms are launched, which monitor if patient uses his physical activity tracker and provide notifications if patient isn't active enough taking into account his initial conditions.

4. Notifications of patient adherence to monitoring regime

DSS algorithms described in this section are meant to inform medical expert on the patient's adherence to a self-monitoring regimes as those described by the algorithms in the previous section.

4.1. Adherence to blood pressure monitoring

DSS for medical expert has algorithms that support patient's adherence to a blood pressure monitoring regime. If patient doesn't follow individualized blood pressure regime (e.g. irregular measurements or discontinuation of monitoring), an appropriate message is generated for the medical expert and sent to him/her in preselected time intervals corresponding to the monitoring regime that patient is following: twice per day (Figure 8) or once per week[6] (Figure 9).

[6] 2013 ESH/ESC Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC).

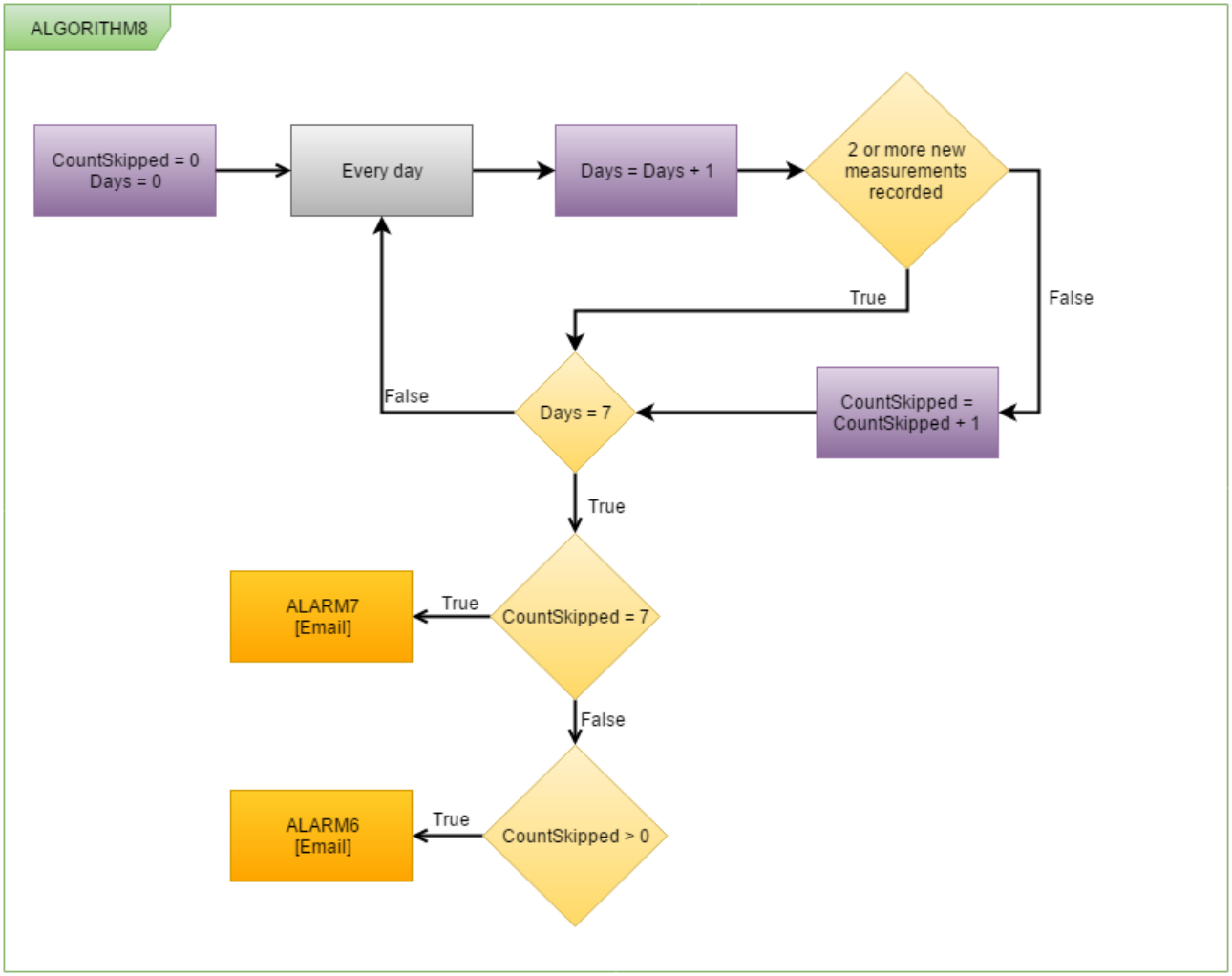


Figure 8. Patient's adherence to monitoring regime, when blood pressure is measured twice per day.

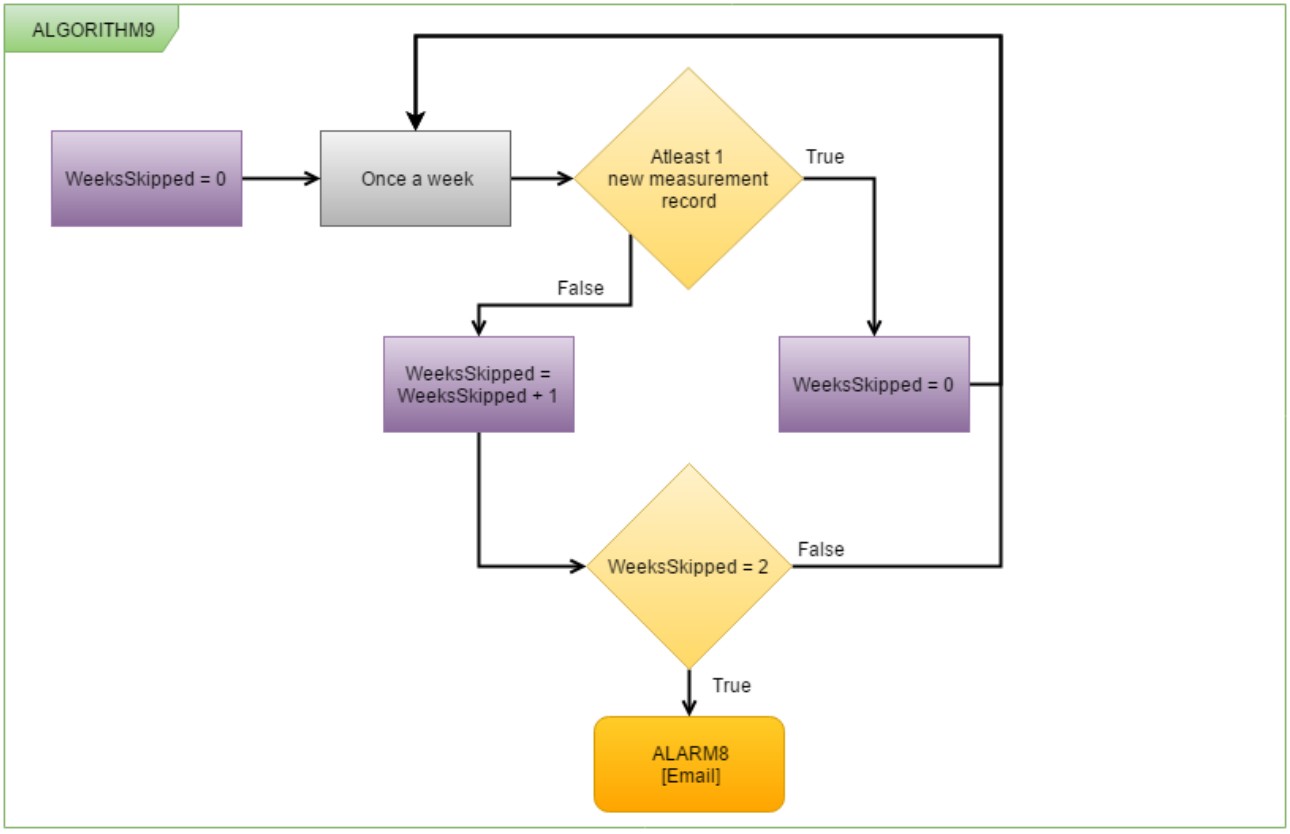


Figure 9. Patient's adherence to monitoring regime, when blood pressure is measured once per week.

4.2. Adherence to body weight monitoring

It is important to perform regular body weight measurements and even more – every time they should be performed at the same time and on the same conditions (preferably, in the morning, before breakfast, before medications and any liquids and after urinating, with the same type of clothes on, without shoes, on the same scale and in the same spot).

DSS for medical expert has algorithms that support patient's adherence to body weight monitoring regime. If the patient doesn't follow his/her body weight monitoring regime according to his/her personalized schedule an appropriate message is generated for the medical expert. Figure 10 shows the algorithm that supports adherence to a body weight self-monitoring regime for patients with chronic heart failure or chronic kidney disease[7]. If such patient has not performed regular body weight measurement during the last week or has not used scales at all, the medical expert will be informed with a message. Similarly, Figure 11 shows the algorithm that supports adherence to a body weight self-monitoring regime for patients with diabetes[8] or with increased body weight[9]. Also messages will be sent to the medical expert in every case if the patient doesn't perform body weight measurements on preselected time intervals. Alarms are also created for both algorithms to inform medical expert if scales are used inappropriately in order to help medical expert recognise false alarms generated by the DSS.

[7] 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure.

[8] 2015 American Diabetes Association (ADA) Diabetes Guidelines Summary Recommendations from NDEI.

[9] European Guidelines on cardiovascular disease prevention in clinical practice (version 2012).

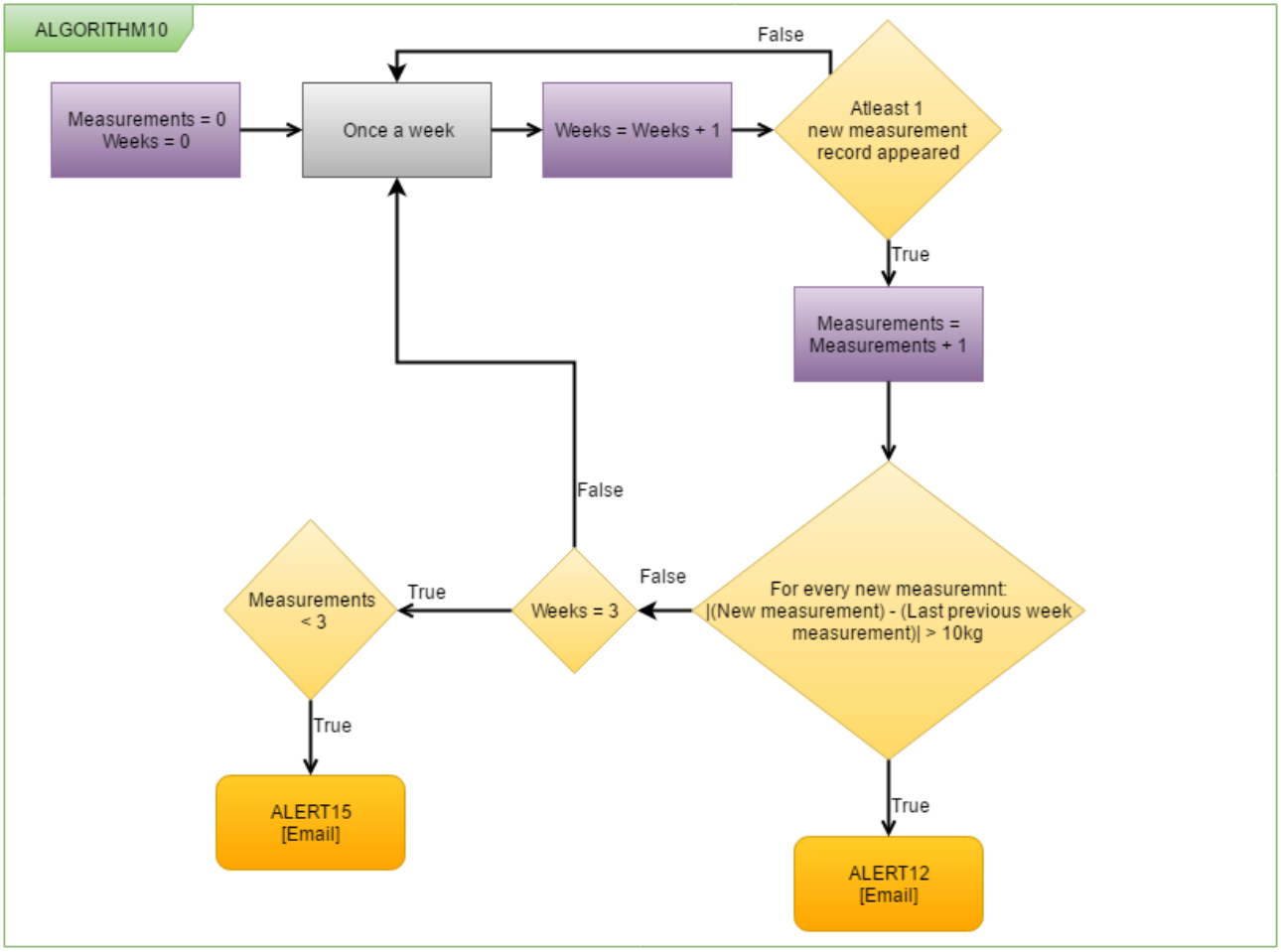


Figure 10. Patient's adherence to body weight monitoring regime once per week.

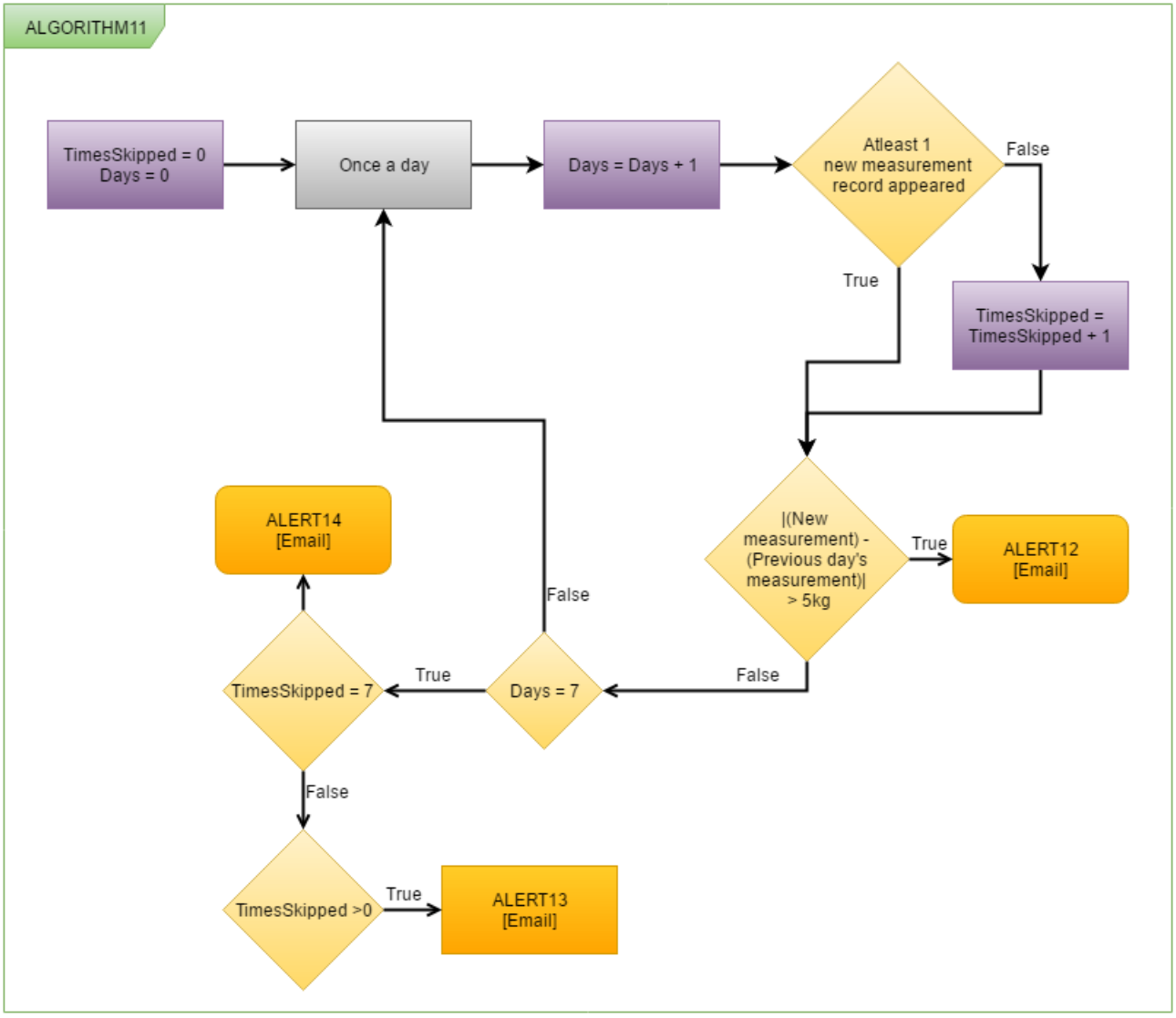


Figure 11. Patient's adherence to body weight monitoring regime when monitoring once per day.

4.3. Adherence to blood glucose monitoring

If the patient doesn't follow his/her body weight monitoring regime according to his/her personalized schedule, an appropriate message is generated for the medical expert.

Figure 11 shows the algorithm that supports adherence to a body weight self-monitoring regime for patients with heart failure or chronic kidney disease. If such a patient has not performed regular body weight measurement during the last week or hasn't used scales at all, the medical expert will be informed with a message.

Similarly, Figure 13 shows the algorithm that supports adherence to a body weight self-monitoring regime for patients with diabetes or with increased body weight. Also messages will be sent to medical expert in every case if the patient doesn't perform weight measurements on preselected time intervals.

DSS for medical expert has algorithms that support patient's adherence to blood glucose monitoring regime. Figure 12 shows the algorithm that supports adherence to a blood glucose self-monitoring regime for patients with diabetes[10]. If the patient doesn't follow his/her blood glucose monitoring according to his/her personalized

[10] 2015 American Diabetes Association (ADA) Diabetes Guidelines Summary Recommendations from NDEI.

schedule an appropriate reminder is generated for the medical expert after preselected time intervals. Furthermore, if the diabetic patient doesn't perform blood glucose measurement at all, the medical expert is also informed with a message.

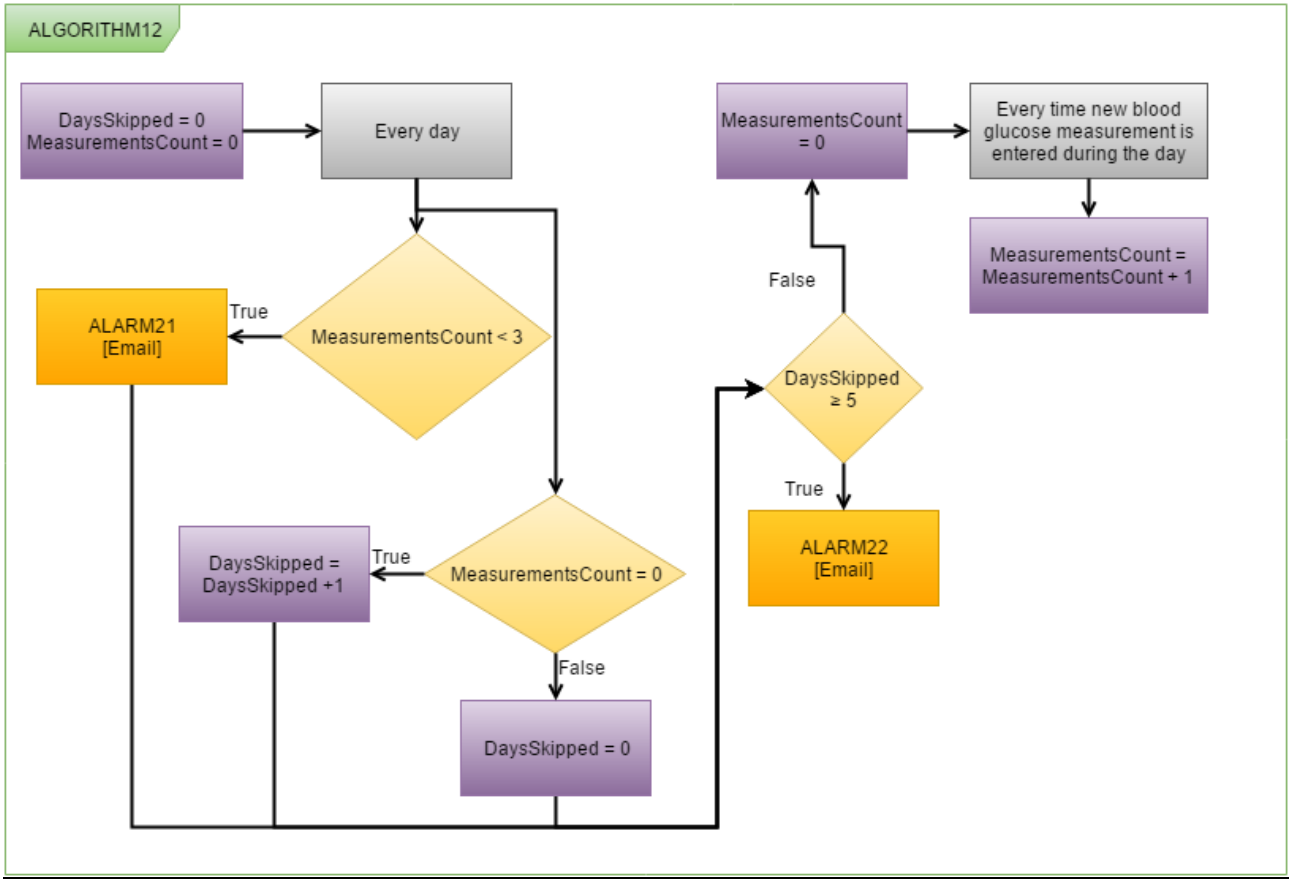


Figure 12. Patients' with diabetes diagnosis adherence to glucose measurement regime.

Figure 13 shows the algorithm that supports adherence to a blood glucose self-monitoring regime for patients with risk factors for diabetes. If such patient doesn't follow his/her blood glucose monitoring according to his/her personalized schedule, an appropriate reminder is generated for the medical expert after preselected time intervals.

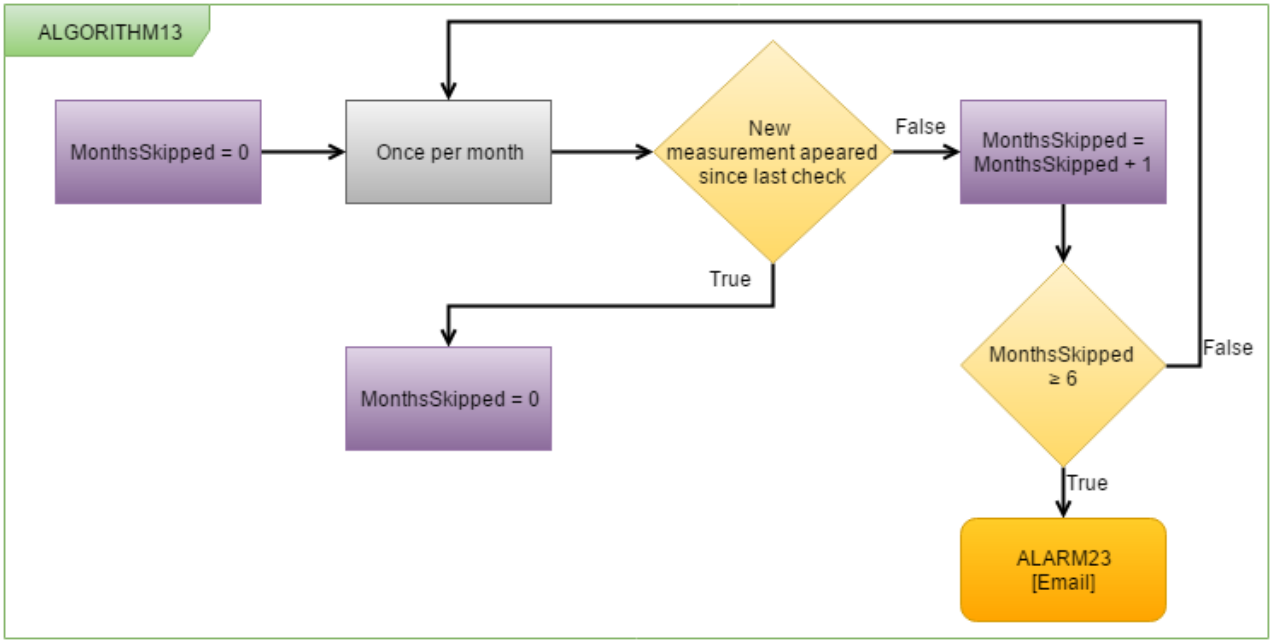


Figure 13. Patients' with risk factors for diabetes adherence to glucose measurement regime.

4.4. Adherence to physical activity monitoring

As it is important to exercise regularly, algorithms were created to support patient adherence to a physical activity regime based on their health condition. It is considered that doctor during patient's visit may improve his/her compliance to exercise more, the alarms will be sent to the doctor if the patient doesn't keep recommended psychical activity regime. If the patient doesn't use his tracking device to track his physical activity medical expert will be notified to discuss with a patient the reasons for not using physical tracker during his next visit (Figure 14).

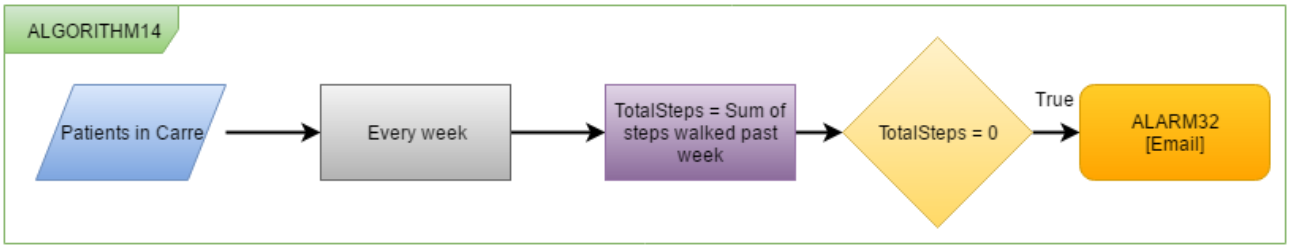


Figure 14. Patient's adherence to using physical activity monitoring device.

5. Notifications about patient's health status change

DSS algorithms described in this section intend to inform the medical expert about the potential changes in patients' health status based on their vital parameter values coming to DSS.

Red alarms are created to let medical expert know that patient experiences urgent situations: when he/she is recommended to call to Emergency Medical Service (EMS) centre immediately.

Yellow alarms are created to inform medical expert that his/her patient has abnormal values of parameters he/she is monitoring at home and to discuss about this during next visit.

5.1. Blood pressure evaluation

DSS for the medical expert after every last blood pressure measurement determines highly abnormal blood pressure values[11] measured by patient at home and sends a message for the medical expert (Figure 15).

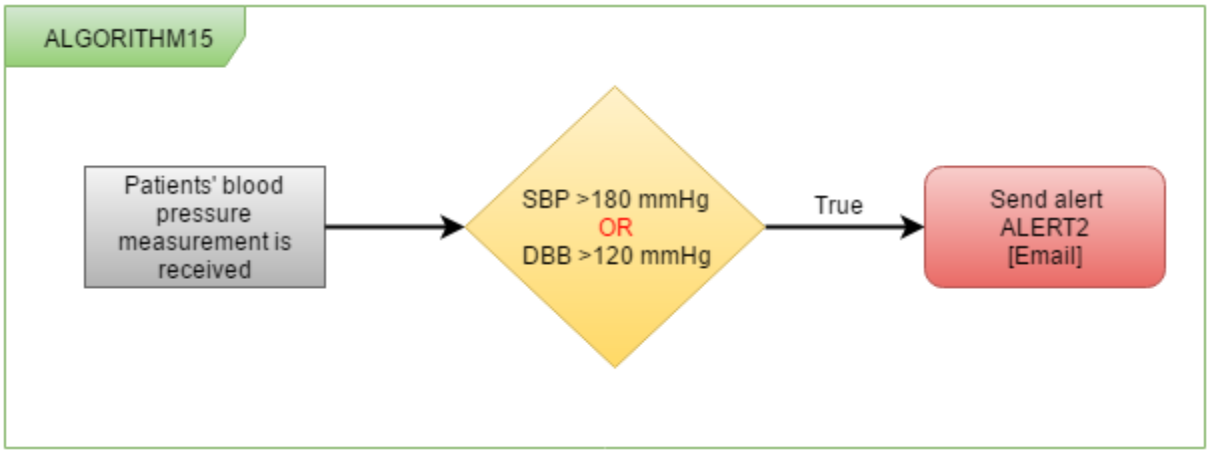


Figure 15. Evaluating highly abnormal blood pressure values.

Other algorithms are based on evaluating the average of the patient's blood pressure measurements performed during the week (Figure 16 and Figure 17) or once per week (Figure 18)[12,13]. According to counted average blood pressure values particular messages are sent to inform medical expert.

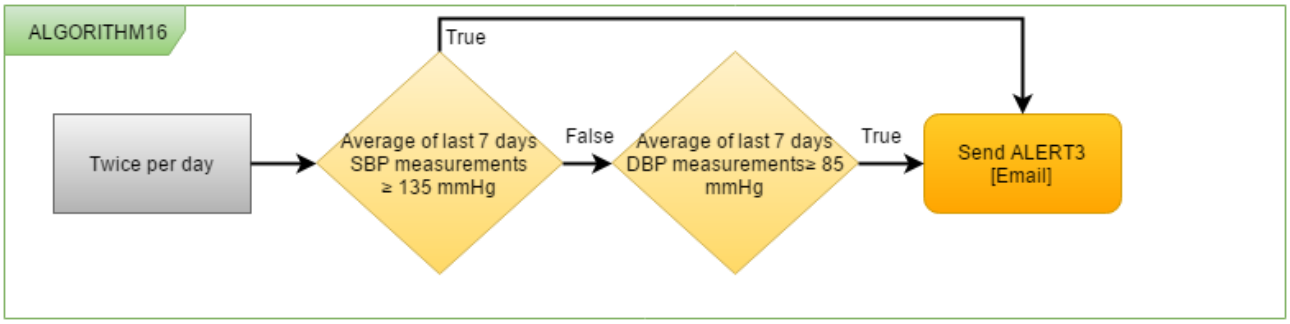


Figure 16. Evaluating blood pressure values when BP is abnormal (abnormal home BP ≥135 and/or≥85mmHg) during seven days (monitoring regime twice/day).

[11] 2013 ESH/ESC Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC).

[12] Parati G, Stergiou GS, Asmar R, Bilo G, de Leeuw P, Imai Y, Kario K, Lurbe E, Manolis A, Mengden T, O'Brien E, Ohkubo T, Padfield P, Palatini P, Pickering TG, Redon J, Revera M, Ruilope LM, Shennan A, Staessen JA, Tisler A, Waeber B, Zanchetti A, Mancia G; ESH Working Group on Blood Pressure Monitoring. European Society of Hypertension practice guidelines for home blood pressure monitoring. J Hum Hypertens. 2010 Dec;24(12):779-85. doi: 10.1038/jhh.2010.54. Epub 2010 Jun

[13] 2013 ESH/ESC Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC).

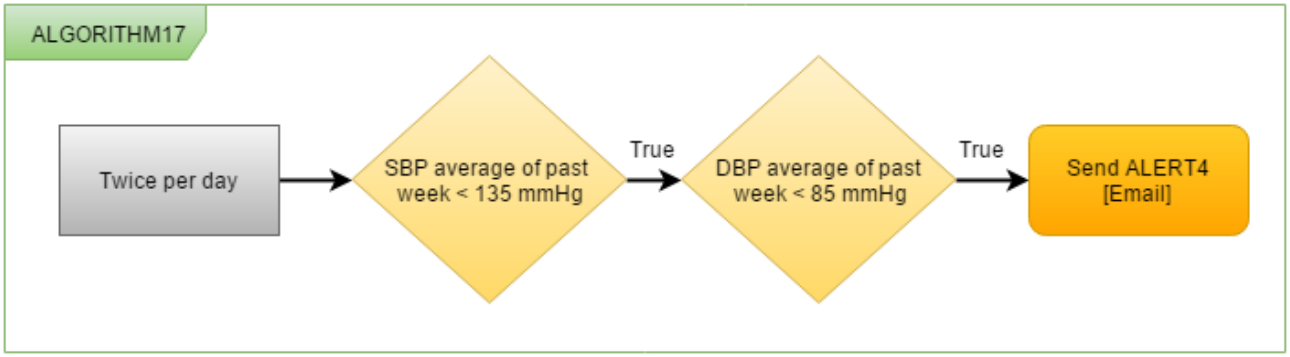


Figure 17. Evaluating blood pressure values when BP is normal during seven days (monitoring regime twice/day).

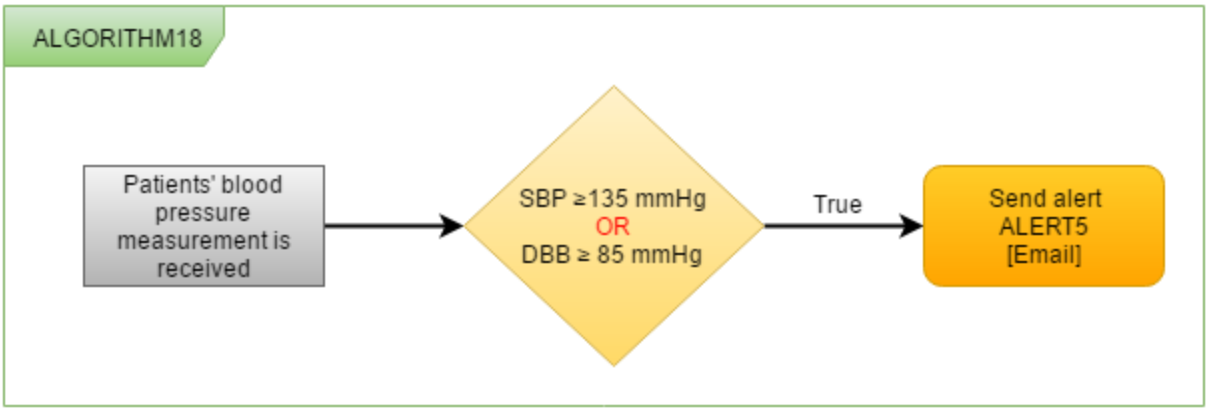


Figure 18. Evaluating blood pressure values when BP is abnormal (monitoring regime once/week).

5.2. Body weight evaluation

Patients with chronic heart failure or chronic kidney disease are at risk to develop acute episodes of their chronic diseases. These states are life threatening and patients are advised to call to EMS centre immediately[14,15,16,17]. DSS for the medical expert has created algorithms that detect highly abnormal measurement values that may show sudden deterioration of the patient state and messages to medical expert

[14] Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, Falk V, González-Juanatey JR, Harjola VP, Jankowska EA, Jessup M. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. European Heart Journal. 2016 May 20:ehw128.

[15] AHA. Warning signs of heart failure. Retrieved May 26, 2016 from the World Wide Web: http://www.heart.org/HEARTORG/Conditions/HeartFailure/WarningSignsforHeartFailure/Warning-Signs-of-Heart-Failure_UCM_002045_Article.jsp#.V0bCJ-R_wQ1

1. [16] Congestive Heart Failure Basics. Retrieved May 26, 2016 from the World Wide Web: http://www.ghc.org/healthAndWellness/?item=/common/healthAndWellness/conditions/heartDisease/chfBasics.html

2. [17] Patient handout. CHF& weight monitoring. Retrieved May 26, https://nursing.advanceweb.com/sharedresources/advancefornurses/resources/DownloadableResources/nurseweightfeb18.pdf

is also sent. Emergencies on sudden gaining weight for patients with HF or CKD are described in Figure 19 and Figure 20.

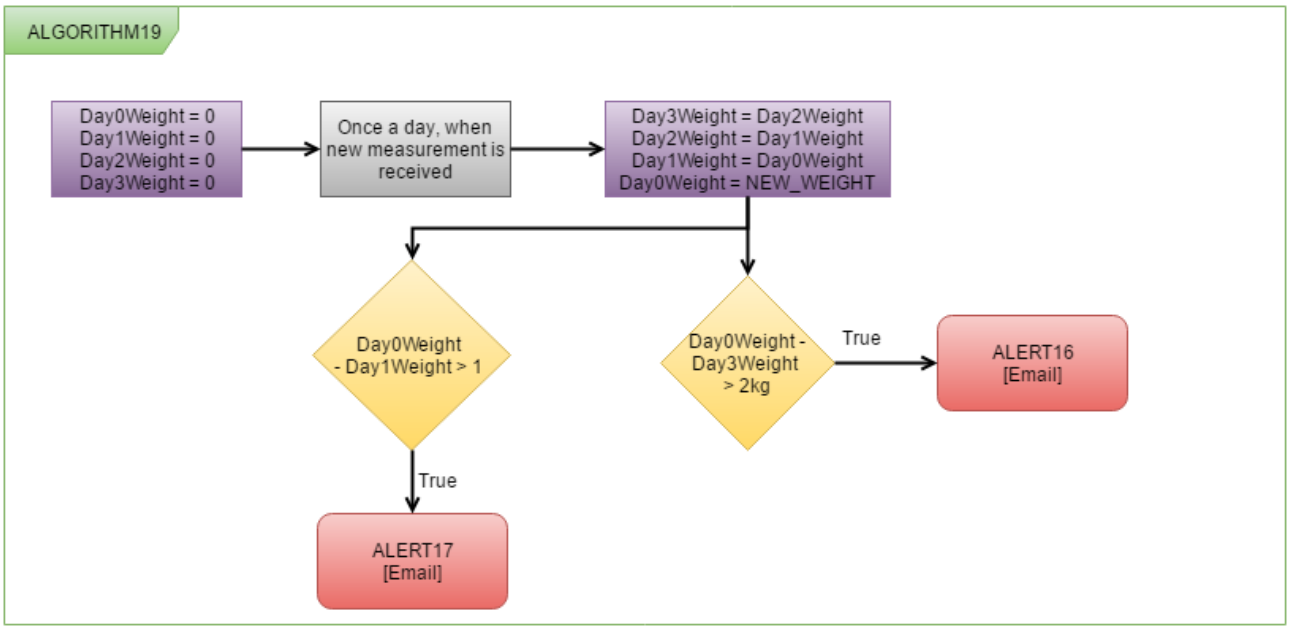


Figure 19. Evaluating sudden weight gain for patient with CHF or CKD.

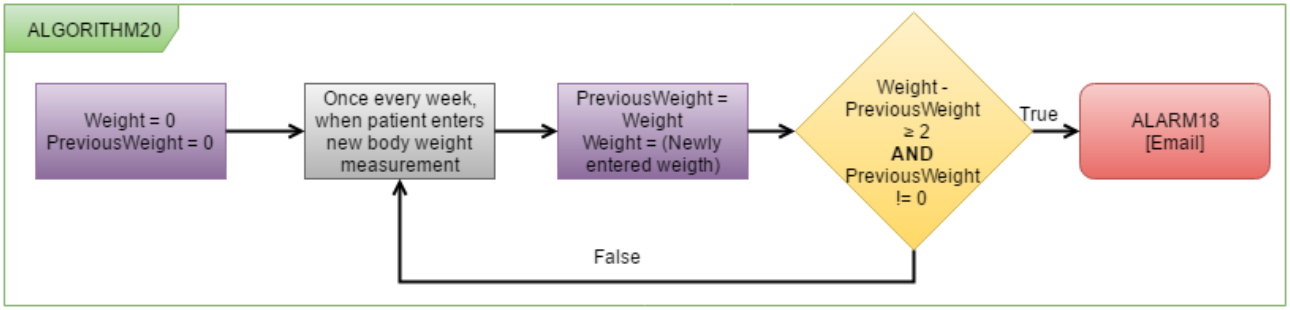


Figure 20. Evaluating sudden weight gain for patient with CHF or CKD.

The following algorithms are developed to inform medical expert if the patient with diabetes or increased body weight is still gaining weight despite recommended lifestyles changes and treatment (Figure 21).

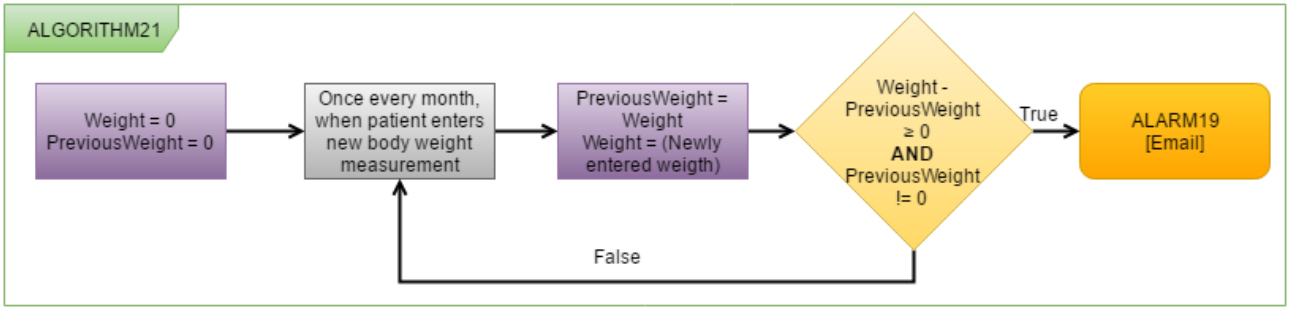


Figure 21. Evaluating weight gain for patients with diabetes or increased body weight (BMI ≥25).

5.3. Blood glucose evaluation

Patients with diabetes are at risk to develop acute episodes of their chronic disease. These states are life threatening and patients are advised to call to EMS centre immediately. DSS for the medical expert has created algorithms that detect highly abnormal blood glucose values that may show sudden deterioration of the patient state and messages to medical expert are also sent[18,19,20]. Emergencies of hypoglycaemic or hyperglycaemic state for diabetics are described in Figure 22 and Figure 23.

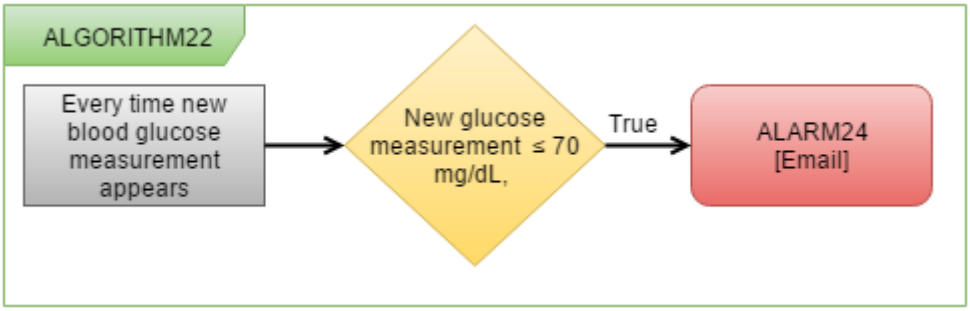


Figure 22. Evaluating highly abnormal blood glucose values for patients with diabetes[21].

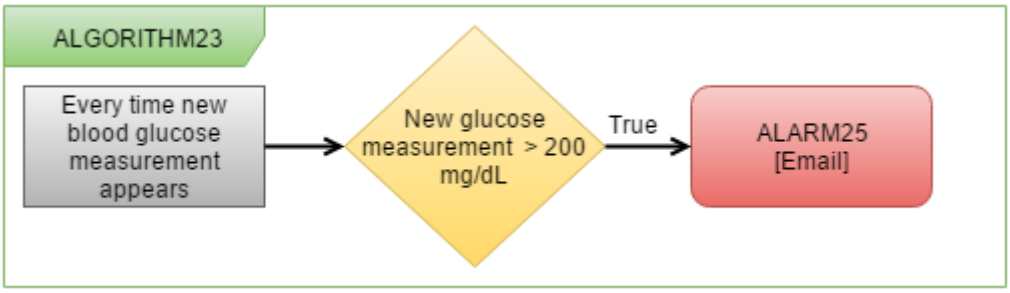


Figure 23. Evaluating highly abnormal blood glucose values for patients with diabetes[22].

Algorithm to inform medical expert if the patient is not able to reach appropriate blood glucose control is also created (Figure 24).

18 Global Guideline for Type 2 Diabetes, Clinical Guidelines Task Force. International Diabetes Federation, 2012.

19 2015 American Diabetes Association (ADA) Diabetes Guidelines Summary Recommendations from NDEI.

20 American Diabetes Association. Standards of medical care in diabetes—2015. Diabetes Care. 2015;38(suppl 1):S1-S93.

21 ADA/Endocrine Society Consensus Report on Hypoglycemia. Seaquist ER, Anderson J, Childs B, et al. Hypoglycemia and diabetes: a report of a workgroup of the American Diabetes Association and The Endocrine Society. *Diabetes Care*. 2013;36(5):1384-1395.

22 Hyperglycemic Crises in Diabetes. American Diabetes Association. Diabetes Care. Jan 2004;27,1:94-102.

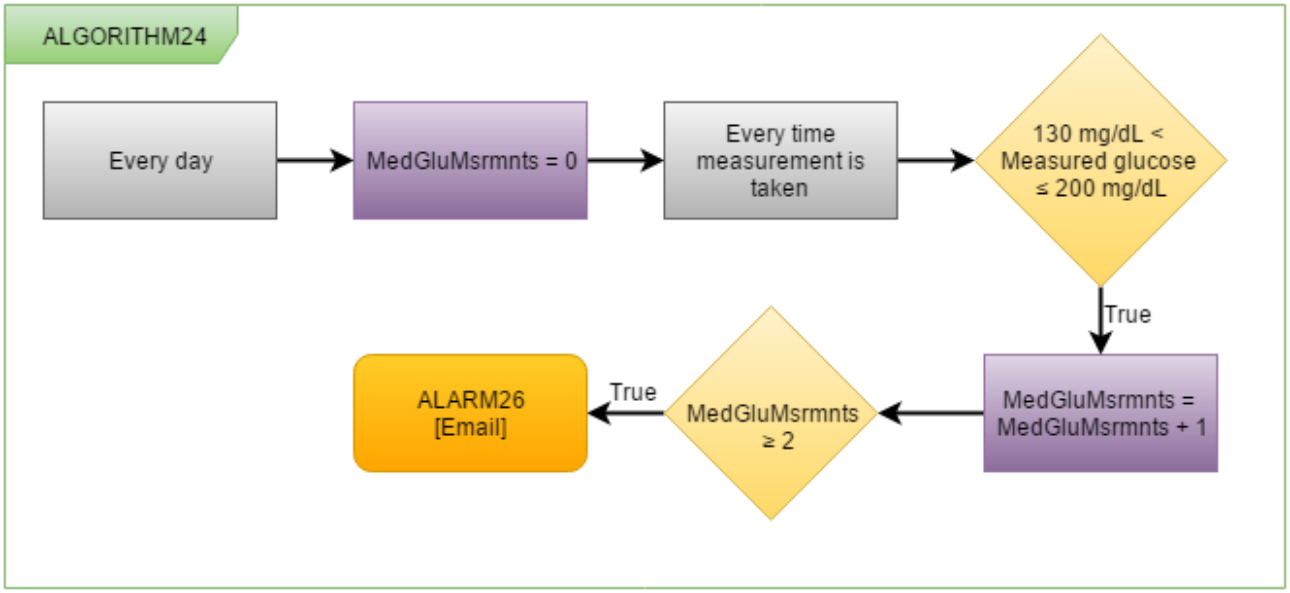


Figure 24. Evaluating abnormal blood glucose values for patients with diabetes.

Figure 25 shows the algorithm which evaluates blood glucose measurements for patients at risk for diabetes (those with 25 ≤ BMI, hypertension or dyslipidemia diagnosis, or CHF). The main goal of this algorithm is to detect the abnormal blood glucose values and to inform the physician, if they exist.

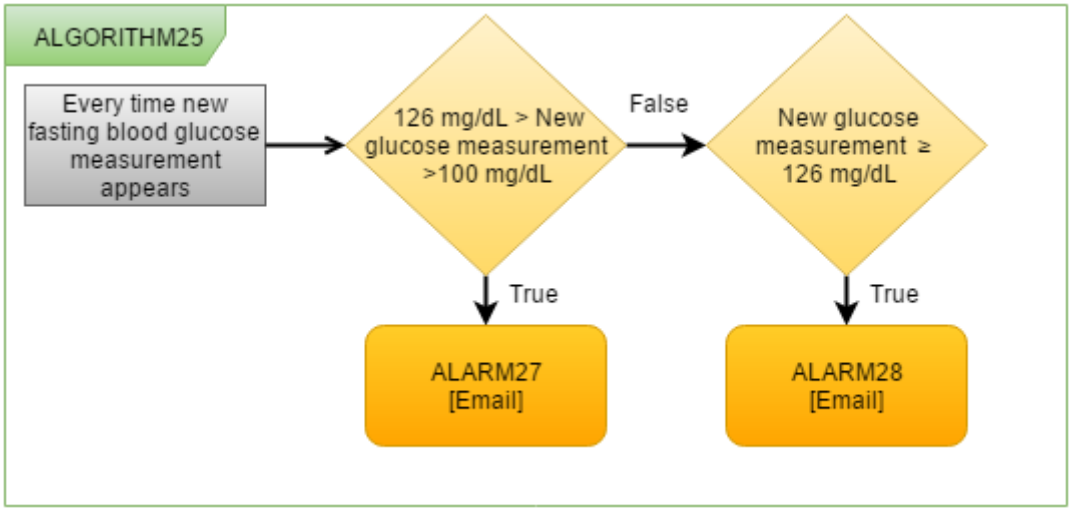


Figure 25. Evaluating blood glucose values of patients with risk of diabetes.

5.4. Physical activity evaluation

As it is very important for the certain patients according to their health conditions to exercise at least recommended minimum, algorithms are created for the medical experts to inform them, if the patient isn't physical active as recommended (counted steps/day). Different algorithms are created depending on patient

state: if she/he has chronic heart failure (Figure 26) [23],[24] or end stage of chronic kidney disease[25], chronic kidney disease Stage 2-4 [26,27], hypertension[28], dyslipidemia[29], diabetes[30], increased body weight[31], or diabetes with increased body weight[32] (Figure 27).

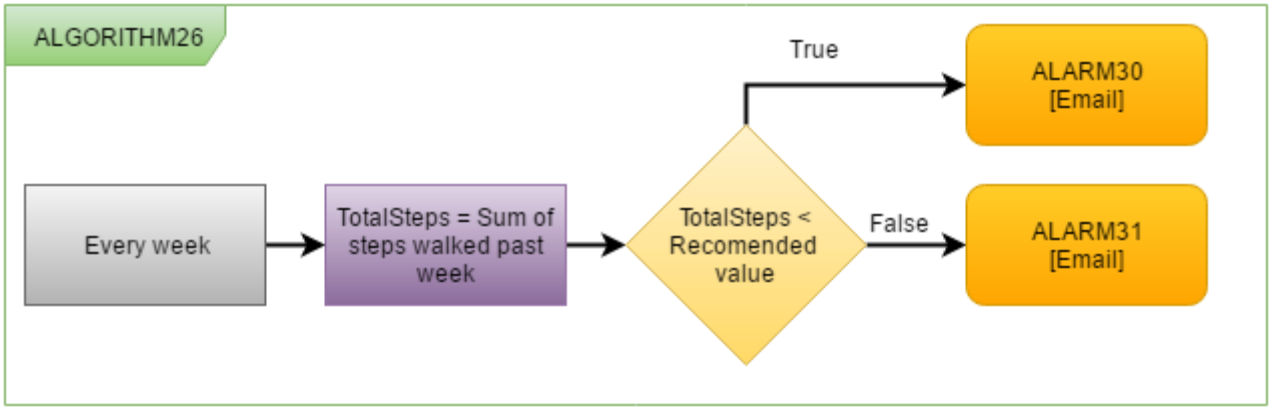


Figure 26. Evaluating physical activity of patient with chronic heart failure.

The Algorithm 27 is created to generate alerts for medical expert on preselected time intervals that is weekly. It splits into two parts: if patient fulfils minimum requirements for exercising or if he/she exercises at all (Figure 8). The algorithm refers to various different patient initial conditions.

[23] Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, Falk V, González-Juanatey JR, Harjola VP, Jankowska EA, Jessup M. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. European Heart Journal. 2016May 20:ehw128.

[24] European Guidelines on cardiovascular disease prevention in clinical practice (version 2012).

[25] Johansen K. L. Disease of the Month: Exercise in the End-Stage Renal Disease Population JASN June 2007 18: 1845-1854; published ahead of print April 18, 2007, doi:10.1681/ASN.2007010009.

3. [26] Walking: An Ideal Exercise for People with Kidney Disease. Retrieved 8 June 2016 from the World Wide Web:https://www.davita.com/kidney-disease/overview/living-with-ckd/walking:-an-ideal-exercise-for-people-with-kidney-disease/e/7573

4. [27] National Kidney Foundation. Staying Fit With Kidney Disease. Retrieved 8 June 2016 from the World Wide Web:https://www.kidney.org/atoz/content/stayfit

[28] 2013 ESH/ESC Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC).

[29] Catapano AL, Reiner Z, De Backer G, Graham I, Taskinen MR, Wiklund O, Agewall S, Alegria E, Chapman M, Durrington P, Erdine S, Halcox J, Hobbs R, Kjekshus J, Filardi PP, Riccardi G, Storey RF, Wood D; European Society of Cardiology (ESC); European Atherosclerosis Society (EAS).ESC/EAS Guidelines for the management of dyslipidaemias The Task Force for the management of dyslipidaemias of the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS). Atherosclerosis. 2011 Jul;217(1):3-46.

[30] Global Guideline for Type 2 Diabetes, Clinical Guidelines Task Force. International Diabetes Federation, 2012.

[31] Obesty and exercise. Retrieved 8 June 2016 from the World Wide Web: http://www.acsm.org/public-information/articles/2012/01/19/obesity-and-exercise.

[32] Obesity,Type 2 Diabetes,and Physical Activity. Retrieved 8 June 2016 from the World Wide Web: http://www.diabetesselfmanagement.com/nutrition-exercise/weight-loss-management/obesity-type-2-diabetes-and-physical-activity/

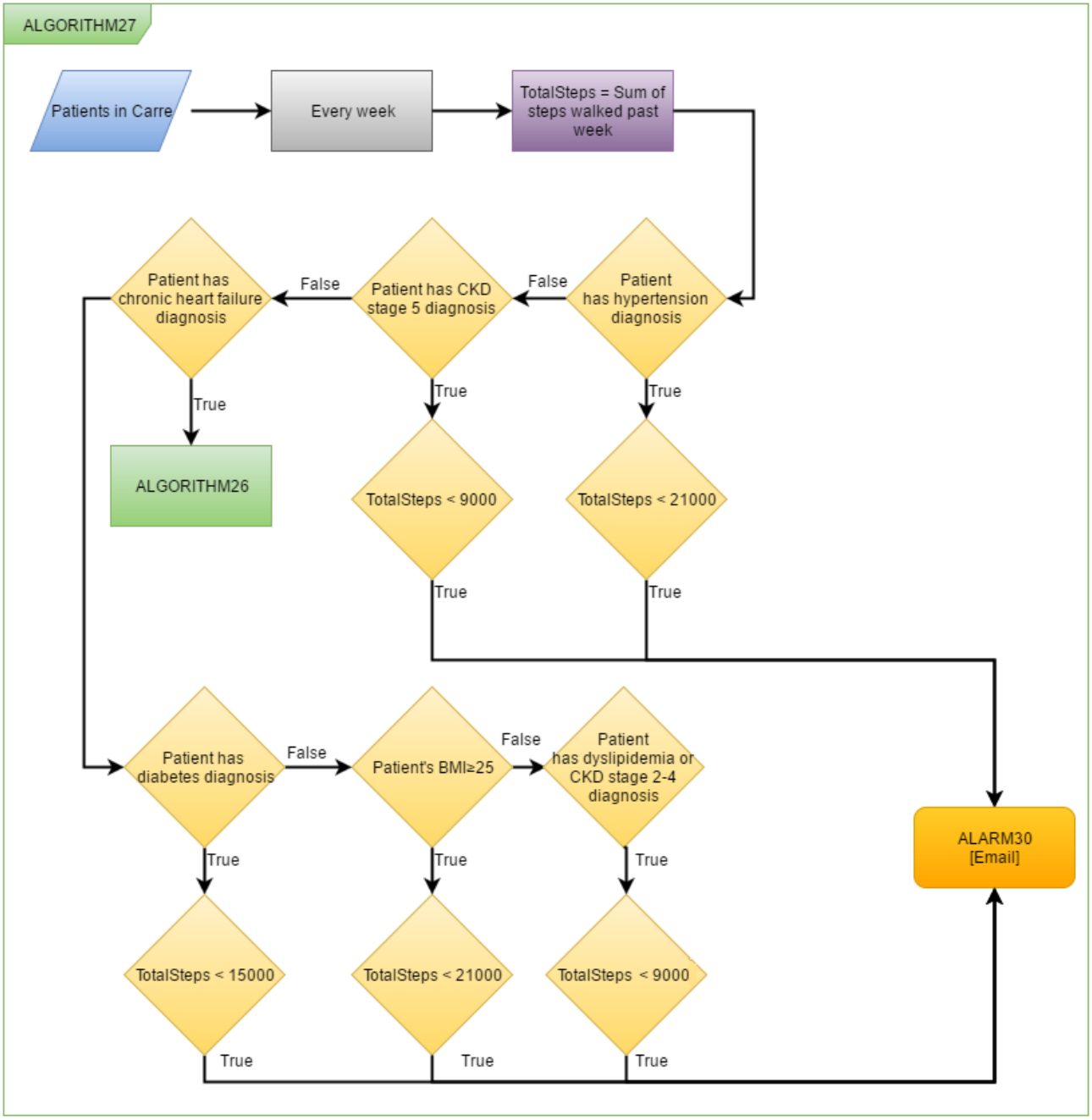


Figure 27. Physical activity monitoring scheme for patients with end stage of chronic kidney disease, chronic kidney disease Stage 2-4, hypertension, dyslipidemia, diabetes, increased body weight, diabetes with increased body weight.

6. Updates on medical evidence based literature personalized to the medical expert

This section describes the part of DSS which is responsible for providing notification on personalized medical evidence based literature updates for medical expert. DSS provides capability for medical expert to receive notifications about new evidence based medical literature according to preferred keywords. DSS provides references to new articles for medical expert when a new one appears (a new article is considered such article that has appeared since last notification about new evidence based literature was sent) via email.

Medical expert can select from 3 different categories of medical evidence based literature notifications he prefers to receive:

1. Medical expert can manually select keywords on which he would like to receive medical literature updates.
2. Selecting keywords based on patient's condition – DSS determines patient condition and selects keywords related to articular condition.
3. Selecting keywords from a preset of medical specialty e.g. if medical expert chooses "nephrologist", a set of keywords like "chronic kidney disease", "albuminuria", "acute renal injury", "hyperuricemia", "diabetic nephropathy" occurs in the query.

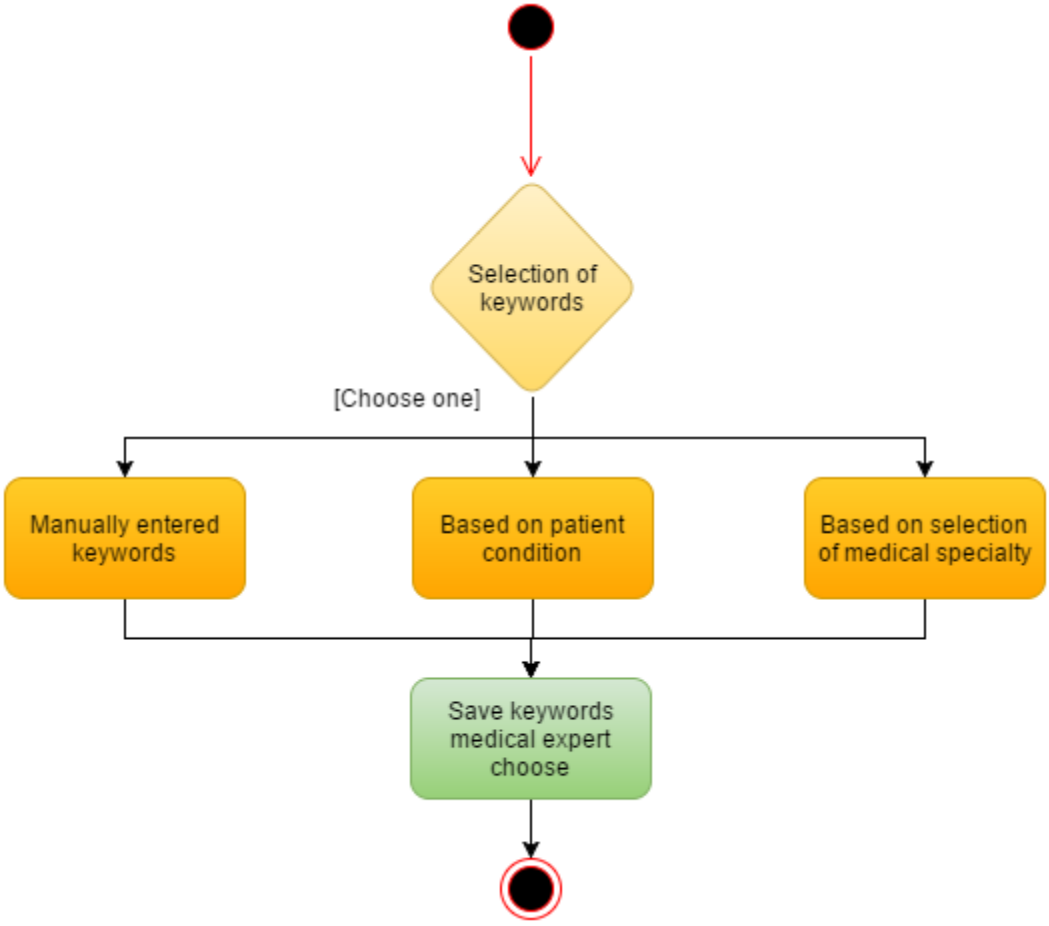


Figure 28. Selection of keyword set.

Figure 28 above illustrates options that medical expert chooses from for notifications on new medical evidence. Once the option is chosen it is stored for further usage.

Notifications about new medical evidence on selected keywords are aggregated and sent on specific interval.

The notification about new medical evidence sending process is as follows:

1. Keywords which are going to be searched for are retrieved.
    a. If medical expert selected to look for keywords that are related to patient's condition - all patients that are related to this medical expert are retrieved, their medical conditions are calculated and keywords generated from it.
    b. Otherwise keywords are retrieved from storage.
2. "Pubmed" search is performed for given keywords and date, which must be newer than the previous notification was sent.

3. Email is composed which consists of links to medical literature found.
4. Email is sent to medical expert.

Figure 29 below is a diagram that illustrates how these actions are performed.

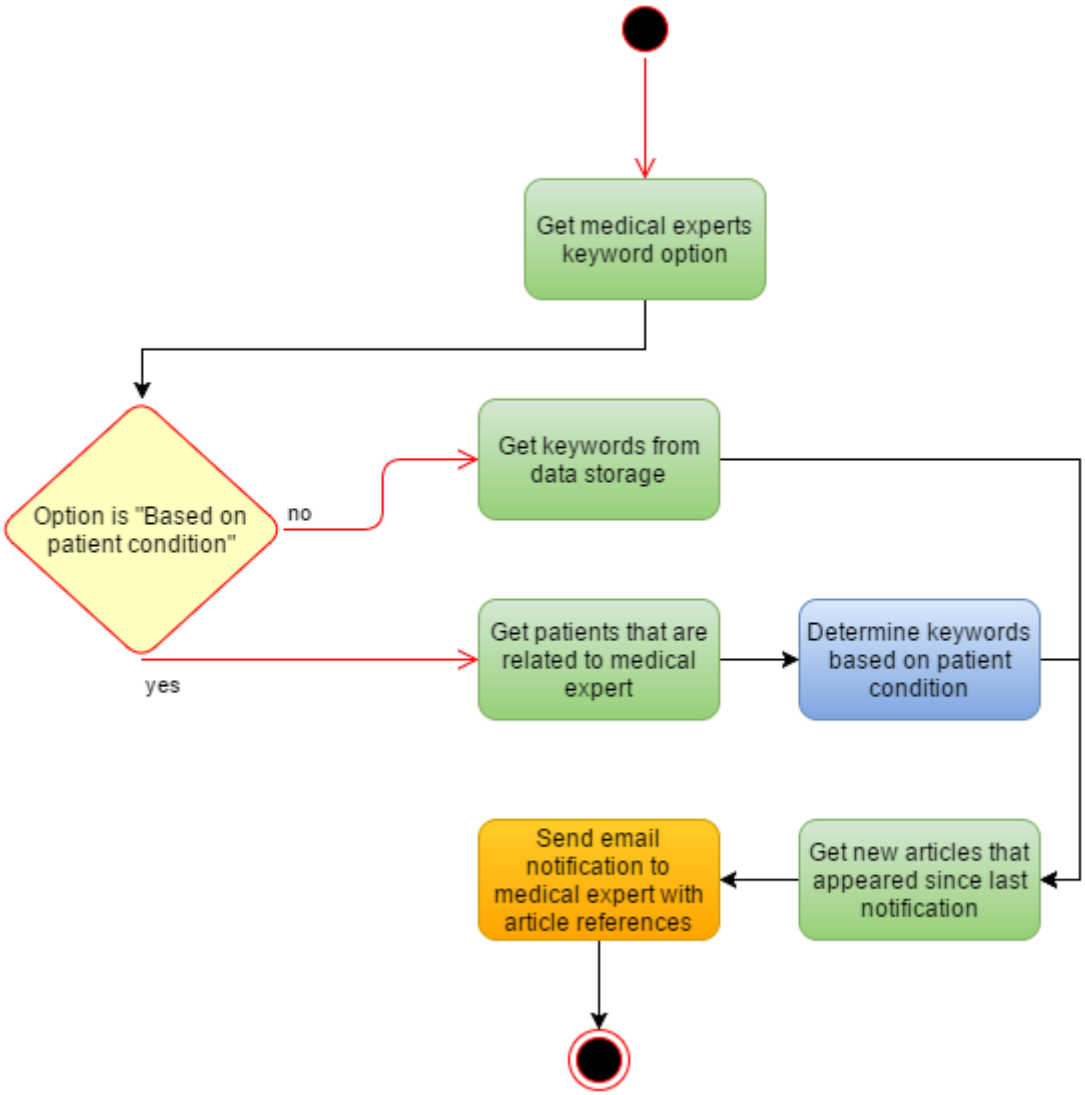


Figure 29. Sending notifications about new medical articles.

Annex 1

DSS Messages

Message ID	Actual message to the expert
ALARM1	Your patient has started home blood pressure monitoring twice per day for one week. You'll be informed is patient following recommended monitoring regime, the changes on monitoring regime proposed by the system according incoming his/her health data and finally if he/she is hypertensive.
ALARM2	Your patient's blood pressure >180 mmHg (systolic) or >120 mmHg (diastolic) was detected by system, patient was advised to call to Emergency Medical Service Centre immediately.
ALARM3	During the last week home blood pressure monitoring (twice per day) the mean value of your patient's blood pressure was abnormal (≥135 and/or ≥85 mmHg)
ALARM4	During the last week home blood pressure monitoring (twice per day) the mean value of your patient's blood pressure was BP <135 and/or < 85 mmHg. From today he/she was advised to perform less frequent, regular home BP measurements for a long-term follow-up (once per week).
ALARM5	Your patient's home blood pressure was abnormal (when it is measured once per week). It was≥135 and/or ≥85 mmHg. Please reconsider monitoring regime (set twice per day for 7 days) and blood pressure management during his/her next visit
ALARM6	Your patient hasn't followed recommended blood pressure monitoring regime during this week, please, don't forget to remind him/her the importance of regular blood pressure measurements on his/her condition and ask to follow recommended blood pressure monitoring regime during his/her next visit.
ALARM7	Your patient hasn't perform any blood pressure measurement all the week (recommended regime twice per day), please ascertain the problems he/she met during his/her next visit.
ALARM8	Your patient hasn't perform any blood pressure measurement during two weeks (recommended regime once per week), please ascertain the problems he/she met during his/her next visit."
ALARM11	Your patient has started his/her body weight monitoring. You'll be informed with a message about your patient weight monitoring during his/her monitoring period
ALARM12	Suspected inappropriate use of scales
ALARM13	Your patient doesn't monitor his/her body weight regularly, please discuss why he/she doesn't want to follow his/her body weight next visit.
ALARM14	Your patient doesn't perform body weight measurements at all, please ascertain the problems he/she met during his/her next visit
ALARM15	Your patient doesn't monitor his/her body weight, please discuss why he/she doesn't want to follow his/her body weight next visit
ALARM16	Your patient's weight has increased too much in a 3 days (>2 kg).
ALARM17	Your patient's weight have increased too much over the 2 day period (≥ 1kg).
ALARM18	Your patient's weight has increased too much over the week period (≥ 2 kg)
ALARM19	Your patient is still gaining weight during this month.

ALARM20	Your patient has started his/her blood glucose monitoring. You'll be informed with a message about your patient blood glucose monitoring during his/her monitoring period.
ALARM21	Your patient doesn't monitor his/her blood glucose regularly, please discuss with him/her the importance of regular blood glucose monitoring on his/her condition
ALARM22	Your patient hasn't performed any blood glucose test during 5 days, please, don't forget to remind him/her the importance of blood glucose monitoring on his/her condition and ask to follow recommended blood glucose monitoring regime during his/her next visit.
ALARM23	Your patient hasn't performed any blood glucose test during 6 months, please, don't forget discuss this issue
ALARM24	Your patient has measured his/her blood glucose ≤ 70 mg/dL (MEASUREMENT_DATE)
ALARM25	Your patient has had his/her blood glucose >200mg/dL (MEASUREMENT_DATE)
ALARM26	Your patient's maximum of one day blood glucose was between 130 mg/dL and 200 mg/dL (and it was detected for ≥2 times), during next visit, please, discuss with him/her about the possible reasons of hyperglycemia and consider the diabetes management
ALARM27	The value of your patient's blood glucose>100 mg/dL and ≤126 mg/dL was detected (monitoring regime once /month). During next visit, please, check him/her for increased risk of diabetes
ALARM28	The value of your patient's blood glucose ≥126 mg/dL was detected (monitoring regime once /month). During next visit, please, check him/her for diabetes
ALARM29	Your patient has started his/her physical activity monitoring. You'll be informed with a message about your patient physical activity during his/her monitoring period.
ALARM30	Your patient's isn't active enough, please discuss limiting factors during his/her next visit.
ALARM31	Your patient's is highly active, please re-evaluate his/her ability to exercise during his/her next visit.
ALARM32	The patient doesn't use his/her physical activity tracker for the whole week.

Annex 2
Software for Personalized Services for the Experts

What is CARRE: Personalized Services for the Patient and the Medical Expert?

In CARRE system, the **Personalized Services for the patient and the medical expert** constitute components of the decision support service (DSS). These personalized services are for disease progression management and are mainly responsible for providing alerts depending on major dangerous patient health condition levels, advice and personal life-style guidance, based on monitoring of current medical treatment data in order to manage risks for comorbidities or progression of disease to more severe stages.

In CARRE system, the data to Personalized Services for Patient and Medical Expert are retrieved via the RESTful API web service provided both by the public and private CARRE data repositories. After receiving the appropriate data the DSS analyses the data to determine optimal recommendation and solutions for patient and additionally informs medical experts. Based on assessment of inputs from the semantic data entry system and the current disease state and risks of patients, the DSS creates personal diet (e.g. salt intake) and physical activity plans as well as provides alerting mechanisms and appropriate advice for changes.

All above information is sent to the private CARRE RDF repository and are also displayed in the visual interface.

Download

DSS – Personalized Services for the patient and the medical expert:

v1.0 (Released 15 May 2016, Deliverable 6.2 & 6.3)

- Source code: CARRE_DSS_Personalized_Services_v1.0.zip (Python code)

The CARRE Personalized Services for Patient and Medical Expert are Open Source

CARRE Personalized Services for Patient and Medical Expert are Open Source and can be freely used in Open Source applications under the terms GNU General Public License (GPL).