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D.6.2. Personalized services for the patient

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Executive Summary

CARRE patient empowerment and decision support services (DSS) aim to support personalised disease prevention and/or progression management. The CARRE DSS meshes evidence on risk factors as in the CARRE public repository and personal information on the patient as in the CARRE private repository, in order to trigger personalized guidance messages and alerts for the patient. Also, the service provides identification of important changes in personal medical variables and the corresponding changes at the estimated risk level.

The 6.2 task “Development of personalized services for the patient” 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 deliverable report of 6.2 “Personalized services for the patient” of WP6 in CARRE project. In particular it covers tasks designated in Task 6.2. This deliverable includes the description and implementation (within the DSS) of personalized empowerment and decision support services for the patient.

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, 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 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 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
AHA	American Heart Association
BMI	Body mass index
BP	Blood pressure
CKD	Chronic kidney disease
DBP	Diastolic blood pressure
DSS	Decision support system
ESC	European Society of Cardiologists
HF	Heart failure
HR	Heart rate
IDF	International Diabetes Federation
KDIGO	Kidney Disease | Improning Global Outcomes
LDL-C	Low-density lipoprotein cholesterol
NYHA	New York Heart Association
PHR	Personal health record
SBP	Systolic blood pressure
TC	Total cholesterol

1. Introduction

Traditionally, medical decision support systems (DSS) can be generally viewed[1] as either (a) the so-called 'strong' artificial intelligence systems whose behaviour is at some level indistinguishable from humans; or (b) an alternative approach that looks at human cognition and decides how it can be supported in complex or difficult situations, something like a form of 'cognitive prosthesis' that will support the human in a task.

The CARRE approach for decision support follows the 'cognitive aid' line. Most importantly, as the patient is the focus of the CARRE project, our approach for decision support mainly aims to support the patient in making informed decisions for their active health management. CARRE decision support services thus mainly address treatment critiquing and planning, information retrieval and education.

Such services are based on the real-time data/model driven coupling of the personalized/instantiated CARRE model with relevant medical evidence (WP2, Task 2.2) as well as with relevant on-line educational resources. Such resources are harvested via the CARRE data aggregators and are semantically annotated (WP3, Task 3.4). Enrichment and interlinking is then performed based on Linked Data principles in order to deduce personalized relevancy (WP4). A data/model driven decision support service run-time infrastructure (WP6, Task 6.1) is then used to deliver personalized services to the patient.

In the context of this deliverable, we take into account functional requirements as stated in previous deliverables and design the specific personalized alert services for the patient. The basis of these alerts is self management guidelines for different patient groups in the area of cardiorenal disease and comorbidities, as derived from medical literature and especially as practiced in the clinical routine in the two CARRE medical partners' institutes, namely DUTH and VULSK. Note that Task T.6.4 aims to develop a user friendly mechanism so that new alerts can be easily developed by medical experts and patients alike to account for requirements either of different clinical practices or needs of different individuals.

Section 2 presents a conceptual overview of the DSS mechanism for constructing personalized services for the patient. Section 3 lists detailed descriptions of specific DSS algorithms we designed to meet the functional requirements as listed in previous deliverables. These algorithms have been implemented in the DSS software (described in Annex 2 of this deliverable) and will be deployed for the CARRE pilot evaluation. However, these DSS algorimths are not all inclusive; rather they are meant for a pilot demonstration of the CARRE system, and they can be complemented and/or changed based on specific expert/patient requirements via user-friendly software to be developed in T.6.4 (D.6.4).

The pilot DSS algorithms designed in this deliverable are meant to serve as a means to support self-management. In no case they intend to substitute medical expert guidelines and therapy or self-management instructions as given by the medical expert. So, the philosophy behind the alerts is to help the patient follow self-management instructions, encourage them and provide timely education, without inflicting or increasing burden or stress by message cascades that could result in harassing the patient. Formal guidelines for home self monitoring where followed wherever they exist. Otherwise, we followed common clinical practice.

2. Overview of personalized services for patients

Each personalized service for the patient is basically founded on a specific DSS algorithm. This can be viewed as a decision tree which requires entry and exit points. The DSS algorithm entry point is generally a condition that has to be met to determine whether the alert algorithm will be executed for this particular patient. This condition is associated with one or more observables which either derive directly from the sensor measurements or other health information 'measurements' of the patient (as in the private CARRE repository) or are calculated based on such personal measurements (for example, the Body Mass Index can be used in the initial condition of an alert and this is calculated based on the current measurement of body weight as measured by the personal scale and on the measurement of height as retrieved from the personal health record). Therefore, in order to be able to describe properly the initial condition, or entry point to the DSS algorithm, one needs to identify the involved observables and construct a logical expression around certain conditions that have to be met. The outcomes of the DSS algorithm may include one or more different expected exit points. These refer to the variety of alerts that will be generated.

[1] Coiera E., Guide to Health Informatics: 25:Clinical decision support systems, 2nd Ed., Oxford Univ. Press, NY, 2003

Following this line of thought, a personalized DSS algorithm resembles the philosophy of a clinical protocol or any other formal care plan and can thus be modeled using the recently developed eCP ontology[2] (developed by members of this consortium and in part within CARRE project – see Annex 1 for a more detailed presentation).

Figure 1 gives an overview of the logic for creating personalized services for the patient. The main part of the service is the DSS algorithm. This requires input from one or more observables which will be used to calculate the initial condition that will determine whether the alert will be initialized, and (if applicable) it will also determine the outcome. The observables themselves are modeled as the observables in the CARRE risk factor ontology (CARRE D.2.2). These are derived from specific calculation methods that have as input personal measurements of the patient as in his/her private repository (CARRE D.4.1) which is populated by the personal aggregators with data from sensors (CARRE D.3.2) and/or from personal medical and lifestyle data (CARRE D.3.3).

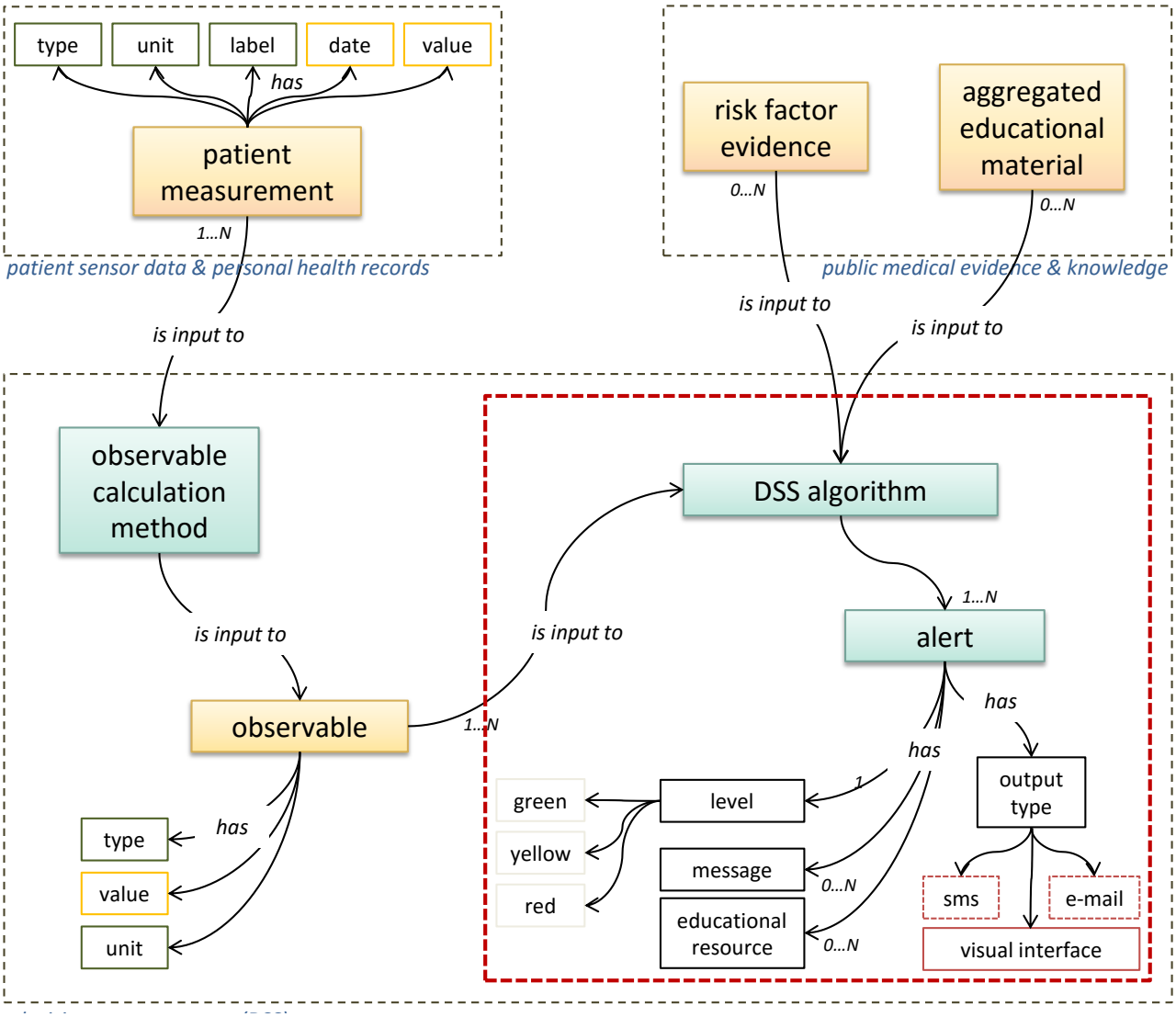

Figure 1. A conceptual overview of the DSS mechanism.

[2] Kaldoudi E., Drosatos G., Portokallidis N., Third A. An Ontology based Scheme for Formal Care Plan Meta-Description. In Proc. of the 14th Mediterranean Conference on Medical and Biological Engineering and Computing (MEDICON 2016), Paphos, Cyprus, 31 Mar. – 2 Apr. 2016

The DSS algorithm may also require as input knowledge from the public CARRE risk factor database and/or the aggregated educational material. These may be used to construct the outcome alert which is characterized by a certain level of importance:

- low importance (green),
- medium importance (yellow), and
- high importance (red).

The outcome alert usually has a message for the patient and/or some educational material. The outcome alert is mainly integrated in the main CARRE visual interface, however there is also the possibility for an SMS or e-mail message. The following section describes the DSS algorithms we have designed together with their alert messages (which are listed in detail in Annex 3), that is the part of Figure 1 enclosed in the red rectangle.

3. DSS algorithms for patient

The DSS algorithms we have designed to meet the functional requirements can be organized into four different categories:

- establish self-monitoring regime
- adhere to a self-monitoring regime
- inform on a potential health status change
- inform on a change in personal risk factors

In the following subsections, we present examples of DSS algorithms for each type. The algorithm descriptions are based on flowcharts, which all use a common symbol and color set, which is summarized in Figure 2. Note that the messages indicated in the DSS algorithm flowcharts are meant to convey only the logic (the actual messages are described in Annex 3 of this deliverable). The actual phrasing of the message is phrased based on common practices for conveying information to the layman in the two different languages of the pilot CARRE demonstration.

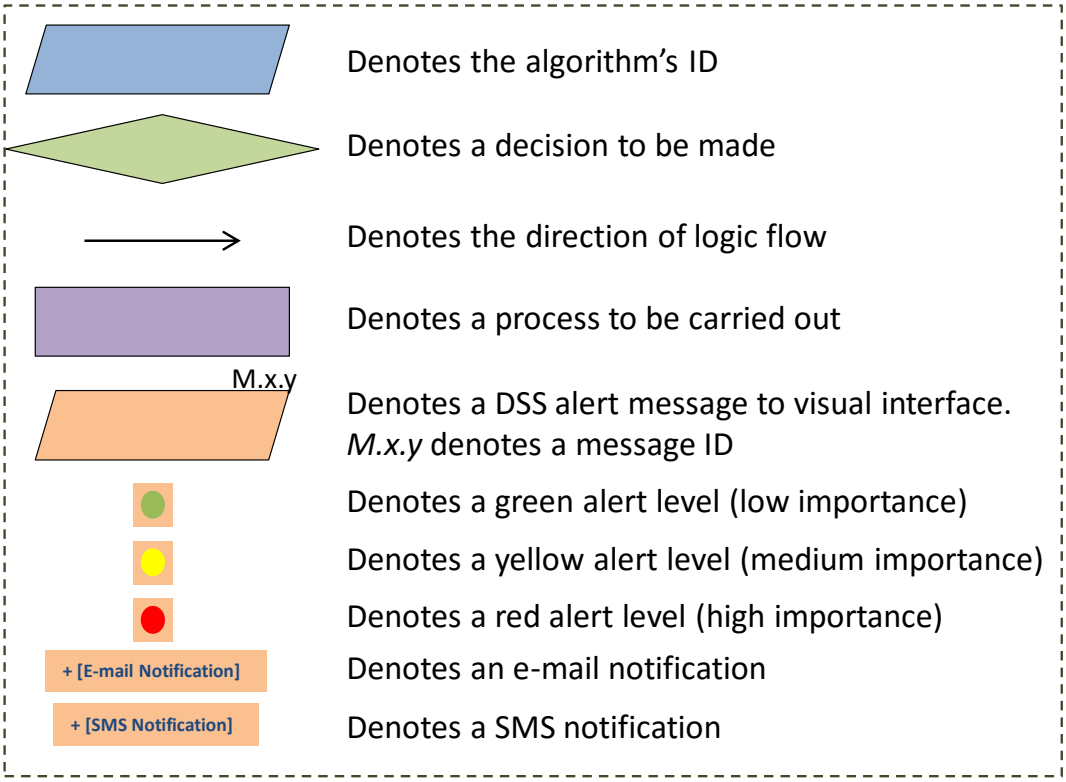

Figure 2. Symbols used in the flowcharts that describe DSS algorithms.

3.1 DSS to support establishment of self-monitoring regime

DSS algorithms that support the establishment of a new self-monitoring regime refer to the four different types of sensors that were selected to be included in the CARRE pilot demonstration, namely:

- blood pressure (BP): systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR);
- body weight: body weight, body fat and body mass index (BMI);
- blood glucose;
- physical activity: steps, distance, floors and active minutes;

3.1.1 Monitoring blood pressure

Home blood pressure is more closely related to hypertension-induced organ damage than office blood pressure and recent meta-analyses of the few prospective studines in the general population, in primary care and in hypertensive patients, indicate that the prediction of cardiovascular morbidity and mortality is significantly better with home blood pressure than with office blood pressure. The American Association of Clinical Endocrinologists also strongly recommends home BP measurements for patients with type 2 diabetes and hypertension and states that, “Patients with type 2 diabetes and hypertension should monitor their blood pressure frequently with home blood pressure self-monitoring.”

Home blood pressure monitoring is considered to be beneficial for all patients in CARRE study/patients with cardiorenal disease or who has a high at risk of developing it. According current recommendations by the American Heart Association (AHA)[3] and the European Society of Cardiologists (ESC)[4],[5] home blood pressure monitoring is useful for those:

- who are suspected of having masked hypertension;
- who have some high readings at the doctor's office, to rule out white-coat hypertension and confirm true HBP;
- who require closer monitoring than intermittent office visits provide, especially individuals with coronary heart disease, diabetes and/or kidney disease;
- who have risk factors for high blood pressure (family history, poor diet, lack of physical activity, overweight and obesity, smoking etc.).

Also, AHA and ESC recommend home monitoring for all people with high blood pressure to help the healthcare provider determine whether treatments are working. To evalute the effect of the drug could take from one to several weeks (usually 2-4 weeks)[6].

Based on current ESC guidelines for the management of arterial hypertension recommendationfor the initial evaluation of hypertension and the assessment of the effects of antihypertensive treatment (including changes in drug or dose) home blood pressure measuremenets should be performed daily preferably 7 days

[3] Pickering T. G, Hall J. E, Appel L. J, Falkner B. E, Graves J, Martha N, Jones D. W, Kurtz T, Sheps Sh. G, Roccella E. J. AHA Scientific Statement: Recommendations for Blood Pressure Measurement in Humans and Experimental Animals: Part 1: Blood Pressure Measurement in Humans: A Statement for Professionals From the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research *Circulation. 2005;111:697-716, doi:10.1161/01.CIR.0000154900.76284.F6*

[4] 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).

[5] 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

[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).

in the mornings as well as in the evenings. If the measurement during this monitoring period are normal treated hypertensive patients may also perform less frequent, regular home blood pressure measurements as a long-term follow-up (for example, once or twice per week), with the additional aim to reinforce their compliance with treatment[7].

The algorithm presented in Figure 3 summarizes blood pressure guidelines. This algorithm will be initiated for every new CARRE user or on user demand, that is whenever a CARRE user wishes to monitor systematically blood pressure (e.g. to check for masked hypertension). Also, this algorithm is initiated every time the health condition of a CARRE user changes such that the initial conditions of this algorithm are met. The algorithm refers to four different patient initial conditions. In short, the algorithm produces alerts that help new hypertensive patients establish a blood pressure monitoring regime of at least twice a day. A different regime of a measurement at least once a day is supported for patients who are not hypertensive but have some renal or heart failure issue, while a blood pressure measurement regime of at least once a week is supported for metabolic syndrome patiens (without hypertension or heart/renal issues). The algorithm then triggers the respective initiation of other DSS algorithms that support the patient in adhering to these minimum blood pressure monitoring regimes.

[7] Teemu J. Niiranen, Jouni K. Johansson, Antti Reunanen, Antti M. Jula. Optimal Schedule for Home Blood Pressure Measurement Based on Prognostic Data The Finn-Home Study Hypertension. 2011;57:1081-1086.

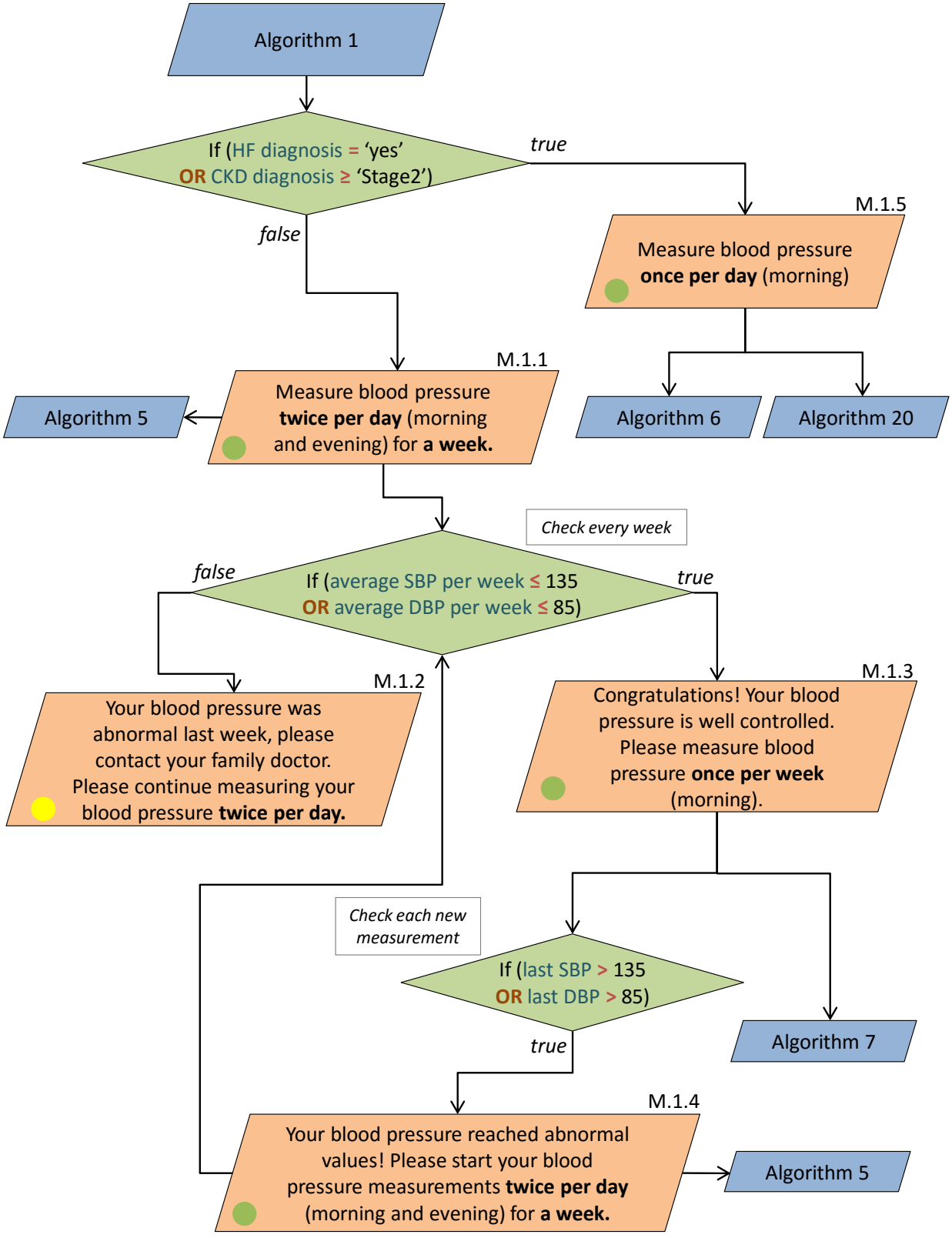

Figure 3. Algorithm for establishing blood pressure self-monitoring regime.

3.1.2 Monitoring body weight

Weight self-monitoring is considered to be beneficial for all patients with cardiorenal disease or who has a high at risk of developing it. This algorithm aims to help patients establish a body weight self-monitoring regime based on their health status. This algorithm will be initiated for every new CARRE user and every time the health condition of a CARRE user changes such that the initial conditions of this algorithm are met. The algorithm refers to four different patient initial conditions and is described in Figure 4. In short, the algorithm produces alerts that help patients with heart failure or chronic kidney disease to establish a body weight monitoring regime of at least once a day[8]. A different regime of a measurement at least once per week[9] is supported for patients who are diabetics (but do not have heart failure or chronic kidney disease), while a body weight measurement regime of at least once per week is supported for patients with increased weight (without hypertension or heart/renal issues or diabetes). The algorithm then triggers the respective initiation of other DSS algorithms that support the patient in adhering to these minimum body weight monitoring regimes.

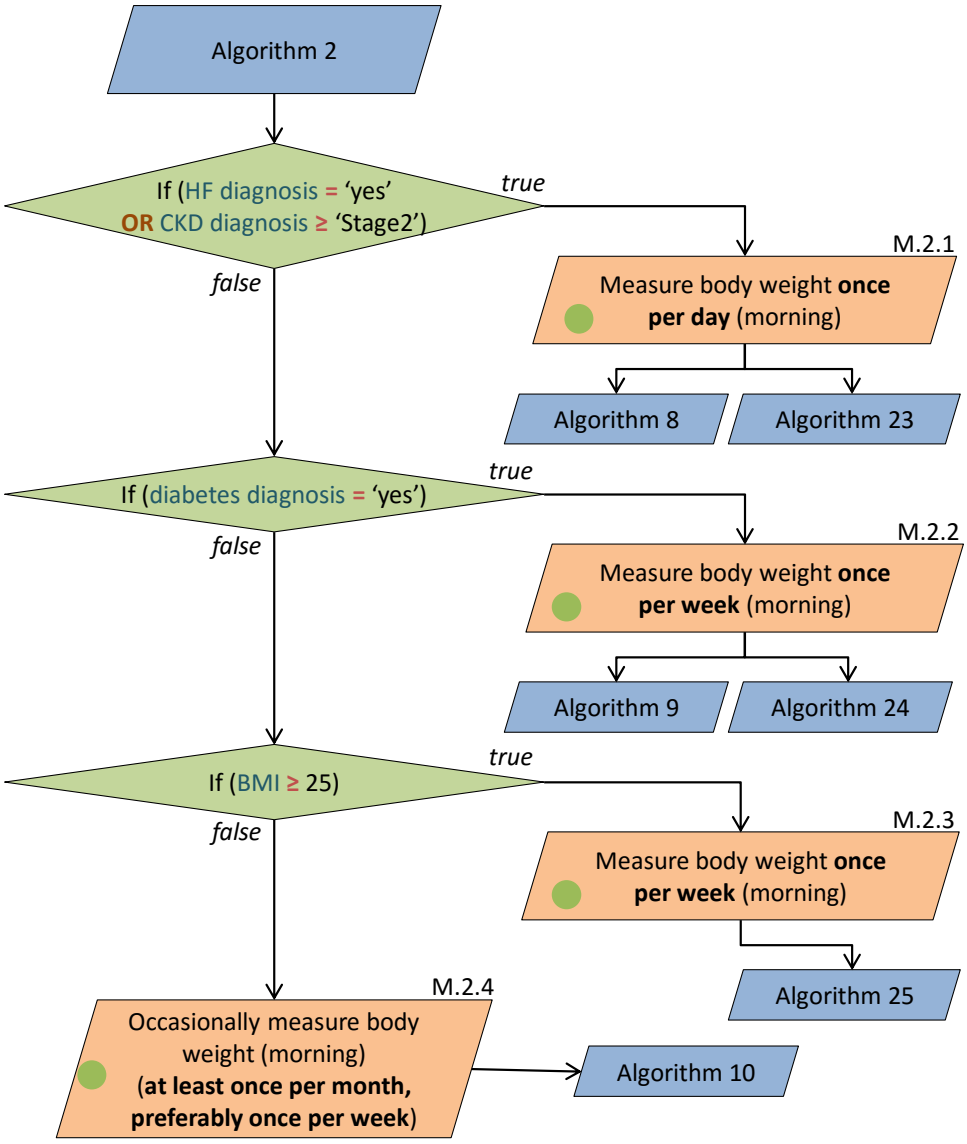

Figure 4. Algorithm for establishing body weight self-monitoring regime.

[8] 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. 2015 May 20:ehw128.

[9] American Diabetes Association. Standards of medical care in diabetes—2016. Diabetes Care. 2016; 39(suppl 1):S1-S106.

3.1.3 Monitoring blood glucose

This algorithm aims to help patients establish a blood glucose self-monitoring regime based on their health status. This algorithm will be initiated for every new CARRE user and every time the health condition of a CARRE user changes such that the initial conditions of this algorithm are met. The algorithm refers to four different patient initial conditions and is described in Figure 5. In short, the algorithm produces alerts that help patients with diabetes diagnosis to establish a blood glucose monitoring regime of at least three times a day[10]. A different regime of a measurement at least once per week is supported for patients who are not diabetics but have a BMI value in the obese region, while a blood glucose measurement regime of at least once per month is supported for other patiens at risk of diabetes. The algorithm then triggers the respective initiation of other DSS algorithms that support the patient in adhering to these minimum body weight monitoring regimes.

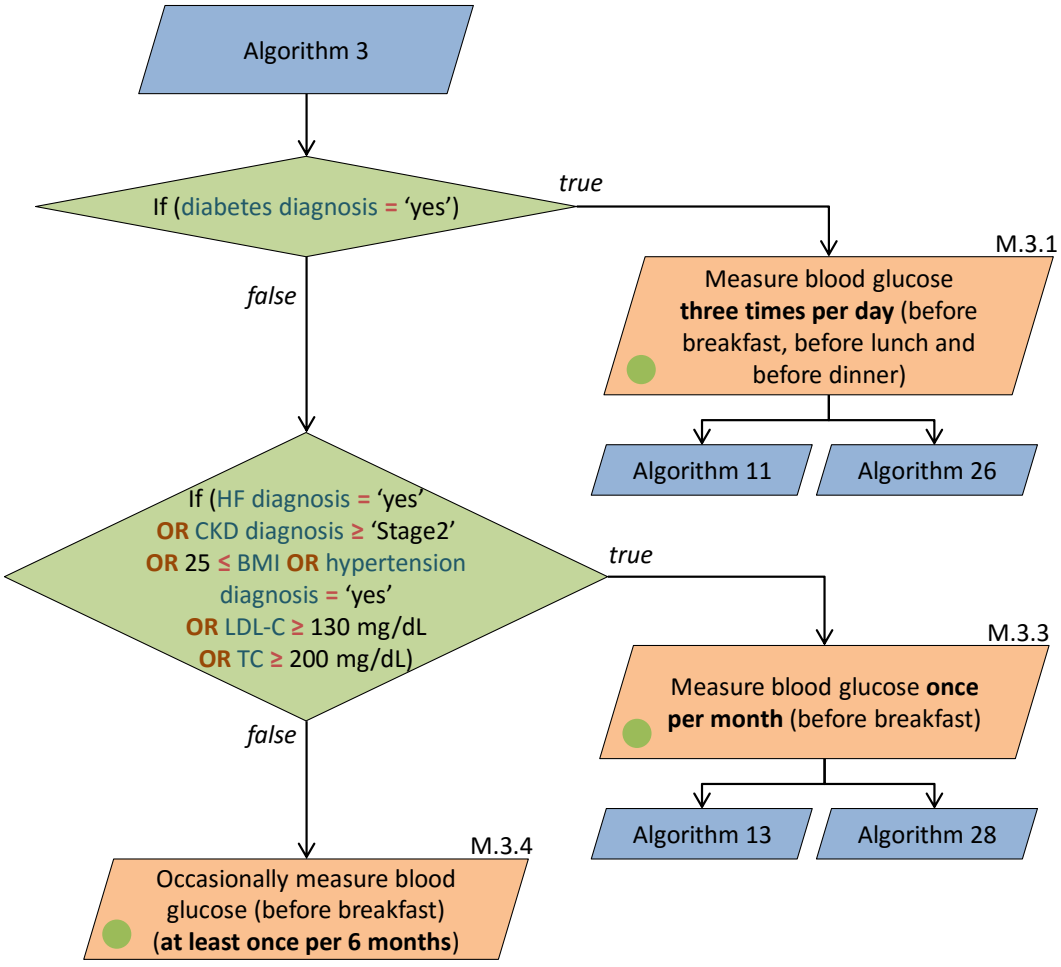

Figure 5. Algorithm for establishing blood glucose self-monitoring regime.

3.1.4 Monitoring physical activity

This algorithm aims to help patients establish a physical activity regime based on their health status[11,12,13]. This algorithm will be initiated for every new CARRE user and every time the health condition of a CARRE

[10] Gagliardino JJ, Bergenstal R, Colagiuri S, Farmer A, Karter A, Kolb H. IDF Guideline on self-monitoring of blood glucose in non-insulin treated type 2 diabetes. International Diabetes Federation (IDF). Bruselas: International Diabetes Federation. 2009.

[11] Eknoyan G, Lameire N, Eckardt KU, Kasiske BL, Wheeler DC, Levin A, Stevens PE, Bilous RW, Lamb EJ, Coresh J, Levey AS. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney Int. 2013;3:5-14.

user changes such that the initial conditions of this algorithm are met. The algorithm refers to various different patient initial conditions and is described in Figure 6. Algorithm for establishing physical activity regime..

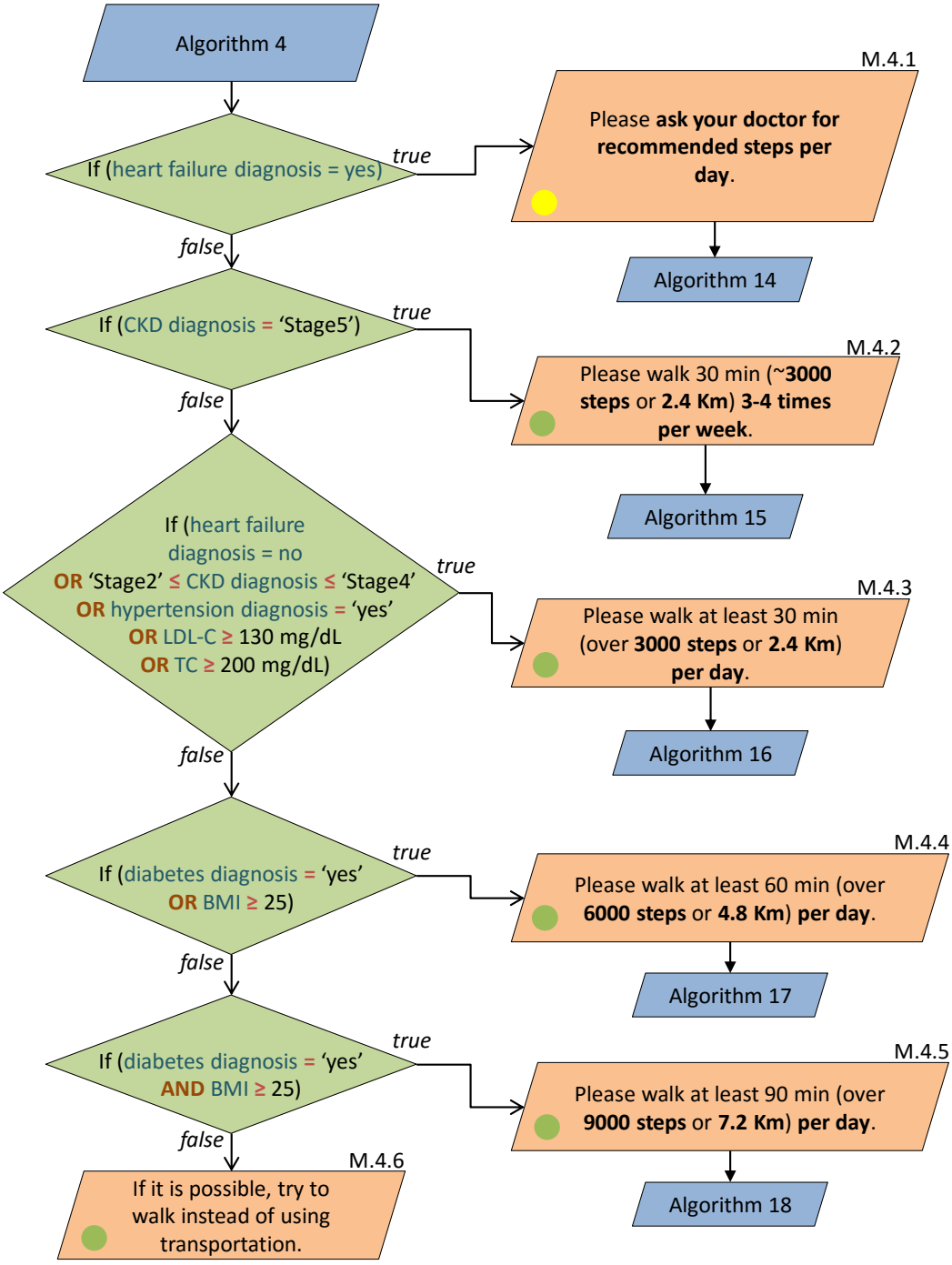

Figure 6. Algorithm for establishing physical activity regime.

[12] Ponikowski P,VoorsA. A, Anker S.D, Bueno H, John G. F. Cleland,. Coats A. J. S, Falk V, González-Juanatey J.R, Harjola V-P, Jankowska E A, Jessup M, Linde C, Nihoyannopoulos P, Parissis J.T, Pieske B, Riley J. P, Rosano G,M. C, Ruilope L. M, Ruschitzka F, Rutten F. H., Meer P. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. European Heart Journal May 2015, ehw128; DOI: 10.1093/eurheartj/ehw128

[13] Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report, 2008. Washington, DC: US Department of Health and Human Services. 2008 Jun 24;2008:A1-H14.

3.2 DSS to support adherence to a self-monitoring regime

DSS algorithms described in this section intend to support the adherence to a self-monitoring regime as those established by the algorithms in the previous section.

3.2.1 Support adherence to blood pressure self-monitoring regime

Figure 7 shows the algorithm that supports adherence to a blood pressure self-monitoring regime of two measurements per day. If the patient doesn't follow his/her blood pressure according to his/her personalized schedule, an appropriate reminder is generated after preselected time intervals. If the patient adequately follows the monitoring regime for a pre-selected time period, a relevant awarding message is generated. Similarly, Figure 8 shows the algorithm that supports adherence to a blood pressure self-monitoring regime of once a day, while Figure 9 of once per week.

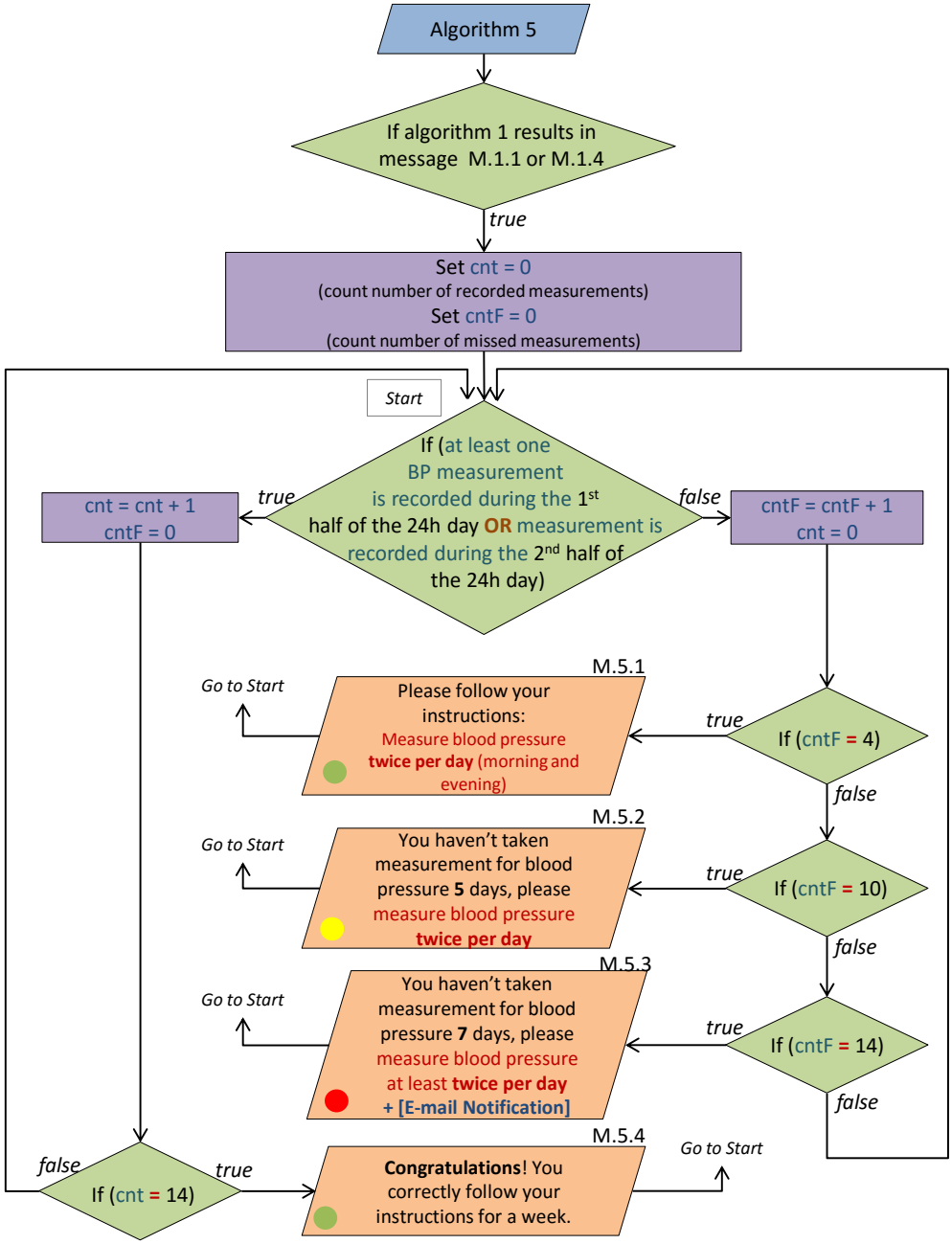

Figure 7. Algorithm to support adherence to blood pressure self-monitoring regime of two measurements per day.

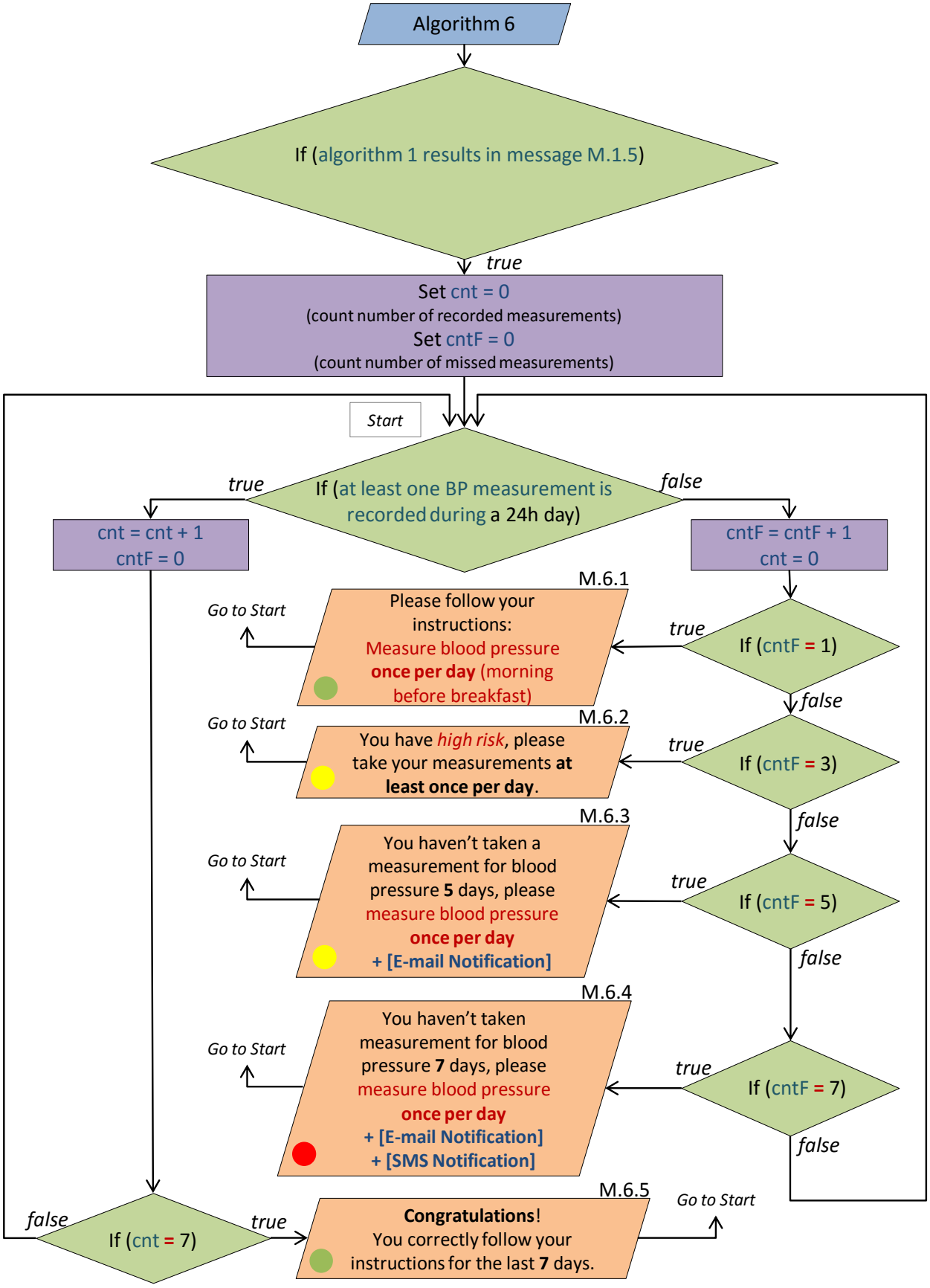

Figure 8. Algorithm to support adherence to blood pressure self-monitoring regime of once per day.

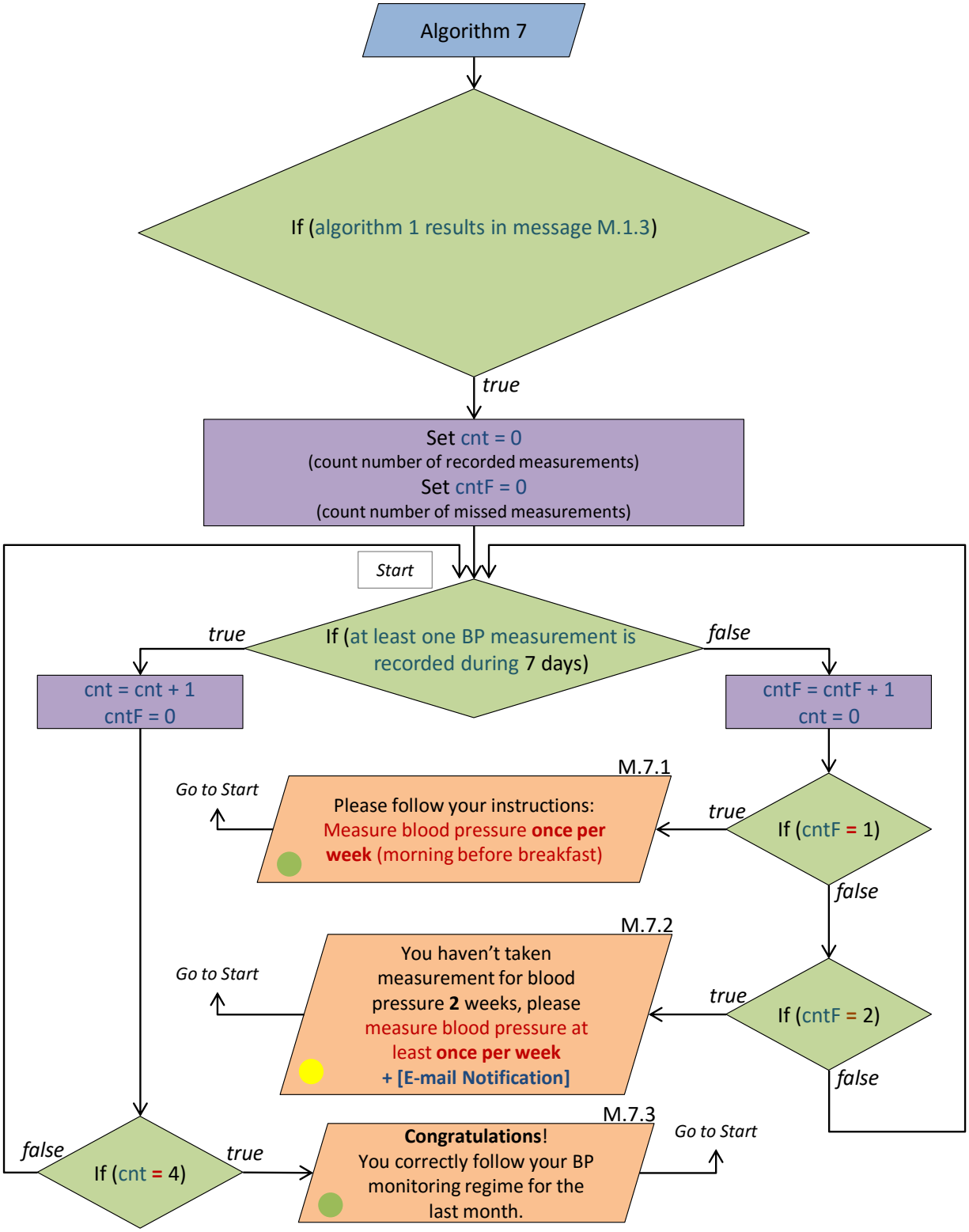

Figure 9. Algorithm to support adherence to blood pressure self-monitoring regime once a week.

3.2.2 Support adherence to body weight self-monitoring regime

Figure 10 shows the algorithm that supports adherence to a body weight self-monitoring regime for patients with heart failure or chronic kidney disease. If the patient doesn't follow his/her blood pressure according to his/her personalized schedule, an appropriate reminder is generated after preselected time intervals. If the patient adequately follows the monitoring regime for a pre-selected time period, a relevant awarding message is generated. Similarly, Figure 11 shows the algorithm that supports adherence to a body weight self-monitoring regime for patients with diabetes, while Figure 12 for patients with increased body weight.

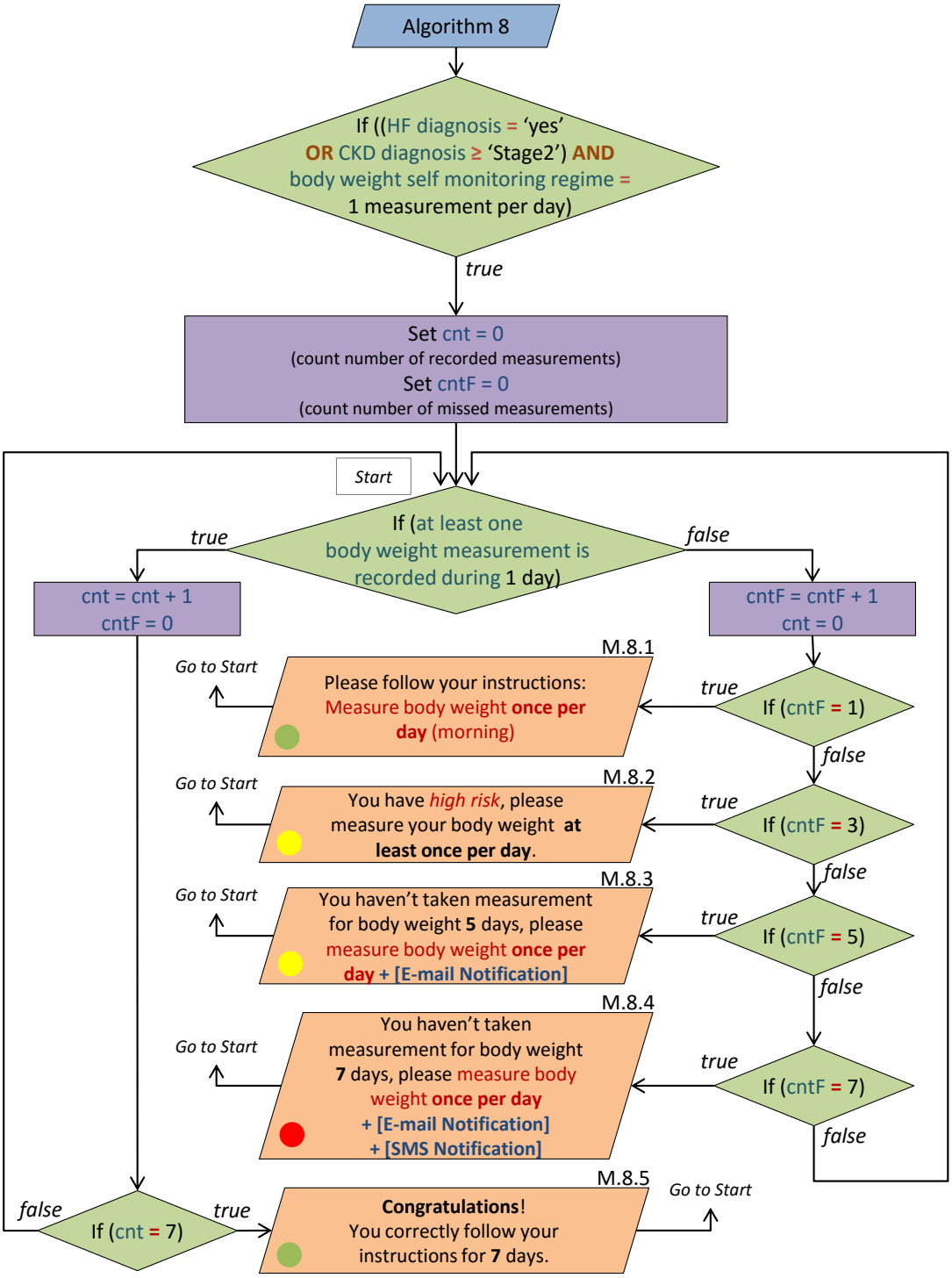

Figure 10. Algorithm to support adherence to body weight self-monitoring regime for patients with HF or CKD.

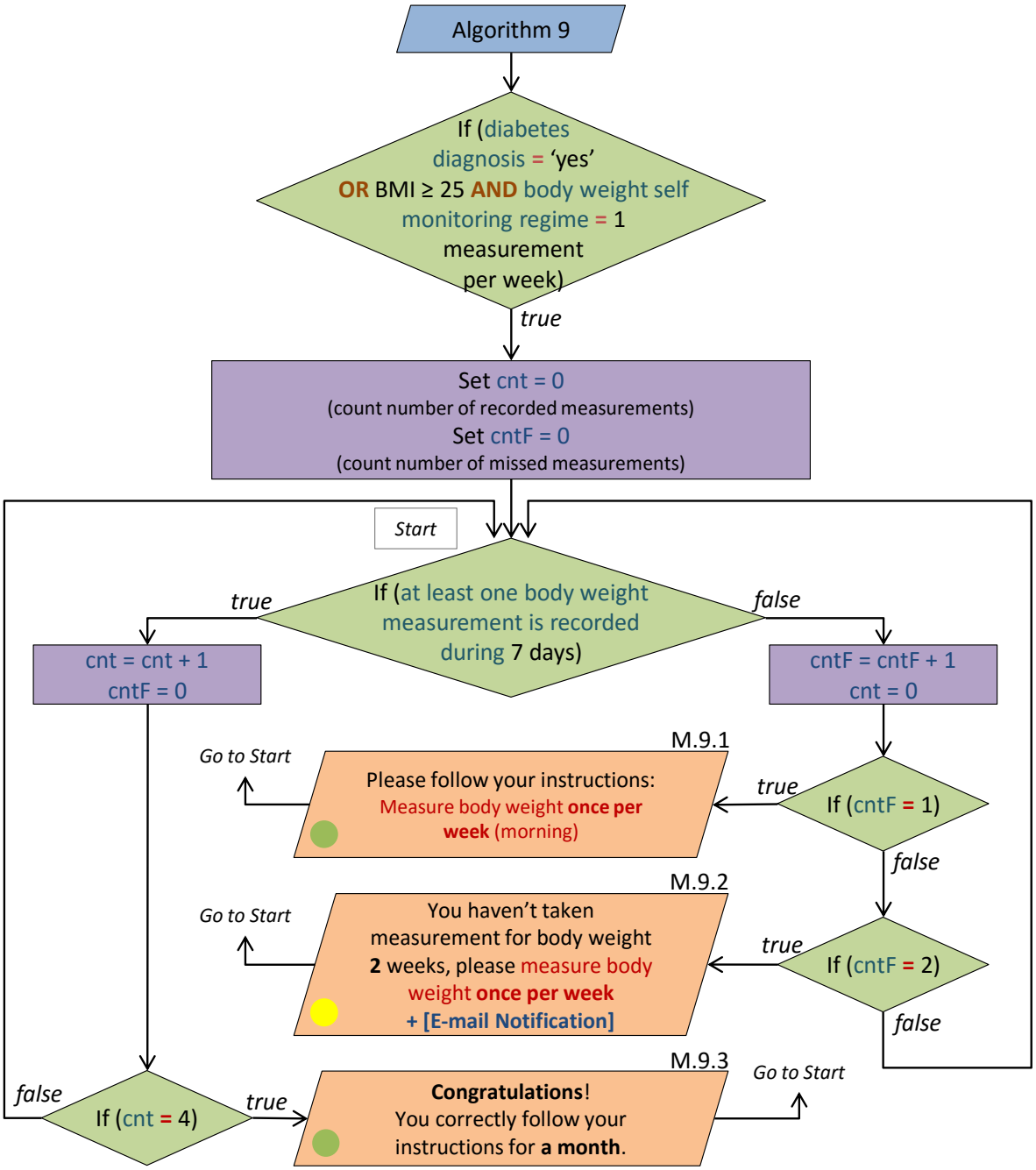

Figure 11. Algorithm to support adherence to body weight self-monitoring regime for patients with diabetes.

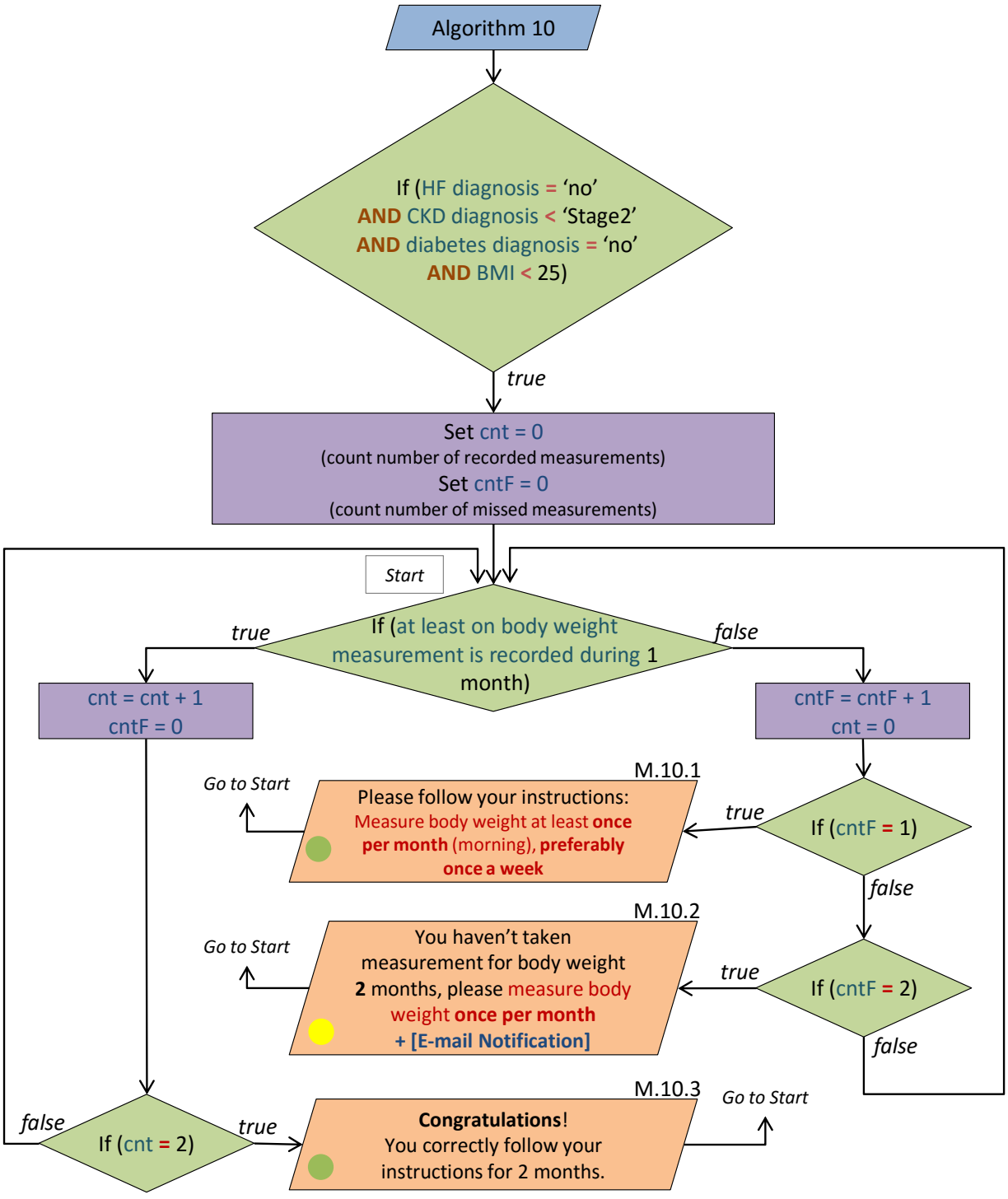

Figure 12. Algorithm to support adherence to body weight self-monitoring regime for patients with BMI ≥ 25.

3.2.3 Support adherence to blood glucose self-monitoring regime

Figure 13 shows the algorithm that supports adherence to a bood glucose self-monitoring regime for patients with diabetes. If the patient doesn't follow his/her bood glucose according to his/her personalized schedule, an appropriate reminder is generated after preselected time intervals. If the patient adequately follows the monitoring regime for a pre-selected time period, a relevant awarding message is generated. Similarly, Figure 14 for other patients with increased risk for diabetes.

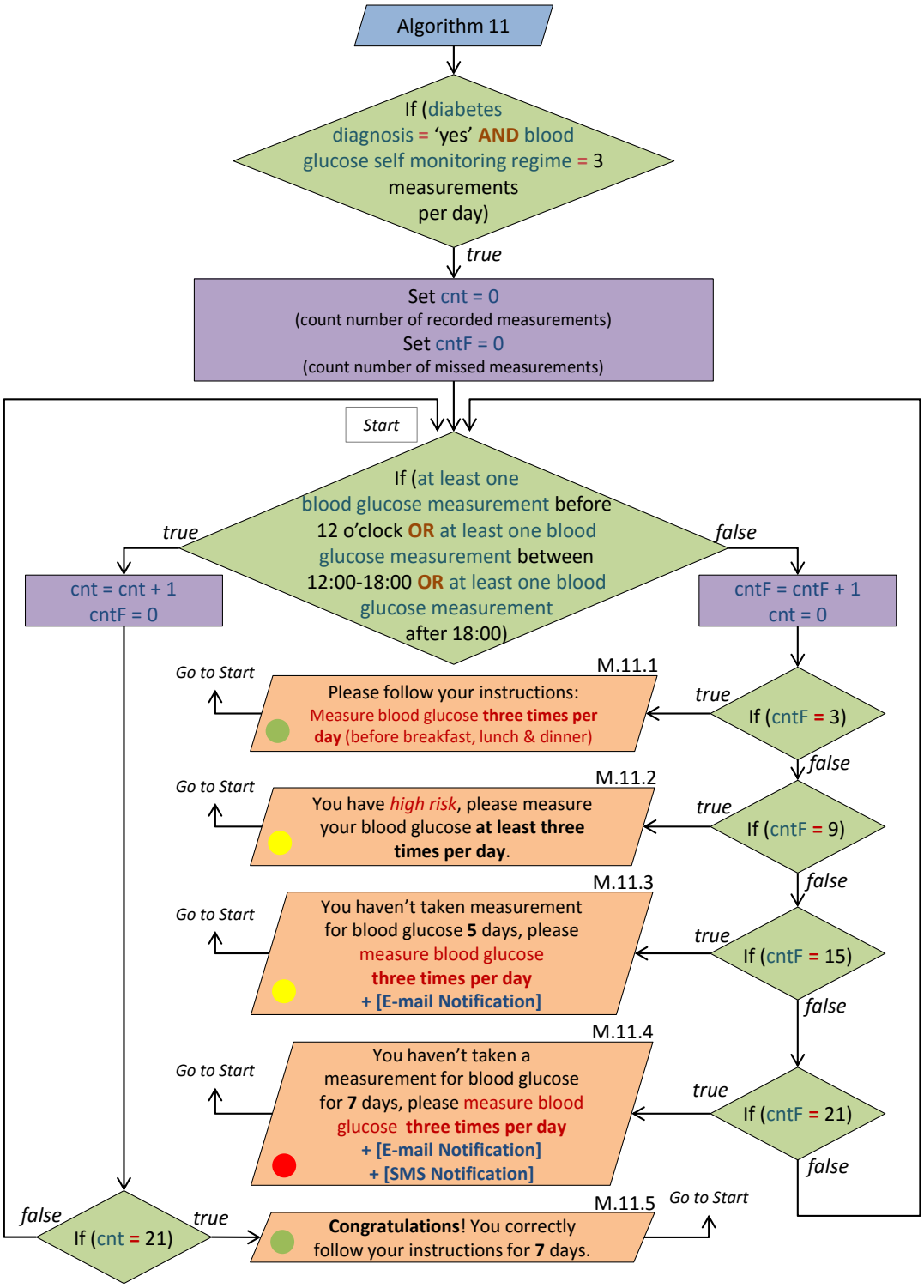

Figure 13. Algorithm to support adherence to blood glucose self-monitoring regime for patients with diabetes.

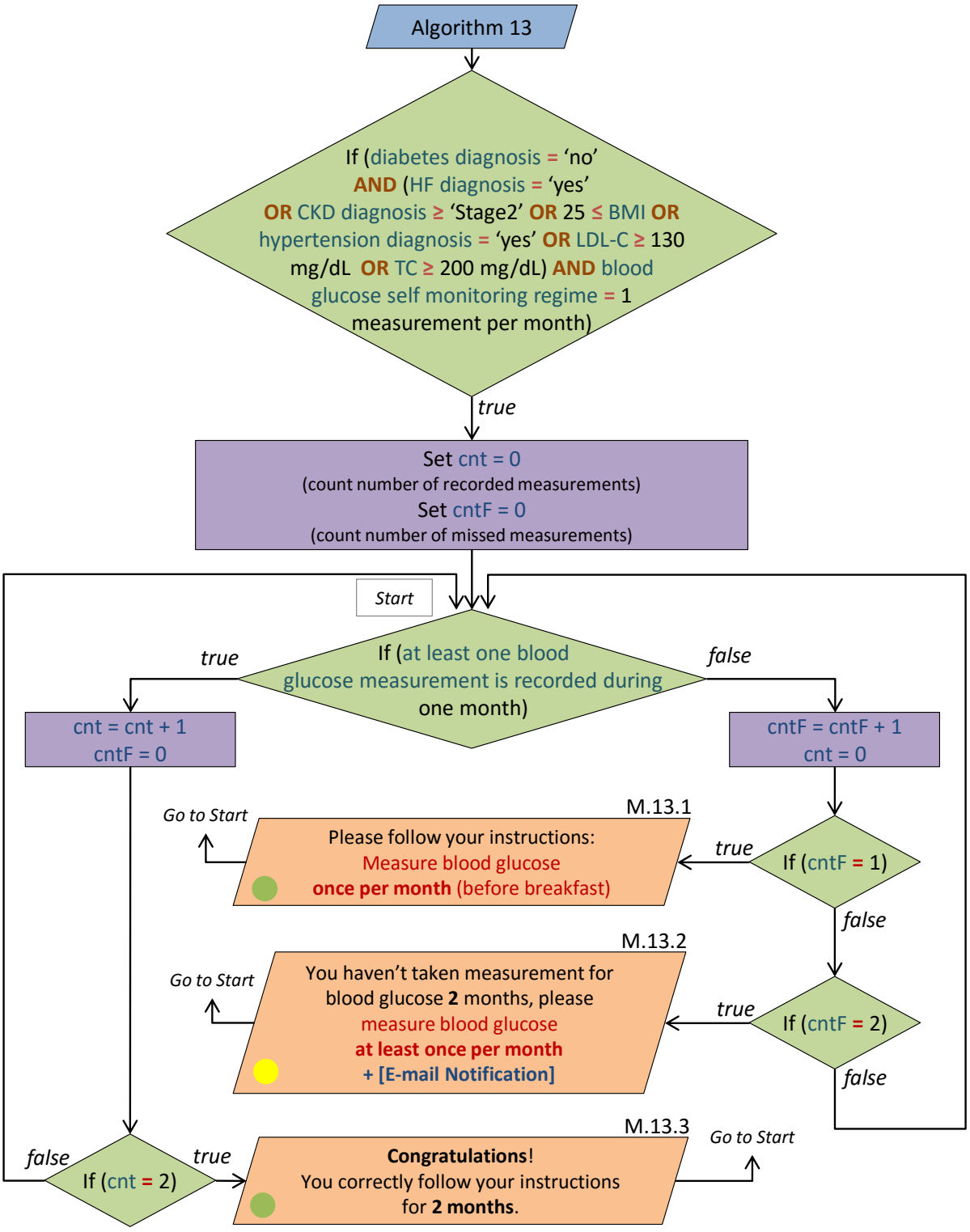

Figure 14. Algorithm to support adherence to blood glucose self-monitoring regime for other patients with increased risk for diabetes.

3.2.4 Support adherence to physical activity regime

According to the current European Society of Cardiology guidelines[14] there is no universal agreement on exercise prescription in chronic heart disease; thus, an individualized approach is recommended, with careful clinical evaluation, including behavioural characteristics, personal goals, and preferences (see Algorithm 14). Only stable and well-treated patients could initiate a home-based programme after a baseline exercise test with guidance and instructions.

The following figures show the algorithms that support adherence to a physical activity regime for patients with cardiac disease (Figure 15), for patients with stage 5 chronic kidney disease (Figure 16), for patients with chronic kidney disease of stage 2 to 4, or hypertension diagnosis or LDL-C ≥ 130 mg/dL or TC ≥ 200 mg/dL (Figure 17), for patients with diabetes or BMI ≥ 25 (Figure 18), and for patients with diabetes AND BMI ≥ 25 (Figure 19).

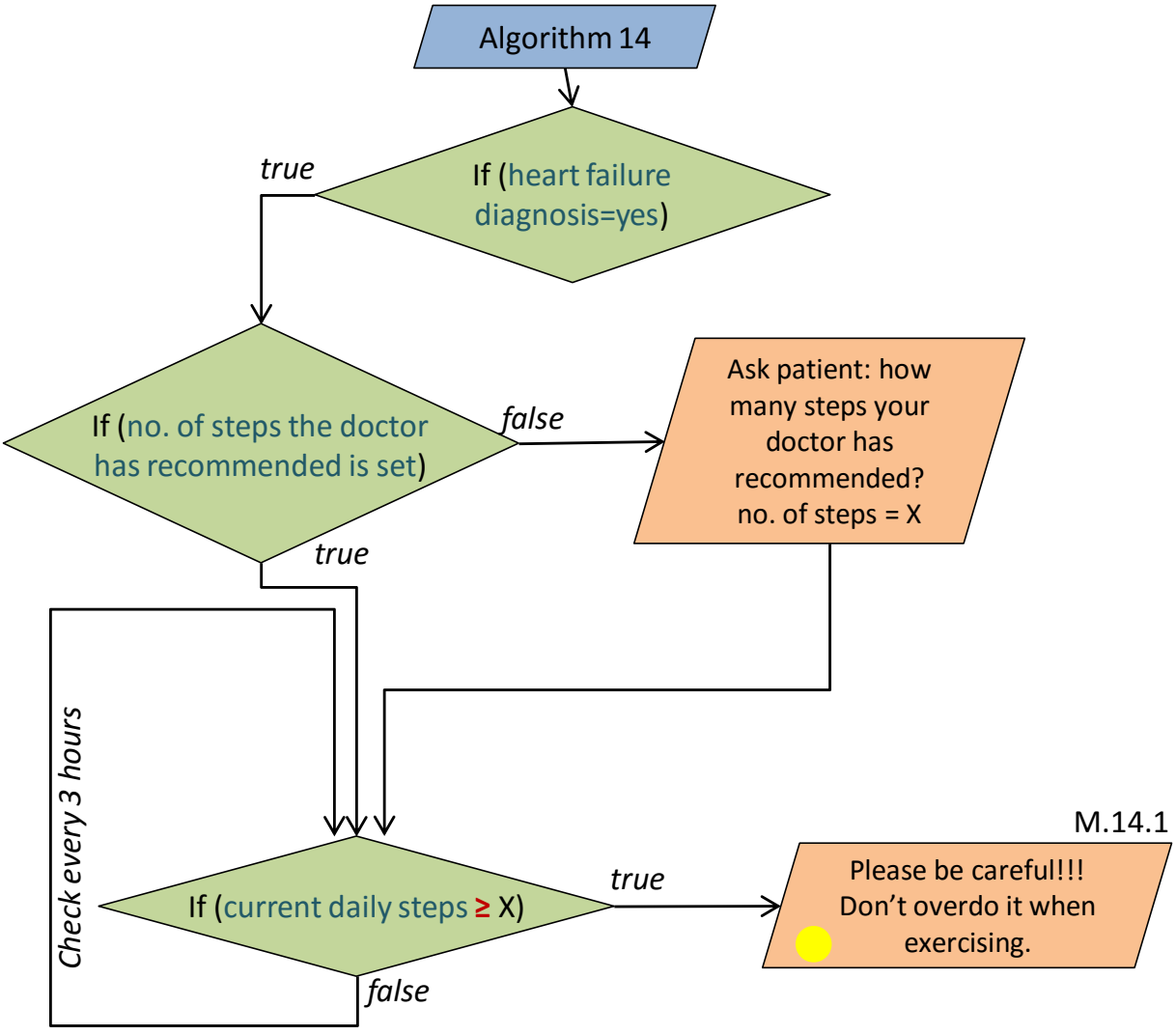

Figure 15. Algorithm to support adherence to physical activity regime for patients with heart failure.

[14] The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC), 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure, European Heart Journal May 2015, ehw128; , doi:10.1093/eurheartj/ehw128

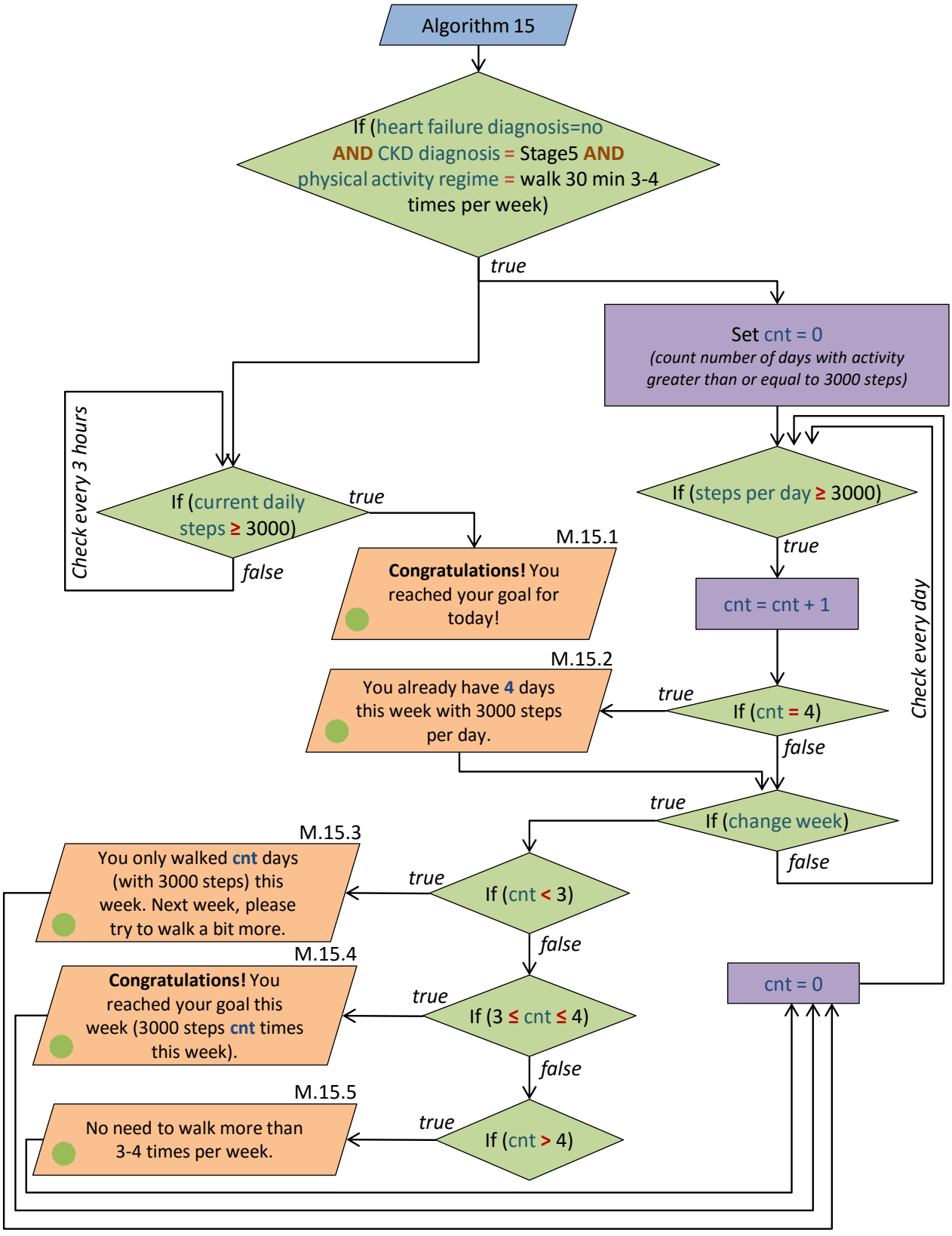

Figure 16. Algorithm to support adherence to physical activity regime for patients with CKD diagnosis = 'Stage5'.

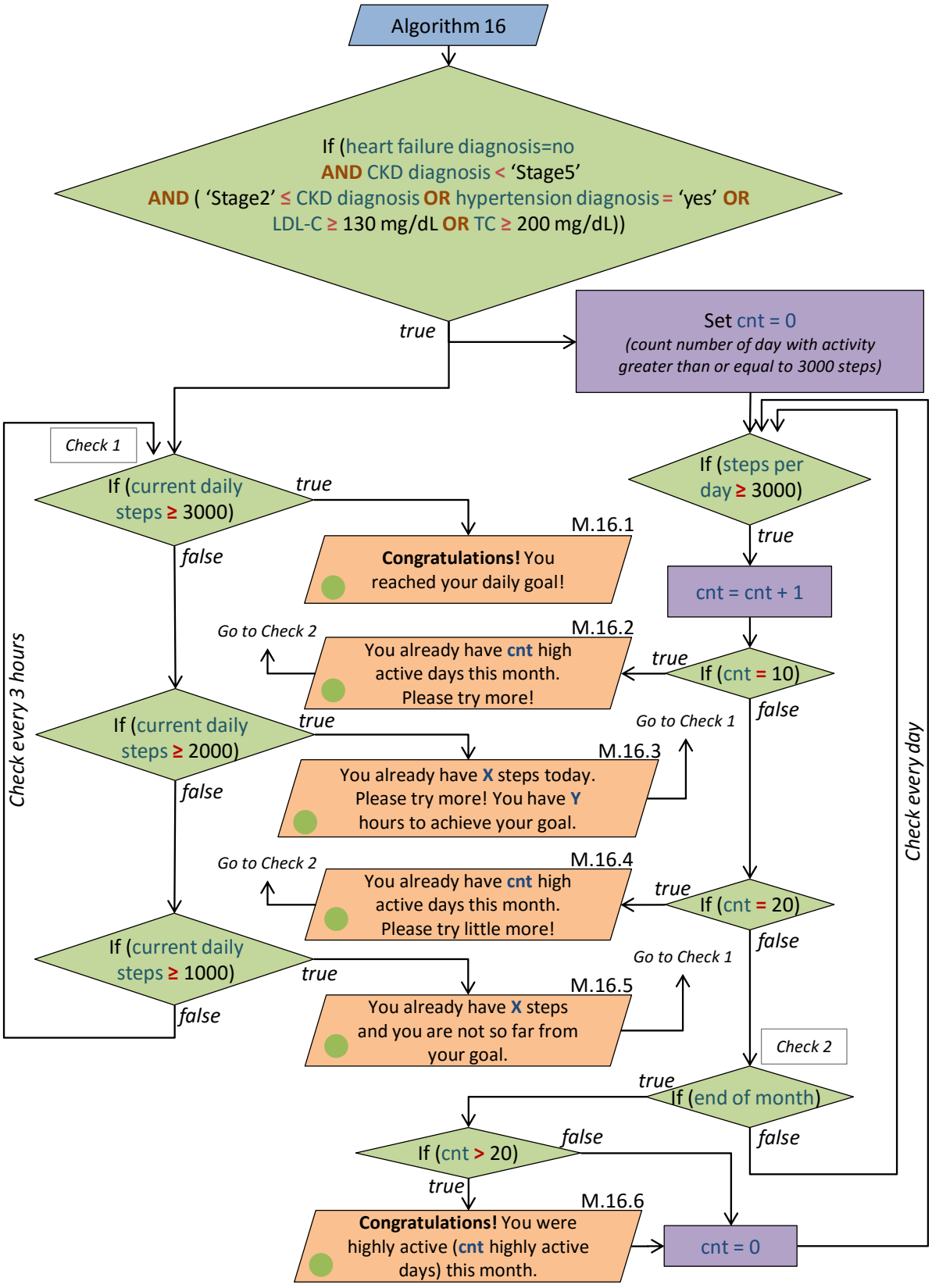

Figure 17. Algorithm to support adherence to physical activity regime for patients with chronic kindney disease (not stage 5) or hypertension diagnosis or LDL-C ≥ 130 mg/dL or TC ≥ 200 mg/dL.

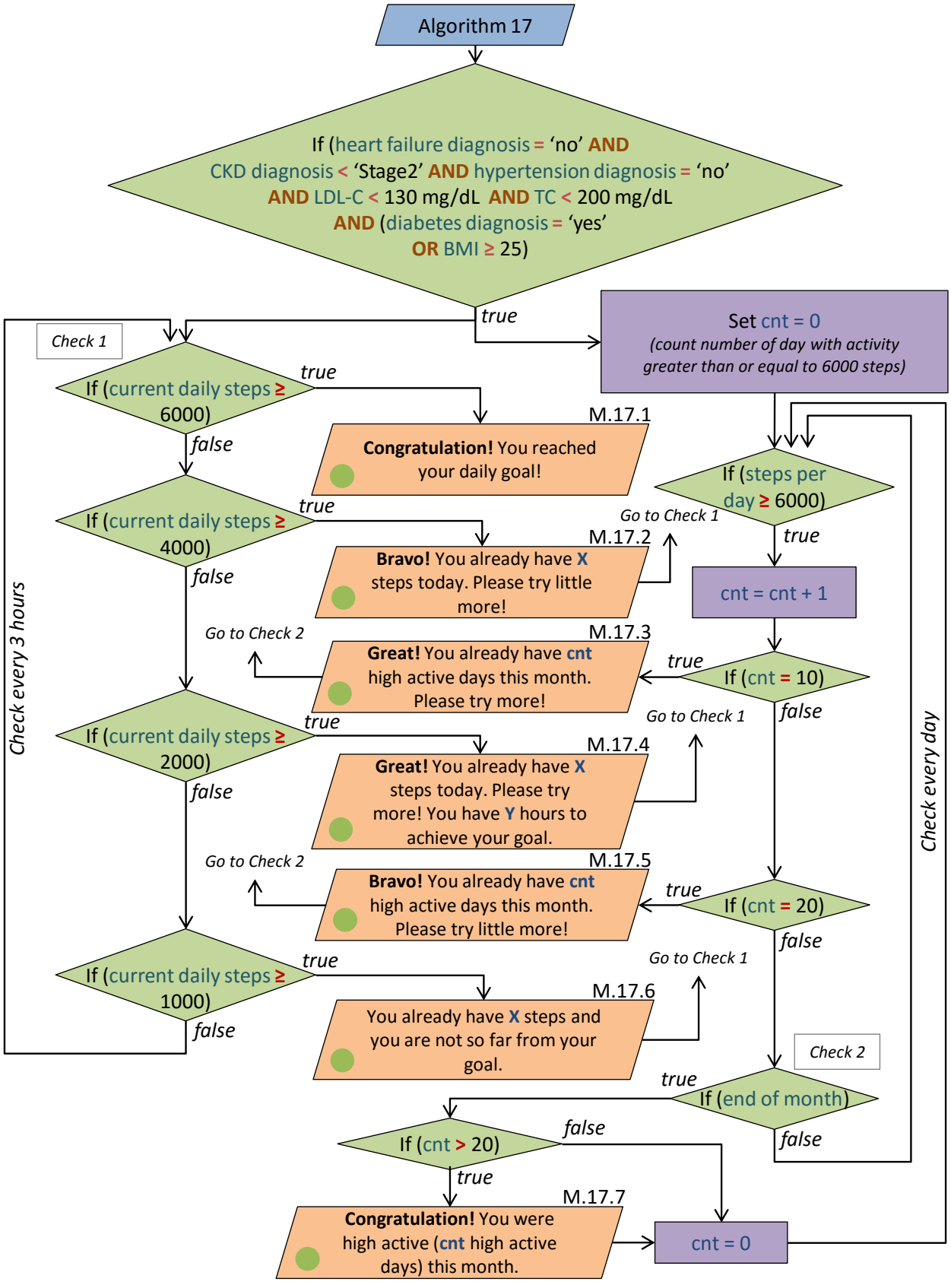

Figure 18. Algorithm to support adherence to physical activity regime for patients with diabetes or BMI ≥ 25.

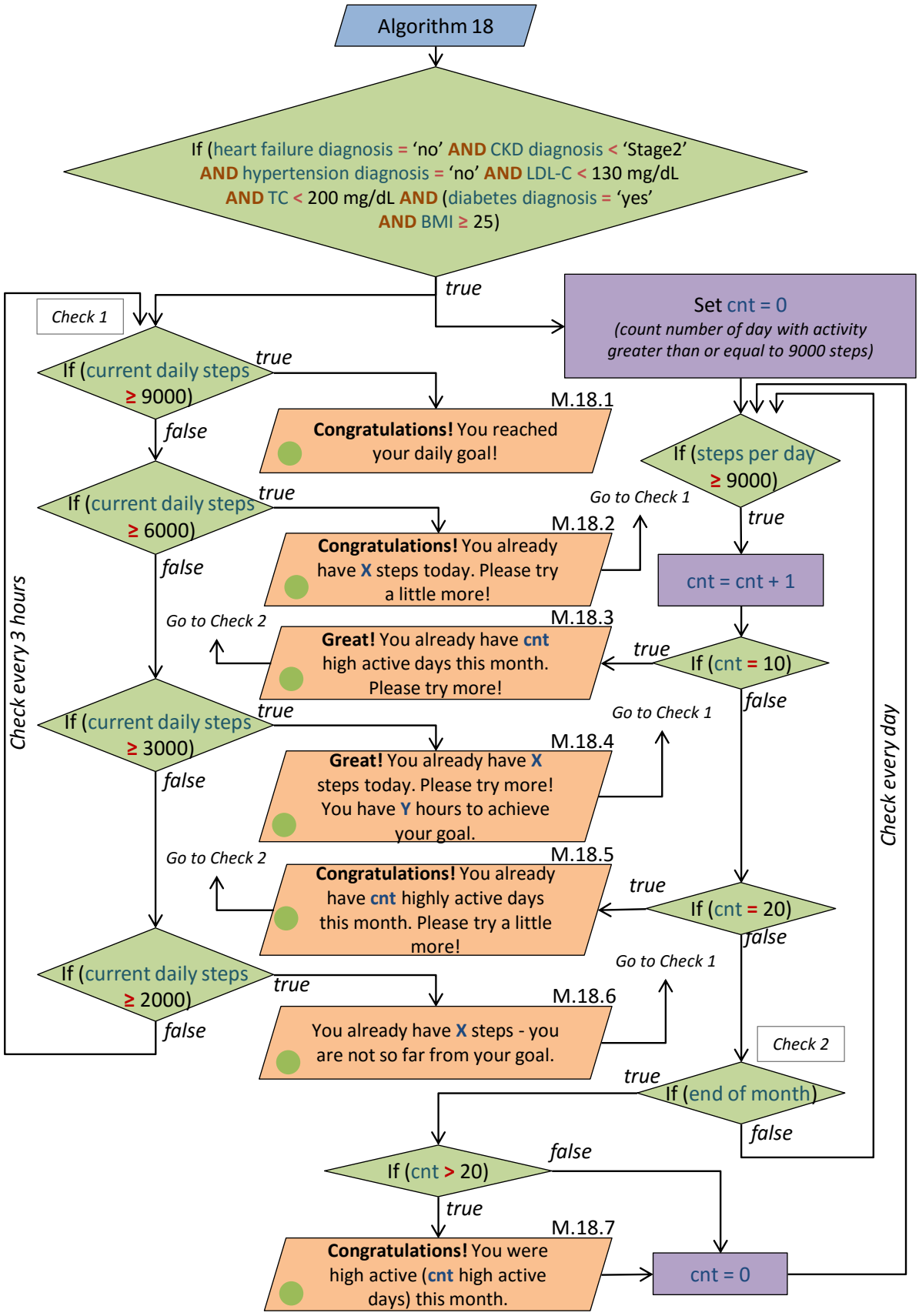

Figure 19. Algorithm to support adherence to physical activity regime for patients with diabetes and BMI ≥ 25.

3.3 DSS to inform on a potential health status change

DSS algorithms described in this section intend to inform the patient about potential changes in their health status based on self-monitoring measurements.

3.3.1 Blood pressure evaluation

Figure 20 shows the algorithm that evaluates blood pressure measurements for patients with hypertension diagnosis. The instructions for these patients are to measure their blood pressure twice per day. The main goal of these alarms is to evaluate the average of SBP and DBP per week based on specific values' ranges and threat levels.

Similarly, Figure 21 shows the algorithm that evaluates blood pressure measurements for patients with HF or CKD (≥ "Stage 2") diagnosis. This algorithm is split into two parts. The first evaluates the average of SBP and DBP per week. The second part evaluates the last taken measurement of SBP and DBP in a time frame of 3 hours. Both evaluation parts generate alerts based on specific value ranges and threat levels.

Figure 22 shows the algorithm that evaluates blood pressure measurements for patients with BMI ≥ 25 or diabetes diagnosis or LDL-C ≥ 130 mg/dL or TC ≥ 200 mg/dL.

Figure 23 shows the algorithm that evaluates blood pressure measurements for seemingly healthy CARRE user to support prevention for abnormal blood pressure.

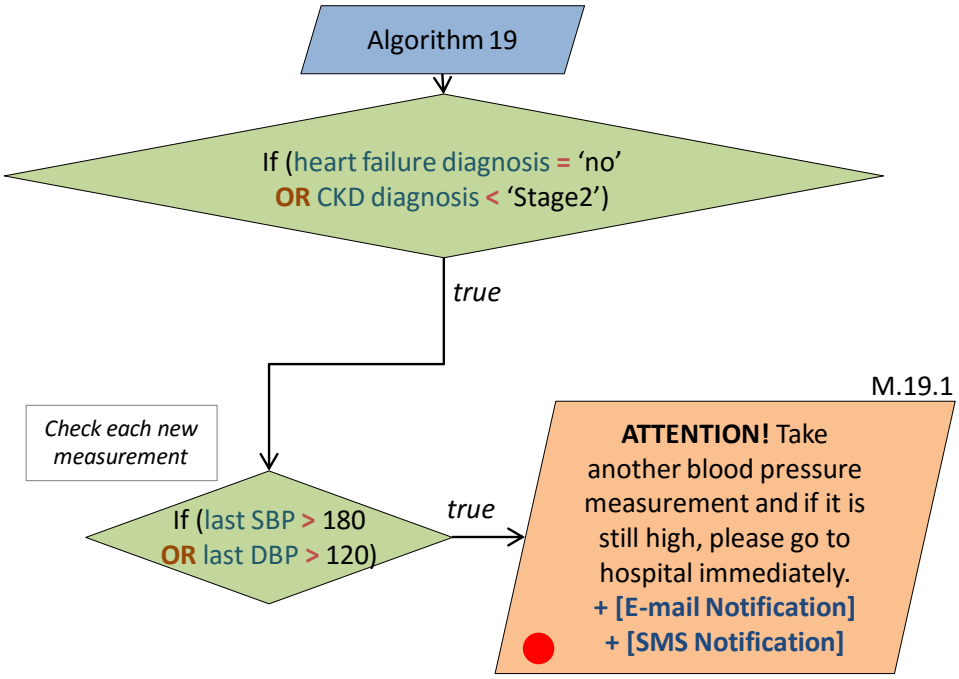

Figure 20. Evaluate blood pressure for any patient without HF or CKD (≥ 'Stage2').

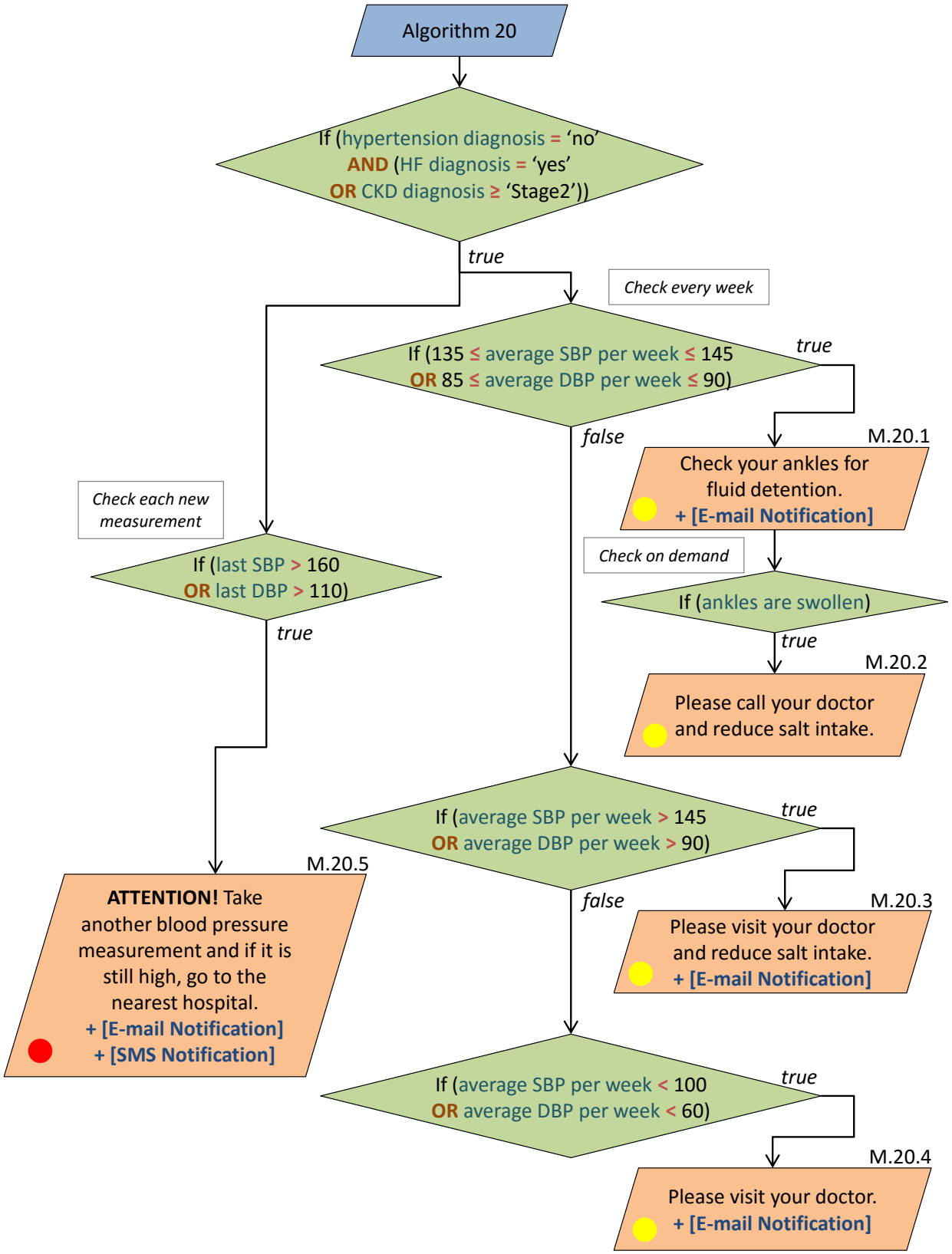

Figure 21. Evaluate blood pressure for patients with HF or CKD (≥ 'Stage2').

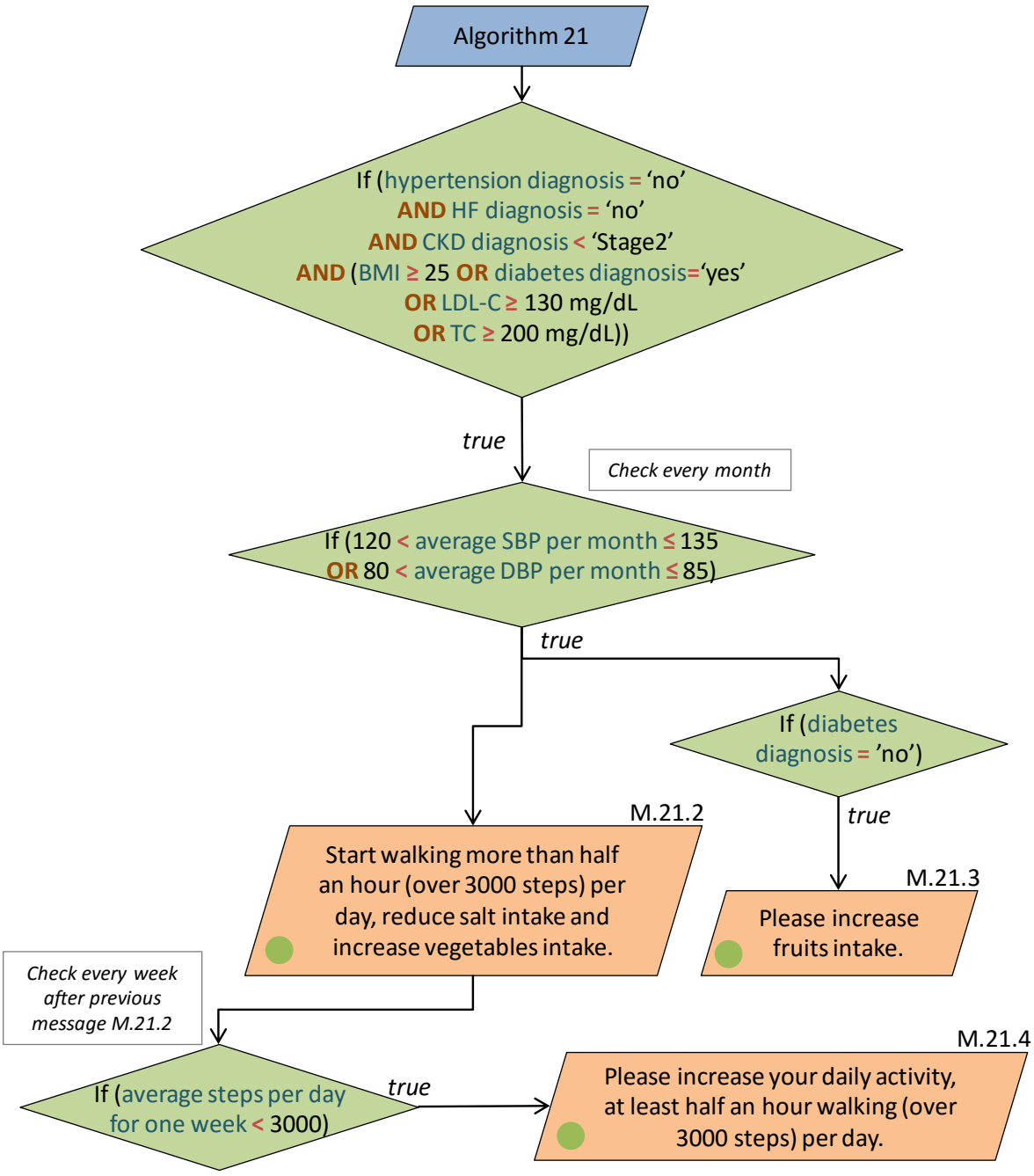

Figure 22. Evaluate blood pressure for patients with BMI ≥ 25 or diabetes or LDL-C ≥ 130 mg/dL or TC ≥ 200 mg/dL.

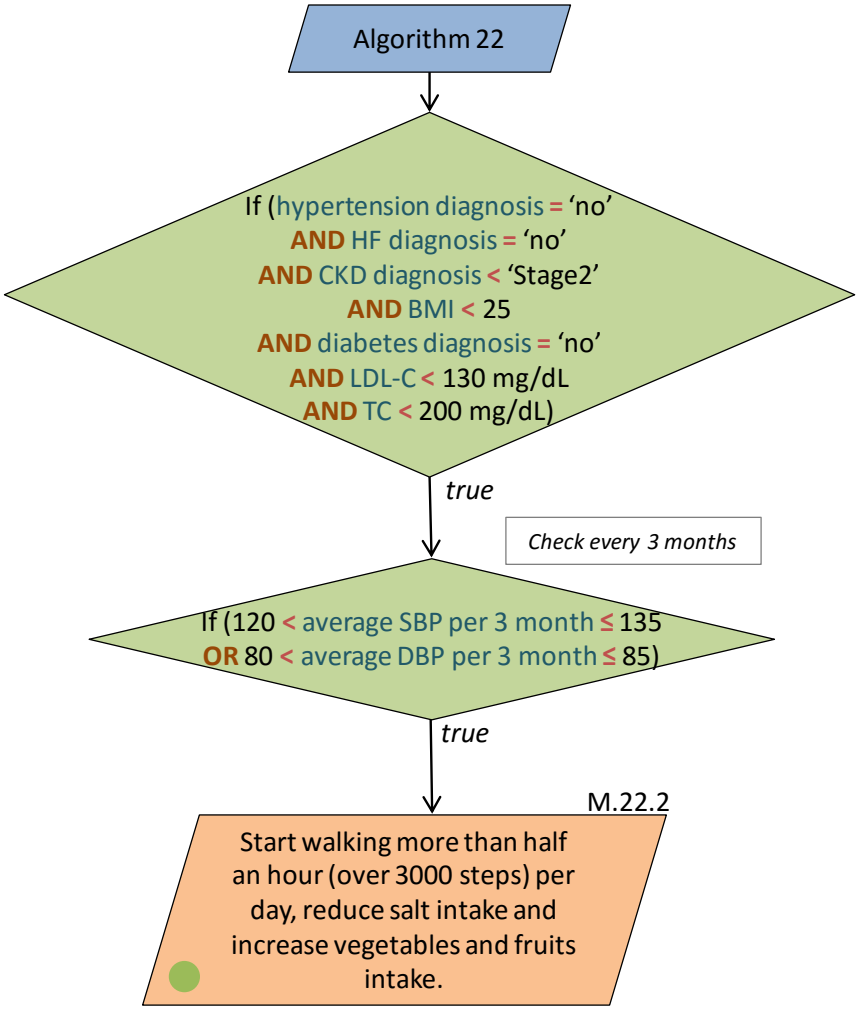

Figure 23. Evaluate blood pressure for patients without metabolic syndrome or HF or CKD.

3.3.2 Body weight evaluation

Figure 24 shows the algorithm that evaluates body weight measurements for patients with HF or CKD (≥ "Stage 2") diagnosis. This algorithm is split into two parts. The first evaluates the the difference of body weight per day. The second part evaluates the difference of body weight per 3 days. Both parts generate alerts based on specific values ranges and alert levels. Similarly, Figure 25 shows the algorithm that evaluates body weight measurements for patients with diabetes. The main goal is to evaluate the difference of body weight per week (> 1 Kg) and additionally evaluate average steps per week in order to help the patient to maintain an adequate physical activity level. Finally, Figure 26 shows the algorithm that evaluates body weight measurements for patients with BMI ≥ 25.

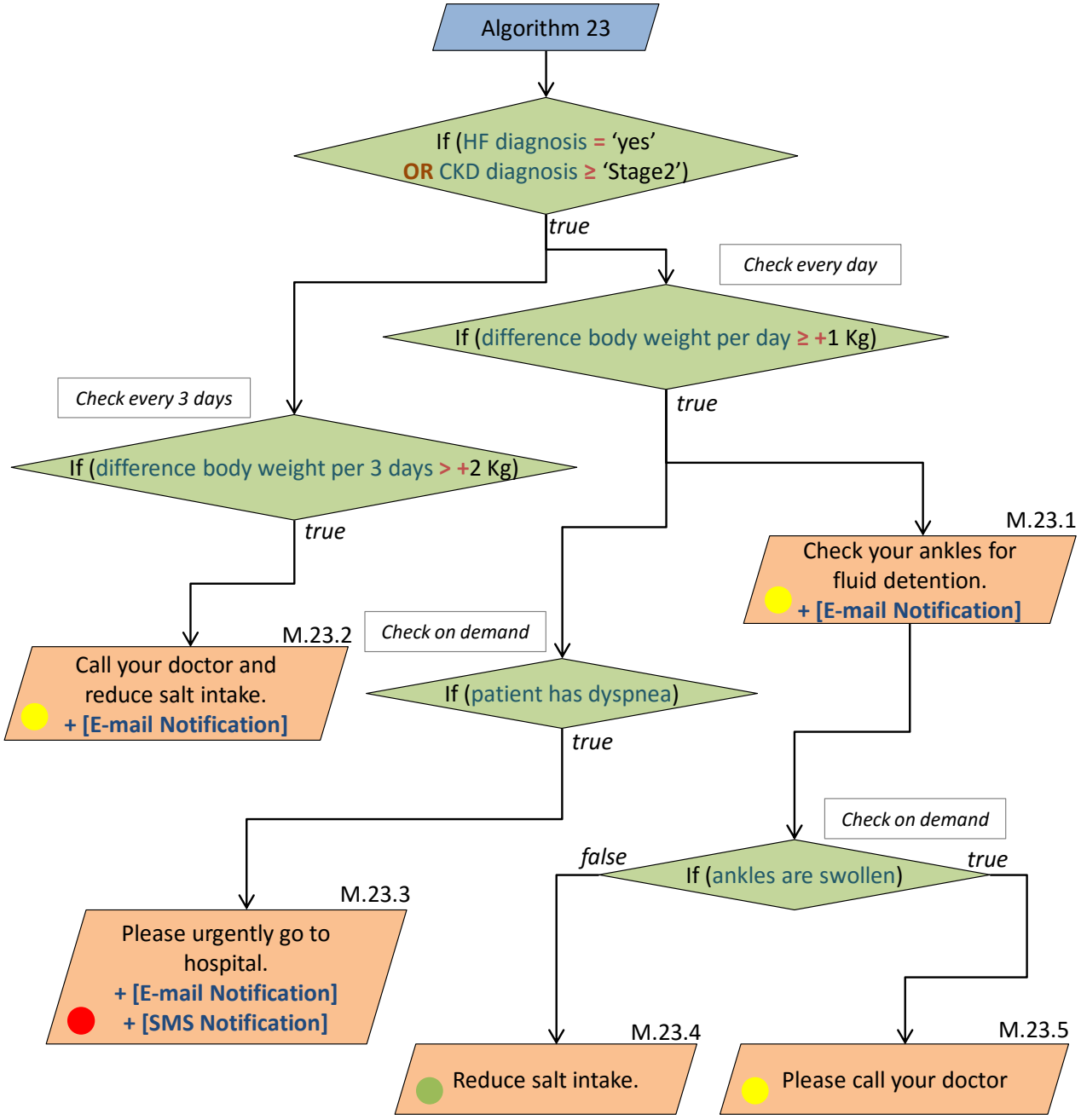

Figure 24. Evaluate body weight for patients with HF and CKD (≥ 'Stage2').

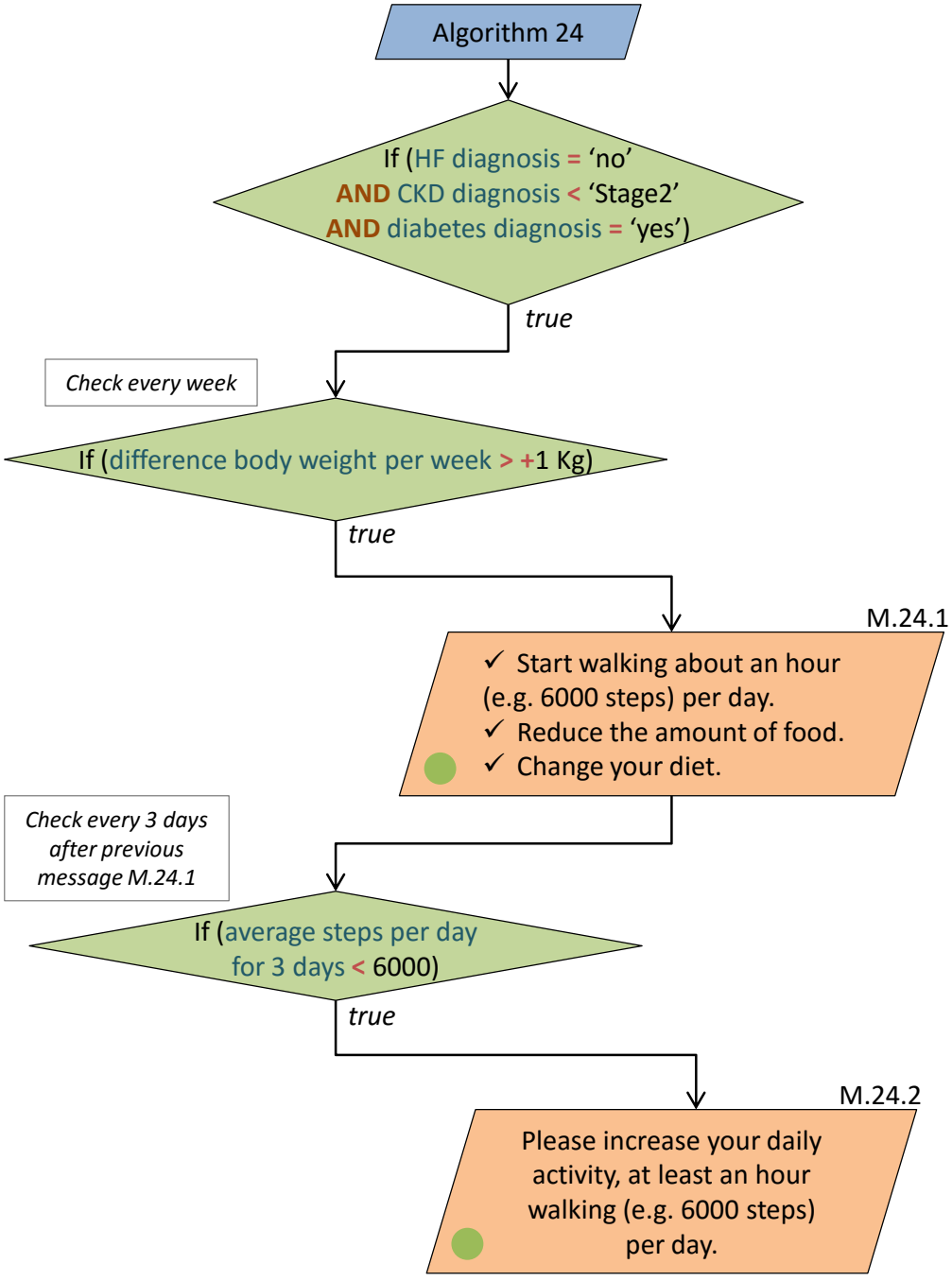

Figure 25. Evaluate body weight for patients with diabetes diagnosis.

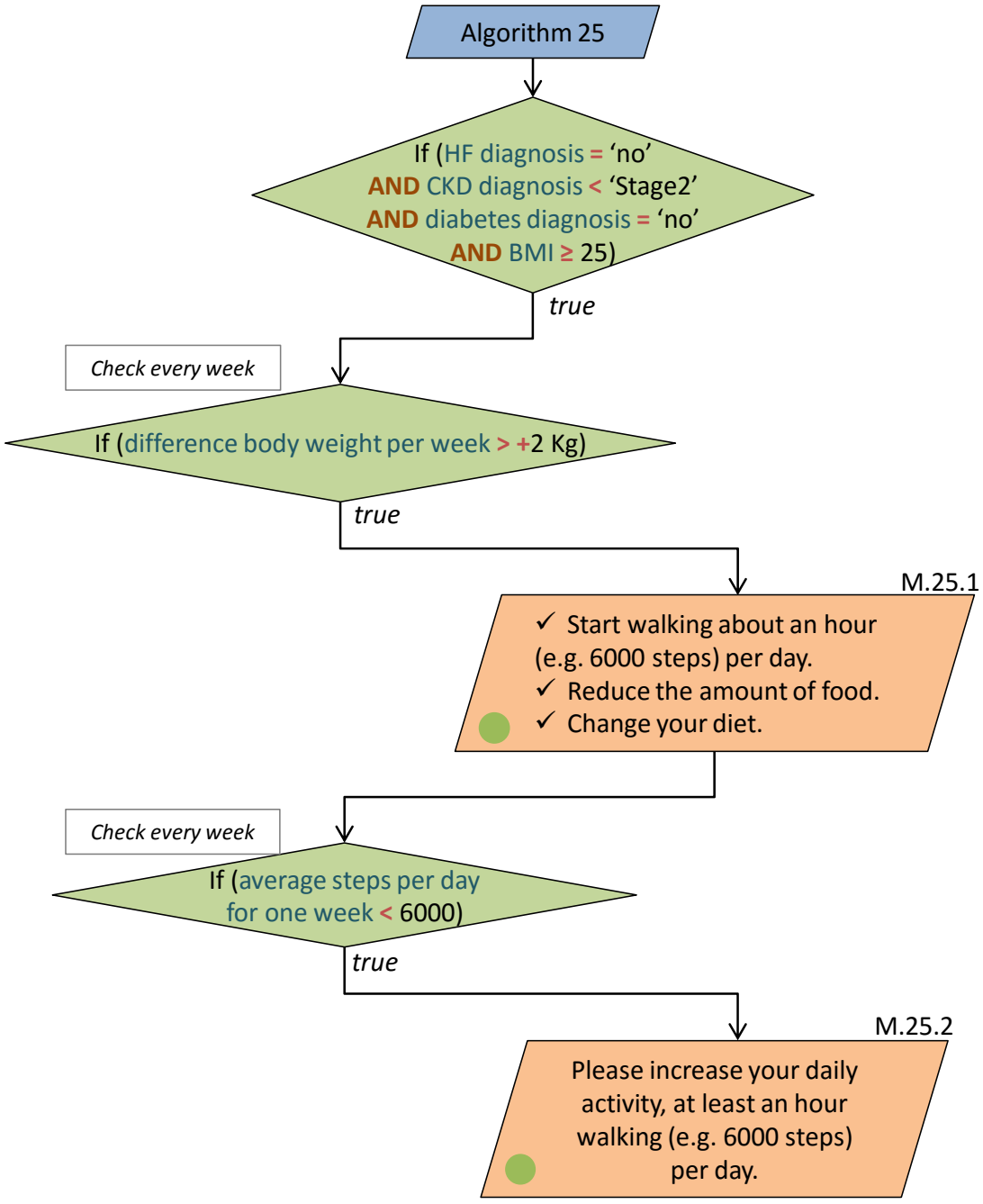

Figure 26. Evaluate body weight for patients with BMI ≥ 25.

3.3.3 Blood glucose evaluation

Figure 27 shows the algorithm that evaluates blood glucose measurements for patients with diabetes. This algorithm is split into two parts. The first evaluates the maximum value for blood glucose within each day. The second part evaluates the minimum value of blood glucose for every 3 hours. Both parts generate alerts based on specific values ranges and alert levels.

Similarly, Figure 28 shows the algorithm that evaluates blood glucose measurements for patients with HF or CKD (≥ 'Stage2') or 25 ≤ BMI or hypertension diagnosis or LDL-C ≥ 130 mg/dL or TC ≥ 200 mg/dL. The goal of this algorithm is to evaluate the maximum value of blood glucose per month based on specific values' ranges and threat levels.

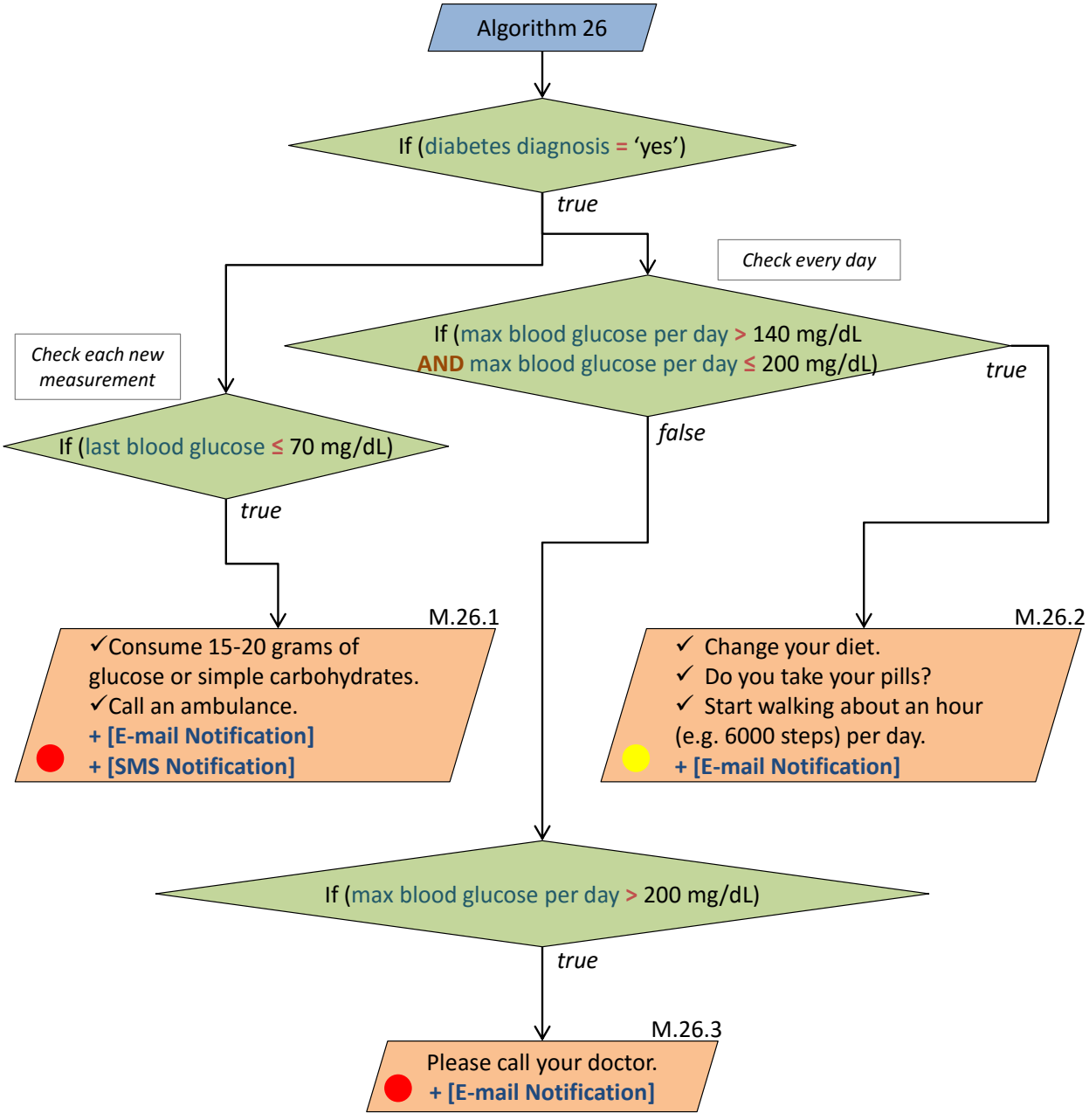

Figure 27. Evaluate blood glucose for patients with diabetes.

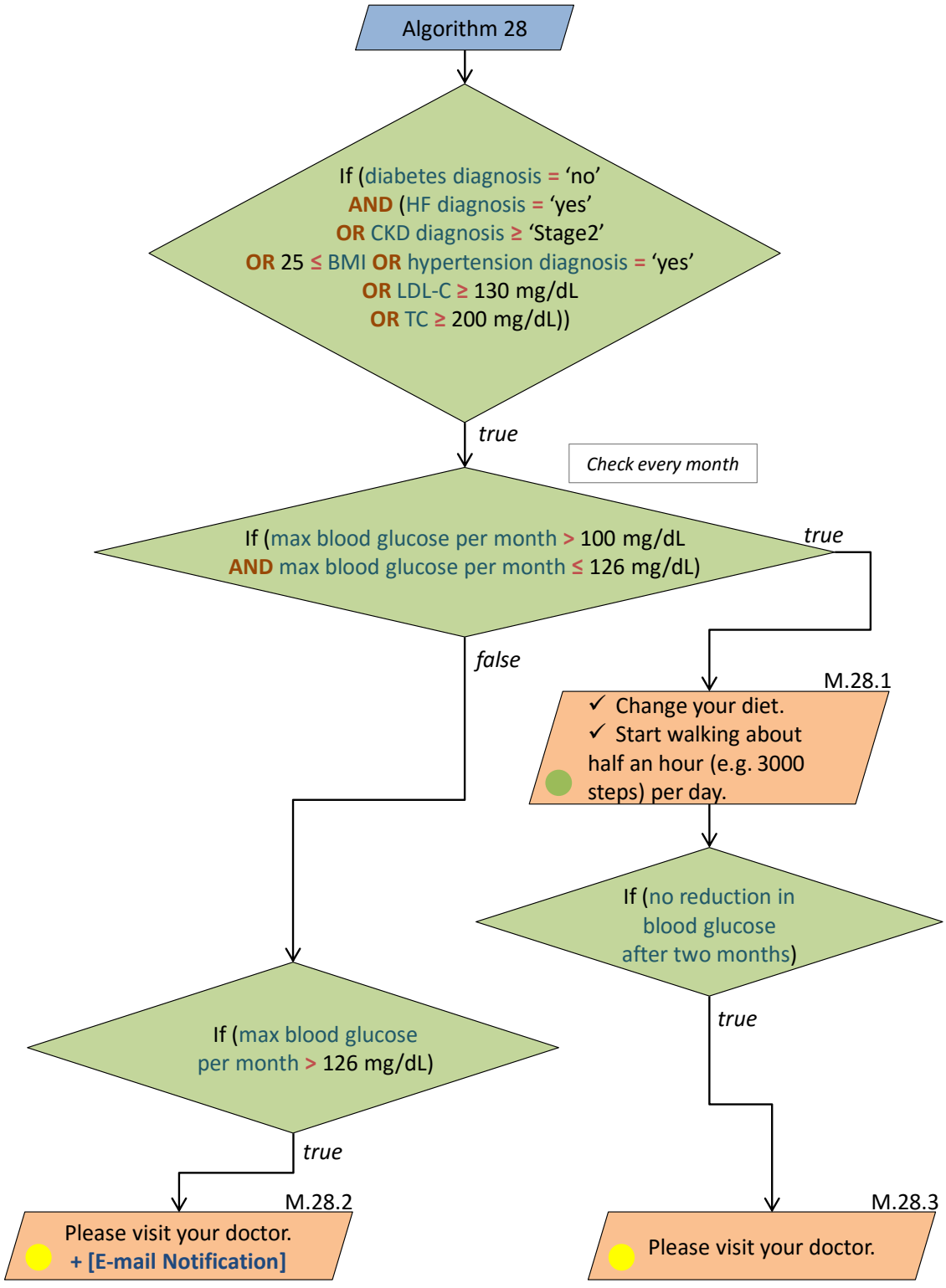

Figure 28. Evaluate blood glucose for patients with HF or CKD (≥ 'Stage2') or 25 ≤ BMI < 30 or hypertension diagnosis or LDL-C ≥ 130 mg/dL or TC ≥ 200 mg/dL.

3.3.4 Heart rate evaluation

Figure 29 shows the algorithm that evaluates heart rate (HR) measurements for patients with HF or CKD (≥ "Stage 2") diagnosis. The goal of this algorithm is to evaluate the average of HR per 3 days (> 90 pulses/min). If this happens, we further evaluate if the body weight or the blood pressure is increased in the same time frame (3 days).

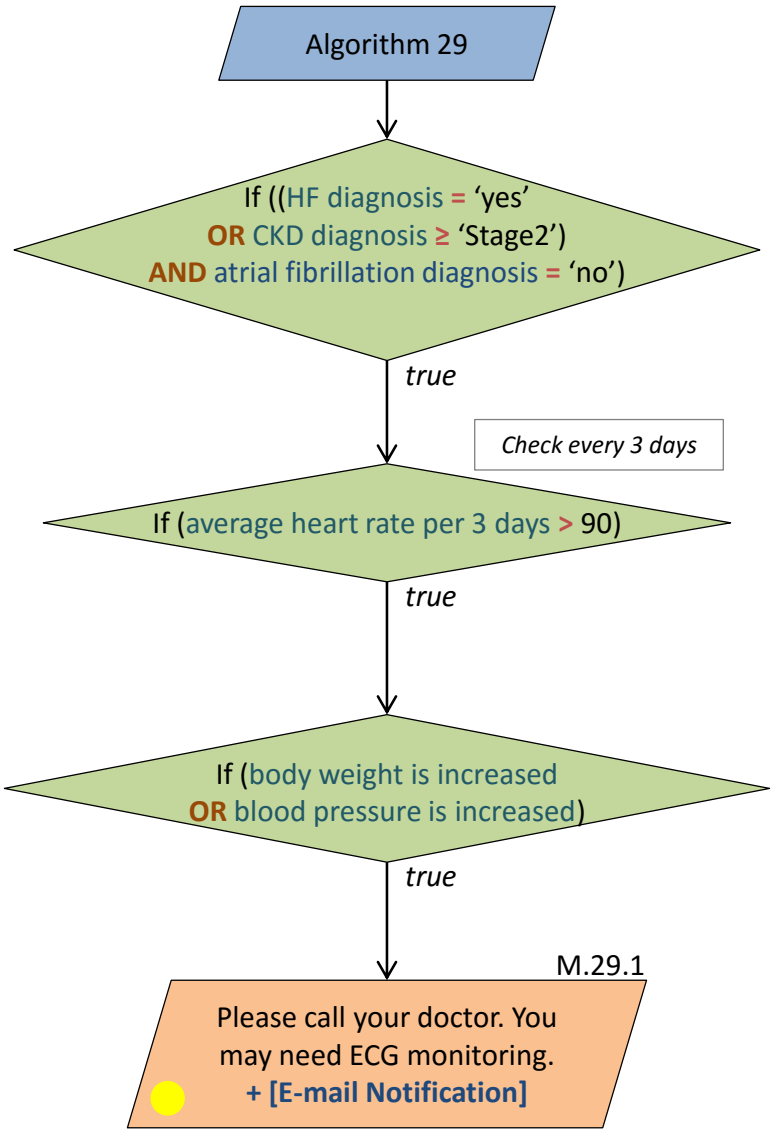

Figure 29. Evaluate heart rate for patients with HF and CKD (≥ 'Stage2').

3.4 DSS to inform on a change in personal risk factors

DSS algorithms described in this section intend to inform the patient about changes in their personal risk factors based on self-monitoring measurements.

To achieve this, the algorithm (Figure 30) calculates the risk ratio for the various CARRE risk factors for the particular patient and informs the patient about any changes as compared with previous risk ratio values (with a monthly frequency). In particular, for each risk factor we evaluate the risk evidence by checking if the observable condition of risk evidence is valid or non valid. As input to the observable condition, we use observables that are measured by sensors or inserted by the patient in the PHR system. The result of this process is a personalized list of risk factors and each of them has a ratio value ([0, +∞), where 1 means that the patient has a risk factor similar to healthy population, while a value between 0 and 1 indicates a protective effect). Then we evaluate the difference of ratio (value for this month minus the value for last month) for each risk factor: if the difference is positive, the particular risk factor is increased or a new risk factor threatens the patient. On the other hand, if this difference is negative, the particular risk factor is decreased.

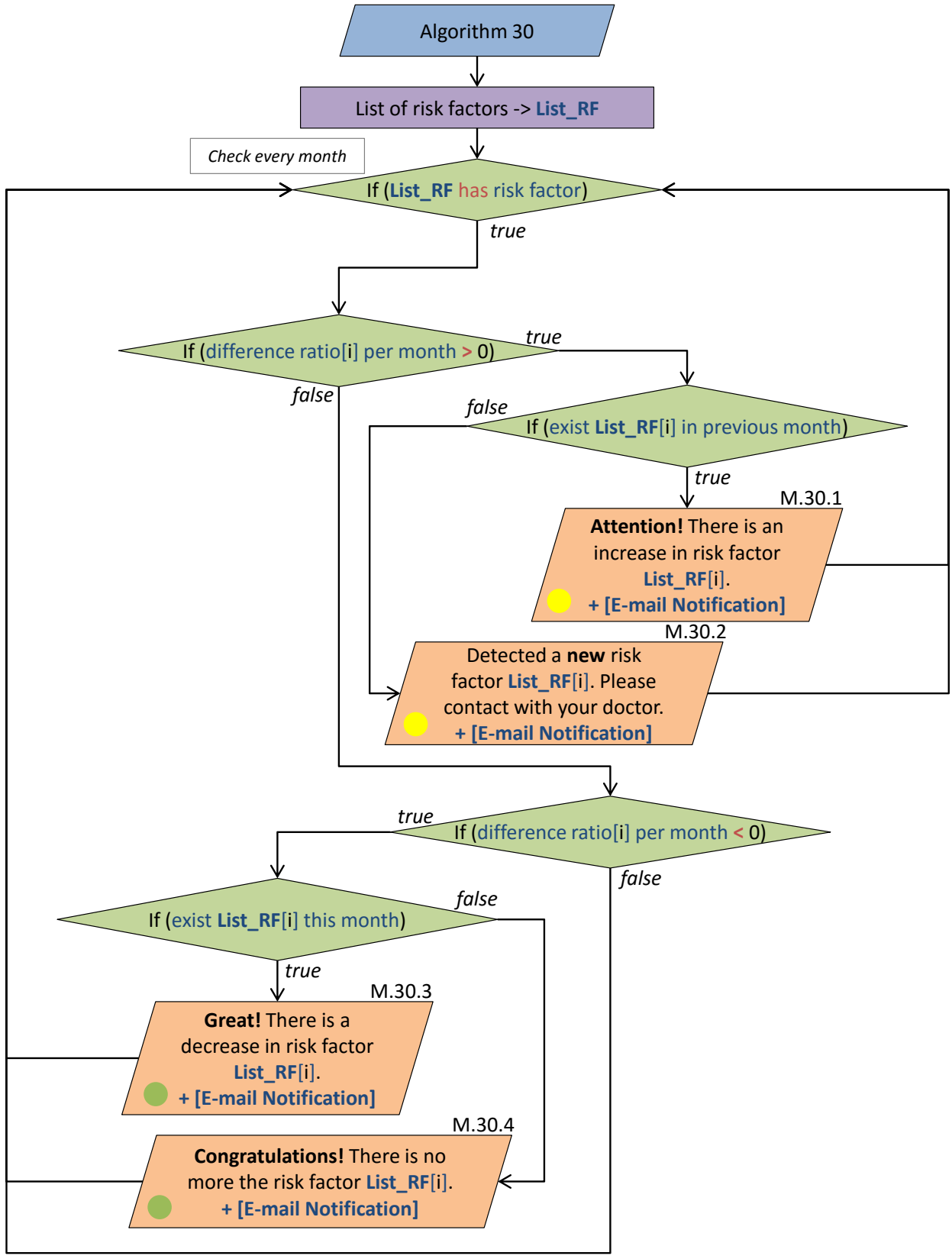

Figure 30. Algorithm to inform on risk factors changes and potential disease progression.

3.5 Educational resources personalization algorithm

Figure 31 shows the algorithm for suggesting relevant educational material for each alert message outcome for all previous DSS algorithms.

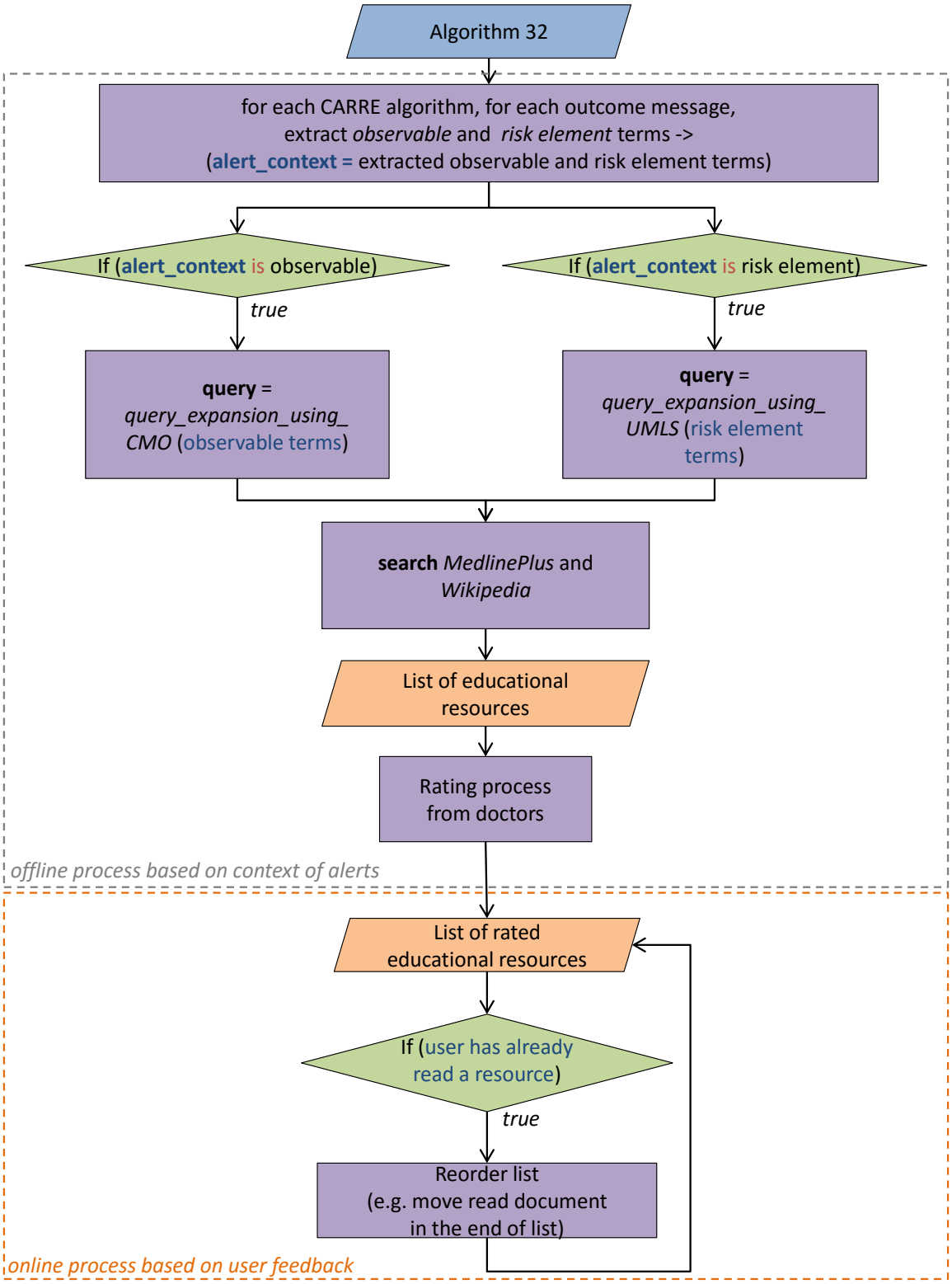

Figure 31. Educational resources retrieval algorithm.

Annex 1

eCP: a formal care plan ontology

This annex reproduces the conference paper publication:

> E. Kaldoudi, G. Drosatos, N. Portokallidis, A. Third. An Ontology based Scheme for Formal Care Plan Meta-Description. In Proc. of the 14th Mediterranean Conference on Medical and Biological Engineering and Computing (MEDICON 2016), Paphos, Cyprus, 31 Mar. – 2 Apr. 2016

which reports on an ontology to describe formal care plans and can also be used to describe decision support algorithms. This work has been performed by members of the CARRE consortium partly within the CARRE project.

Abstract

Contemporary healthcare delivery is based on state-of-the-art scientific best practices captured in systematically developed formal care plans which include guidelines, clinical protocols, integrated care pathways, etc. Research so far has addressed the computerized execution of formal care plans by developing a number of related representation languages, execution engines and integrated platforms to support real time care plan execution. However, much less effort has been put into organizing available formal care plans. In this paper we propose a conceptual model and an ontology for a meta-description of the formal care plan. The proposed conceptual model and ontology allows semantic tagging and enrichment of clinical protocols so that they can be used and re-used across platforms and also be linked directly to other relevant scientific information, e.g. published works in PubMed or personal health records, and other clinical information systems. It also allows modelling of the provenance and justifications for modifications or alterations to care plans.

1. Introduction

Contemporary healthcare delivery is based on state-of-the-art scientific best practices on how to approach each clinical situation. This knowledge is captured in systematically developed standardized procedures of a variety of types, which we collectively refer to as formal care plans and include guidelines, clinical protocols, integrated care pathways, etc. Formal care plans were introduced initially around the 70s[15] and progressively gained their way into routine medical decision making[16]. Despite their wide endorsement, early systematic field research identified barriers in their wide implementation[17] which, together with the advent of clinical decision support systems, led to efforts to create computerized forms of formal care plans[18].

Research so far has addressed the computerized execution of formal care plans and this has resulted in a number of related representation languages, execution engines and integrated platforms to support the real time care plan execution[19,20]. However, much less effort has been put into organizing available formal care plans. Mainly, they are maintained in data silos of the respective issuing body without means for straightforward seamless integration and open availability. Additionally, variations and evolution of care plans is an important topic, and would benefit from formal modelling.

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15 Greenfield S (1978) Clinical algorithms. West J Med 129:230-231

16 Field MJ, Lohr KN (Eds.) (1992) Guidelines for clinical practice: from development to use. National Academy Press, Washington DC

17 Cabana MD, Rand CS, Powe NR et al. (1999) Why don't physicians follow clinical practice guidelines? A framework for improvement. JAMA 282:1458-1465

18 Trivedi MH, Kern JK, Marcee A, et al (2002) Development and implementation of computerized clinical guidelines: barriers and solutions. Methods Inf Med, 41: 435-442

19 Isern D, Moreno A (2008) Computer-based execution of clinical guidelines: a review. International journal of medical informatics, 77(12):787-808

20 Peleg M (2013) Computer-interpretable clinical guidelines: a methodological review. Journal of biomedical informatics, 46(4):744-763

In this paper we propose a conceptual model and an ontology for a meta-description of the formal care plan. Rather than addressing the internal algorithmic steps of a care plan (for which considerable work is published) we discuss the care plan as a whole. The proposed conceptual model and ontology allows semantic tagging and enrichment of clinical protocols so that they can be used and re-used across platforms and also be linked directly to other relevant scientific information, e.g. published works in PubMed or personal health records, and other clinical information systems. It also allows modelling of the provenance and justifications for modifications or alterations to care plans.

2. Related Work

There are several computer-based frameworks for formal care plans in the literature including representation languages, execution engines and integrated platforms. The representation languages allow the encoding of free text care plans into a computerized form that describes their internal structure. Some examples of these languages are: GLIF[21], EON[22], Asbru[23], GUIDE[24], PROforma[25] and PLAN[26]. Accordingly, the corresponding platforms using the above mentioned languages are: GLEE[27], SAGE[28], DeGeL[29], NewGuide[30] and SpEM[31], with the exception of Tallis[32], ArezzoTM[33] and HeCaSe2[34,35] that use the PROforma language. An extensive comparison of these platforms is presented in[19]. In short, each platform utilizes a different language syntax which constitutes a drawback in the dissemination of computerized care plans.

All platforms discussed above include repositories for managing care plans with search and retrieval capabilities but only within the internal structure of each system-specific encoded care plan. This issue has

[21] Peleg M, Boxwala A A, Ogunyemi O et al. (2000) GLIF3: the evolution of a guideline representation format. Proceedings of the AMIA Symposium, pp 645–649

[22] Musen M, Tu S, Das A, et al. (1996) EON: a component-based approach to automation of protocol-directed therapy. Journal of the American Medical Informatics Association, 3(6):367–388

[23] Shahar Y, Miksch S, Johnson P (1998) The Asgaard project: a task-specific framework for the application and critiquing of time-oriented clinical guidelines. Artificial intelligence in medicine, 14(1):29-51

[24] Quaglini S, Stefanelli M, Lanzola G et al. (2001) Flexible guideline-based patient careflow systems. Artificial Intelligence in Medicine 22:65–80

[25] Sutton D R, Fox J (2003) The syntax and semantics of the PROforma guideline modeling language. Journal of the American Medical Informatics Association, 10(5):433–443

[26] Mansour E, Wu B, Dube K et al. (2006) An event-driven approach to computerizing clinical guidelines using XML. Proceedings of the IEEE Services Computing Workshops (SCW 2006), Chicago, USA, IEEE Computer Society, pp 13–20

[27] Wang D, Shortliffe E H (2002) GLEE--a model-driven execution system for computer-based implementation of clinical practice guidelines. Proceedings of American Medical Informatics Association Annual Symposium (AMIA 2002), San Antonio, USA, pp 855–859

[28] Tu S W, Campbell J R, Glasgow J (2007) The SAGE guideline model: achievements and overview. Journal of the American Medical Informatics Association, 14(5):589–598

[29] Shahar Y, Young O, Shalom E et al. (2004) A framework for a distributed, hybrid, multiple-ontology clinical-guideline library and automated guideline-support tools. Journal of Biomedical Informatics, 37(5):325–344

[30] Ciccarese P, Caffi E, Quaglini S et al. (2005) Architectures and tools for innovative health information systems: the guide project. International Journal of Medical Informatics, 74:553–562

[31] Dube K, Mansour E, Wu B (2005) Supporting collaboration and information sharing in computer-based clinical guideline management. Proceedings of 18th IEEE Symposium on Computer-based Medical Systems (CBMS 2005), Dublin, Ireland, pp 232–237

[32] Sutton D R, Fox J (2003) The Syntax and Semantics of the PROforma Guideline Modeling Language, Journal of the American Medical Informatics Association, 10(5), pp 433-443

[33] InferMed (2013) Arezzo Technical White Paper, Tech. rep., InferMed Ltd. URL: http://www.infermed.com/ (Accessed: 12-Jan-2013)

[34] Isern D, Moreno A (2004) Agent-based careflow using CPGs. Recent Advances in Artificial Intelligence Research and Development, Vol. 113 of Frontiers in Artificial Intelligence and Applications, IOS Press, 2004, pp 11–18

[35] Isern D, Sánchez D, Moreno A (2007) HeCaSe2: a multi-agent ontology-driven guideline enactment engine. Proceedings of Fifth International Central and Eastern European Conference on Multi-agent Systems (CEEMAS 2007), Vol. 4696 of LNAI, Springer, pp 322–324

been partially addressed by DeGeL[29] and NewGuide[36] that introduce metadata that describes the internal structure of care plans. Additionally, in some platforms (DeGeL, HeCaSe2 and NewGuide) the repository supports versioning of care plans. In contrast, our focus in this work is to define, in a formal ontology-based way, the platform independent representative metadata and relationships of care plans. This approach aims to be an umbrella over all these systems and provide advantages regarding the management, organization and searching of formal care plans.

3. Formal Care Plans

Formal care plans may be of a variety of types; the most commonly addressed in literature and in medical practice include clinical guidelines, clinical protocols and care pathways. In practice, one can also find other genres of care plans, such as public health guidelines, social care guidelines, even non-formal, evidence-based authoritative advice plans (e.g. NICE advice[37]). The term 'formal care plans' is used here to encompass all the standardized procedures nowadays used in clinical practice and healthcare delivery. The most basic type includes clinical practice guidelines, which are consensus statements, systematically developed to assist health professionals in clinical practice decision-making; thus they are considered formal general recommendations for prevention, diagnosis, treatment, long-term management of disease or advice and information[16]. Clinical protocols (or algorithms) are more detailed statements that set out a precise sequence of activities to be adhered to in the management of a specific clinical condition[15]. On the other hand, care pathways are multidisciplinary care plans that outline the optimal sequencing and timing of interventions for patients for integrated care including procedures inside and outside the health care unit[38]. Irrespective of their type, formal care plans share a number of common characteristics that can be used to describe, identify and thus organize, retrieve and in any way manage a collection of care plans. The following paragraphs describe these basic characteristics, common to all care plans, which are then used to derive an ontology for care plans.

Each care plan comes with some general information. This includes a title and a summary description in textual format. Also, there are a number of different categorizations of care plans, according to their genre, intended clinical use, health issue addresses, and, last but not least, according to the quality of evidence and the strength of recommendation.

Based on their primary clinical goal, care plans can have a variety of purposes, including prevention, diagnosis, treatment, long-term management, and patient training or advice. Also, as each care plan addresses a particular symptom, disease or procedure, it is associated with one (or more) related disorder, disease or other health problem.

Formal care plans are issued by authoritative institutions, such as national and international health organizations and other related regulatory bodies. Care plans are developed based on scientific medical evidence based on published literature. The care plan origin is of outmost importance for a number of reasons. The first is provenance: no one could (or should) trust data purporting to represent medical knowledge without the ability to trace it back to its source. Also, in the case of formal care plans, legal and financial issues may arise from their use and deployment, thus the issuing body is a constraint.

Another important aspect of provenance relates to the actual physical source of the protocol, that is, where one can retrieve it. This conventionally is a document produced by the issuing body, but nowadays care plans are increasingly provided in some computerized form. In any case, the link and the specific of the file formats along with any relevant identifier is information needed for the identification and attainment of the actual care plan. All the above relate to overall information on the care plan and its provenance and source data. However, there still is some important information that is important especially for the management of care plan repositories, and for mechanisms that intend to support meaningful search and retrieval. This

[36] Ciccarese P, Caffi E, Boiocchi L et al. (2004) A guideline management system. Proceedings of 11th World Congress of the International Medical Informatics Association (MEDINFO 2004), Vol. 107 of Studies in Health Technology and Informatics, San Francisco, USA, IOS Press, pp 28–32

[37] National Institute for Health and Care Excellence, UK (2015) NICE advice. URL: https://www.nice.org.uk/About/What-we-do/Our-programmes/NICE-advice, (Accessed: 6-Oct-2015)

[38] Vanhaecht K, Panella M, Zelm R et al. (2010) An overview of the history and concept of care pathways as complex interventions. Int J Care Pathways 14:117-123GRADE Working Group (2004) Grading quality of evidence and strength of recommendations. British Medical Journal (BMJ), 328:1490-1494

information relates somehow to the internal structure of the decision tree and includes the entry point, protocol outcomes and required resources.

Care plans constitute formal recommended procedures and decision trees as derived from scientific evidence. Sources of such evidence can range from small in vitro studies or case reports to large elegant randomized clinical trials that have minimized bias to a great extent. Similarly with evidence, recommendations that are based on the evidence can be of different quality. Poor quality evidence can lead to recommendations that are not in patients' best interests; hence it is essential to assess the confidence we have in the recommendations. Several systems and approaches have been proposed for grading clinical practice guidelines. GRADE[39] is the most widely accepted system, which has been adopted by a large number of evidence review bodies and organizations including the World Health Organization (WHO). In GRADE, medical guidelines are graded along two axes: (a) quality of evidence: A = high, B = moderate, C = low, and D = very low, and (b) strength of recommendation: Level 1 = strong ("we recommend"), and Level 2 = weak or discretionary ("we suggest").

While discussing the origin of a formal care plan, one should also add another factor: often formal care plans are subject to changes during their deployment in clinical practice. These deviations may be due to a number of reasons[40] ; most common ones include local lack of resources, e.g. diagnostic equipment, a low strength recommendation, specific requirements of a concurrent clinical trial protocol, patient refusal to follow certain steps in the plan (e.g. due to religious or other personal issues), insurance policy requirements (e.g. to firstly perform a lower cost procedure), presenting comorbidities not accounted for in the plan or even health professional's direct disagreement due to new contradicting high level medical evidence. For such justified reasons, formal plans may be adapted to local settings. In this case, one has to record the provenance of the adapted plan, i.e. the initial parent plan. This is also true for the cases where an issuing body officially produces a detailed clinical protocol or a care pathway based for example on another more general formal clinical guideline.

In order to deploy a care plan for a particular patient and situation, we need to consider both entry and exit points for care plans, as well as necessary resources to execute them. The protocol entry point is generally a condition that has to be met to determine whether a care plan is relevant for a particular situation and patient. This condition is associated with one or more observables, which is most often a physical or mental property of the patient.

To give an example, the KDIGO Clinical Practice Guideline for the Management of Blood Pressure in Chronic Kidney Disease[41] gives recommendations for patients that meet any of the following conditions: (1) chronic kidney disease patients of any stage who are not undergoing dialysis; (2) chronic kidney disease patients of any stage who are not undergoing dialysis, without diabetes mellitus; (3) chronic kidney disease patients of any stage who are not undergoing dialysis, and present diabetes mellitus; (4) kidney transplants patients; (5) children with chronic kidney disease who are not undergoing dialysis; or (6) elderly with chronic kidney disease who are not undergoing dialysis.

Therefore, in order to be able to describe properly the initial condition, or entry point to the care plan, one needs to identify the involved observables (in this example, chronic kidney disease, dialysis, age, diabetes mellitus, etc.) and construct a logical expression around certain conditions that have to be met.

The outcomes of a care plan may include one or more different expected exit points. These refer to variety of actions or states, e.g. medical diagnosis, instructions to the patient, or initialization of another care plan.

Finally, care plans usually require certain resources in order to be executed. These may include special medical equipment (diagnostic or interventional), special drugs or human resources. In certain cases the availability of such resources may constrain the deployment of a care plan or even may dictate plan adaptation or substitution.

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[39] GRADE working group (2015) Organizations that have endorsed or that are using GRADE. URL: http://www.gradeworkinggroup.org/society/index.htm (Accessed: 6-Oct-2015)

[40] Quaglini S (2008) Compliance with clinical practice guidelines. Stud Health Technol Inform, IOS Press, pp 160–179

[41] Becker G J, Wheeler D C, Zeeuw D D (2012) KDIGO clinical practice guideline for the management of blood pressure in chronic kidney disease. Kidney Int, 2:337–414

4. Formal care plan model and ontology

Based on the above analysis, we propose a conceptual model for the overall description of formal care plans. An overview is shown in Figure 32. The conceptual model and ontology assumes the central entity of *Formal Care Plan* which is related to a number of other entities, grouped in several classes. The class of *General Description* contains classes such as title and description, the *Classification* contains all classes related to different care plans taxonomies, e.g. genre, type, and related health issue.

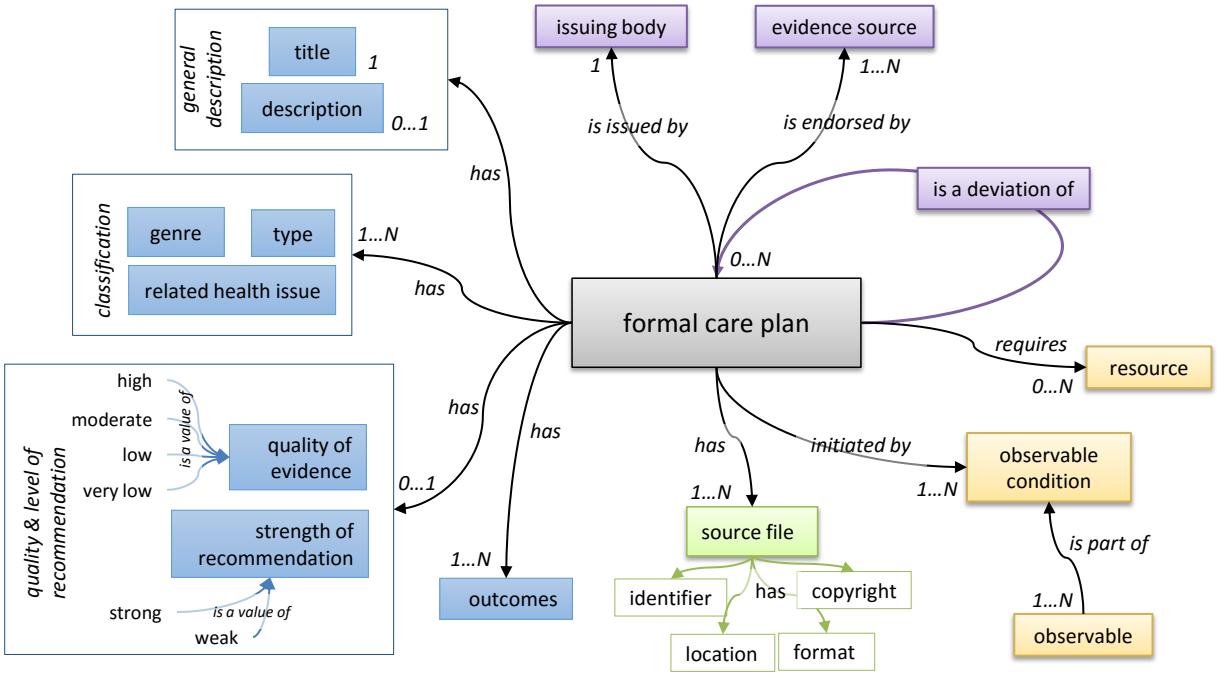

Figure 32. Conceptual model of formal care plan description

The *Quality and Level of Recommendation* groups all subclasses related to the grading of the formal care plan. The Source File subclass refers to the specifics of the actual care plan data, that is, the location, format, any identifier and information on copyrights of the actual file that constitutes the care plan data.

For the care plan to be initiated for a particular patient, certain circumstances should exist. These are reported via certain *Observables*, that is, variables that can be measured or otherwise ascertained (e.g. biomarkers, biometric variables, biological signals and possibly other non-biological factors e.g. environmental). The circumstances thus are ascertained via an explicit logical expression that involves observables; this logical expression is termed *Observables Condition*.

Formal care plans are determined from clinical studies as reported in evidence based medical literature. Thus each care plan is directly related to one (or more) Evidence Source which is a specific scientific publication. Care plans are issued by an authoritative organization represented by the Issuing Body class, which holds amongst else information on the issuing date and any care plan identifier provided by the issuing body.

Figure 33 shows a view of the proposed eCP ontology, the defined classes and the relationships among them. Finally, key to the model and ontology is the Deviation relationship, which defines the history of the care plans in the case it is derived as an update, an evolution or a deviation from other formal care plans. This includes information on the reason for deriving the new care plan, and a more detailed description of the process.

The proposed model was used to develop the eCP ontology, implemented in the Web Ontology Language (OWL2[42]) using the Protégé editor[43]. Protégé is a free, open-source tool for building domain models and ontologies. The eCP ontology is available in NCBO BioPortal[44] http://purl.bioontology.org/ontology/ECP.

To ensure that the model and ontology can be seamlessly integrated into existing medical information systems, we adopt commonly used standards and controlled vocabularies. For example, related health conditions and protocol outcomes include an ICD-10[45] identifier. Observables include a SNOMED-CT[46] identifier, and measurements and units in the observable condition follow the QUDT[47] and UO[48] ontologies. The logical expression for the observable condition that describes the entry point to the care plan is encoded with logical and comparison operators that are derived from OWL Description logic[42]. Furthermore, the observables and the observable condition are mapped with the CARRE Risk Factor Ontology[49]. Evidence sources are described using their DOI and/or their PubMed identifier that are mapped with the Bibliographic Ontology[50], while evidence level and recommendation strength and quality of evidence follows the GRADE system[39]. Issuing bodies are described following the SWRC ontology[51]. Where available UMLS[52] codes are also used. Overall, NCBO BioPortal lists 56 class mappings between the proposed ontology and other ontologies.

The model and ontology were developed based on focus groups with health care professionals (4 medical experts and 4 technology experts). They were tested with 20 protocols and guidelines from the following issuing bodies: National Institute for Health and Care Excellence (NICE), National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF KDOQI), American Diabetes Association (ADA), Hellenic Society of Nephrology and two Greek National University Hospitals, and with protocols developed in the project "Electronic Clinical Protocols" project (MIS 375876), funded under the Greek National Programme Thales, co-funded by the European Commission. This process of testing and using the proposed model resulted in the following qualitative findings. The medical experts found the model straightforward to use to describe existing guidelines and protocols. The terminology used was found to be familiar and thus easy to understand and apply and also to read descriptions already produced by their colleagues. The only difficulty identified related to expressing accurately and rigorously the initial condition that has to be satisfied in order for a care plan to be deployed. Initially, medical experts were asked to produce this condition in the conventional way this is written in the literature, using natural language – which was a straightforward task. Subsequently, they were asked to reformat this condition using a logical operator expression (so that this expression can be easily translated to computer readable format). This task proved to be more cumbersome and required 1-2 hours training and testing before the medical experts could independently produce correct expressions. To aid this process we have developed a web-based system for the description of care plans which includes a graphical logical expression editor (Figure 34). The expression builder follows a web component architecture and it is implemented in Javascript and HTML5 using the AngularJS framework.

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42 Motik B, Patel-Schneider P F, Parsia B et al. (2009) OWL 2 web ontology language: Structural specification and functional-style syntax. W3C recommendation, 27(65)

43 Gennari J, Musen M, Fergerson R et al. (2003) The evolution of Protégé: an environment for knowledge-based systems development. International Journal of Human-Computer Studies, 58(1):89–123

44 Noy N F, Shah N H, Whetzel P L, et al (2009) BioPortal: ontologies and integrated data resources at the click of a mouse. Nucleic Acids Res 1:37, BioPortal can be accessed at http://bioportal.bioontology.org

45 International Classification of Diseases v10 (ICD-10) at http://www.who.int/classifications/icd/en/

46 Systemized Nomenclature of Medicine - Clinical Terms (SNOMED-CT) at http://www.ihtsdo.org/snomed-ct/

47 Quantity, Unit, Dimension and Type Ontologies (QUDT) at http://qudt.org/

48 The Ontology of Units of Measurement (UO) at https://code.google.com/p/unit-ontology/

49 Third A, Kaldoudi E, Gotsis G et al. (2015) Capturing Scientific Knowledge on Medical Risk Factors. K-CAP2015: 8th International Conference on Knowledge Capture, ACM, Palisades, NY, USA (In Press 7-Oct-2015)

50 D'Arcus B, Giasson F (2009) Bibliographic ontology specification. URL: http://bibliontology.com/specification (Accessed: 8-Oct-2015)

51 Sure Y, Bloehdorn S, Haase P et al. (2005) The SWRC ontology-semantic web for research communities. Proceedings of the 12th Portuguese Conference on Artificial Intelligence (EPIA 2005), Vol. 3808 of Lecture Notes in Computer Science, Covilha, Portugal, Springer, pp 218-231

52 The Unified Medical Language System (UMLS) at http://www.nlm.nih.gov/research/umls/

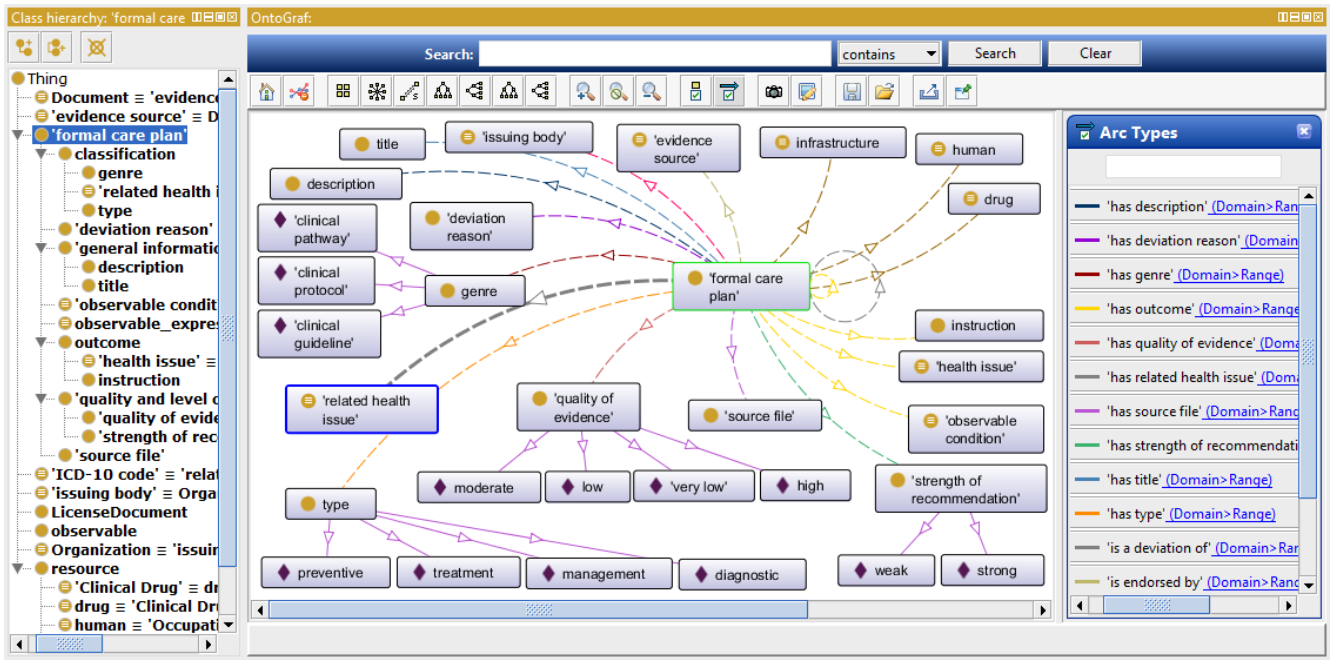

Figure 33. Snapshot of classes and relationships in the Protégé environment

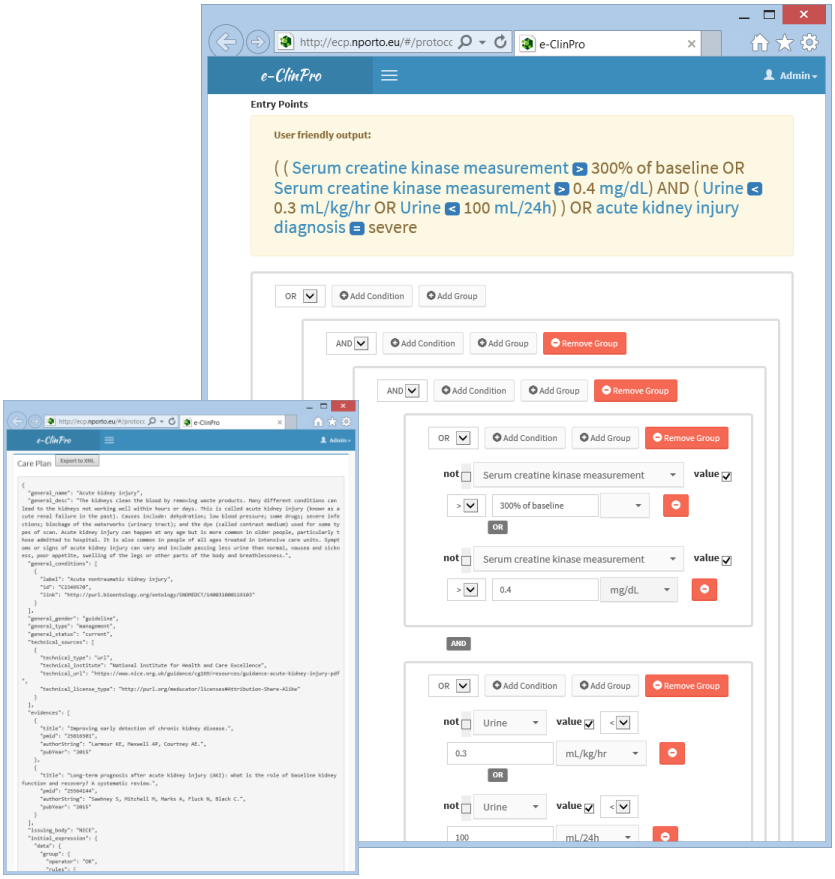

Figure 34. Snapshot of the eCP description environment with the logical expression builder.

5. Conclusions and discussion

This paper introduces a metadata scheme and ontology for the description of formal care plans. The eCP ontology provides a scheme for care plan meta-description in order to support: (a) care plan management in electronic repositories; (b) organization and classification; (c) universal tracking queries of care plans used by search engines or medical portals; (d) literature of evidence provenance; and (e) institutional provenance.

Work in progress includes development of a web-based editor to allow intuitive generation of metadata for formal care plans, following the proposed ontology. The metadata will be exported as XML and also RDF, the later to allow for care plan descriptions to be integrated into the semantic web and the Linked Open Data cloud.

Our focus in this work is to define in a formal, ontology-based, platform-independent metadata set to describe formal care plans and their relationships of care plans.

6. Acknowledgement

This work was supported by the partly funded by eCP: Electronic Clinical Protocols project (MIS 375876), funded under the Greek National Programme Thales, co-funded by the European Commission. Specifically, the observable and logical expression modeling was supported by the FP7-ICT project CARRE (Grant No. 611140), funded in part by the European Commission.

Annex 2

Software of Personalized Services for the Patient

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).

Annex 3

DSS Messages

Message ID	Short message in flowcharts	Actual message to patients
M.1.1	Measure blood pressure twice per day (morning and evening) for a week.	Monitor your blood pressure twice per day for a week; take the first blood pressure measurement in the morning before eating or taking any medications, and the second in the evening. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center**.**
M.1.2	Your blood pressure was abnormal last week, please contact your family doctor. Please continue measuring your blood pressure twice per day.	Your blood pressure was abnormal last week! Please contact your family doctor for further hypertension management recommendations. Please continue measuring your blood pressure twice per day. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center**.**
M.1.3	Congratulations! Your blood pressure is well controlled. Please measure blood pressure once per week (morning).	Congratulations! Your blood pressure is well controlled. Please measure blood pressure once per week; take the blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center**.**
M.1.4	Your blood pressure reached abnormal values! Please start your blood pressure measurements twice per day (morning and evening) for a week.	Your blood pressure reached abnormal values! Please start your blood pressure measurements twice per day for a week**;** take the first blood pressure measurement in the morning before eating or taking any medications, and the second in the evening. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. If you feel any additional symptoms that discomforts you, please consider possibility to contact your doctor. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center**.**
M.1.5	Measure blood pressure once per day (morning)	Monitor your blood pressure once per day; take the blood pressure measurement in the morning before

		eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center**.**
M.2.1	Measure body weight once per day (morning)	Measure your body weight once per day every 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. Be sure the scale is on a flat, hard surface.
M.2.2	Measure body weight once per week (morning)	Measure your body weight once per week 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. Be sure the scale is on a flat, hard surface.
M.2.3	Measure body weight once per month (morning)	Measure your body weight once per month 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. Be sure the scale is on a flat, hard surface.
M.2.4	Occasionally measure body weight (morning) (at least once per 3 months)	Measure your body weight at least once per 3 months 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. Be sure the scale is on a flat, hard surface.
M.3.1	Measure blood glucose three times per day (before breakfast, before lunch and before dinner)	Monitor your blood glucose three times per day; take the first blood glucose measurement in the morning before breakfast or taking any medications, the second before lunch and the third before dinner. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.3.3	Measure blood glucose once per month (before breakfast)	Monitor your blood glucose once per month; take the blood glucose measurement in the morning before breakfast or taking any medications. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.

M.3.4	Occasionally measure blood glucose (before breakfast) (at least once per 6 months)	Monitor your blood glucose at least once per 6 months; take the blood glucose measurement in the morning before breakfast or taking any medications. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.4.1	Non special recommendations about physical activity. Please walk only as long as you feel comfortable.	Please walk only as long as you feel comfortable. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.4.2	Please walk 30 min (~3000 steps or 2.4 Km) 3-4 times per week.	Please walk 30 min (~3000 steps or 2.4 Km) for 3-4 times per week. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.4.3	Please walk at least 30 min (over 3000 steps or 2.4 Km) per day.	Please walk at least 30 min (over 3000 steps or 2.4 Km) per day. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.4.4	Please walk at least 60 min (over 6000 steps or 4.8 Km) per day.	Please walk at least 60 min (over 6000 steps or 4.8 Km) per day. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.4.5	Please walk at least 90 min (over 9000 steps or 7.2 Km) per day.	Please walk at least 90 min (over 9000 steps or 7.2 Km) per day. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.4.6	If it is possible, try to walk instead of using transportation.	Please try to walk instead of using transportation. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.5.1	Please follow your instructions: Measure blood pressure twice per day (morning and evening)	You haven't taken blood pressure measurement for 2 days! Please measure your blood pressure twice per day; take the first blood pressure measurement in the morning before eating or taking any medications, and the second in the evening. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.5.2	You haven't taken measurement for blood pressure 5 days, please	You haven't taken blood pressure measurement for 5 days! Please measure your blood pressure twice per day; take the first blood pressure measurement in the

	measure blood pressure twice per day	morning before eating or taking any medications, and the second in the evening. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.5.3	You haven't taken measurement for blood pressure 7 days, please measure blood pressure at least twice per day	You haven't taken blood pressure measurement for 7 days! You are at high risk! Please measure your blood pressure twice per day; take the first blood pressure measurement in the morning before eating or taking any medications, and the second in the evening. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.5.4	Bravo! You go great! You correctly follow your instructions for a week.	Bravo! You go great! You correctly follow your instructions for a week. Keep measure your blood pressure twice per day; take the first blood pressure measurement in the morning before eating or taking any medications, and the second in the evening. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.6.1	Please follow your instructions: Measure blood pressure once per day (morning before breakfast)	You haven't taken blood pressure measurement for a day! Please measure your blood pressure once per day; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.6.2	You have high risk, please take your measurements at least once per day.	You haven't taken blood pressure measurement for 3 days! Please measure your blood pressure once per day; take your blood pressure measurement in the morning before eating or taking any medications. Blood

		pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1- 2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.6.3	You haven't taken a measurement for blood pressure 5 days, please measure blood pressure once per day	You haven't taken blood pressure measurement for 5 days! Please measure your blood pressure once per day; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.6.4	You haven't taken measurement for blood pressure 7 days, please measure blood pressure once per day	You haven't taken blood pressure measurement for 7 days! You are at high risk! Please measure your blood pressure once per day; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1- 2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.6.5	Congratulations! You correctly follow your instructions for the last 7days.	Bravo! You go great! You correctly follow your instructions for the last 7 days. Keep measure your blood pressure once per day; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.7.1	Please follow your instructions: Measure blood pressure once per week (morning before breakfast)	You haven't taken blood pressure measurement for a week! Please measure your blood pressure once per week; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and

		with two measurements per occasion taken 1-2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.7.2	You haven't taken measurement for blood pressure 2 weeks, please measure blood pressure at least once per week	You haven't taken blood pressure measurement for 2 weeks! Please measure your blood pressure once per week; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1 – 2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center.
M.7.3	Congratulations! You correctly follow your BP monitoring regime for the last month.	Bravo! You go great! You correctly follow your instructions for the last month. Keep measure your blood pressure once per week; take your blood pressure measurement in the morning before eating or taking any medications. Blood pressure is measured in a quiet room, in the seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1 – 2 min apart. Avoid food, caffeine, tobacco and alcohol for 30 minutes before taking a measurement. REMEMBER! If your blood pressure is ≥180 mmHg (systolic) or ≥110 mmHg (diastolic), and remains so high after repeated measurement performed within 1-3 min – please call to Emergency Medical Service Center**.**
M.8.1	Please follow your instructions: Measure body weight once per day (morning)	You haven't taken body weight measurement for a day! Please measure your body weight once per day 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. Be sure the scale is on a flat, hard surface.
M.8.2	You have high risk, please measure your body weight at least once per day.	You haven't taken body weight measurement for 3 days! Please measure your body weight once per day 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. Be sure the scale is on a flat, hard surface.
M.8.3	You haven't taken measurement for body weight 5 days, please measure body weight once per day	You haven't taken body weight measurement for 5 days! Please measure your body weight once per day 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. Be sure the scale is on a flat, hard surface.
M.8.4	You haven't taken measurement for body weight 7 days, please measure body weight once per	You haven't taken body weight measurement for 7 days! Please measure your body weight once per day in the morning, before breakfast, before medications and any

	day	liquids and after urinating, with the same type of clothes on, without shoes, on the same scale and in the same spot. Be sure the scale is on a flat, hard surface.
M.8.5	Congratulations! You correctly follow your instructions for 7 days.	Bravo! You go great! You correctly follow your instructions for 7 days. Keep measure your body weight once per day 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. Be sure the scale is on a flat, hard surface.
M.9.1	Please follow your instructions: Measure body weight once per week (morning)	You haven't taken body weight measurement for a week! Please measure your body weight once per week 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. Be sure the scale is on a flat, hard surface.
M.9.2	You haven't taken measurement for body weight 2 weeks, please measure body weight once per week	You haven't taken body weight measurement for 2 weeks. Please measure your body weight once per week 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. Be sure the scale is on a flat, hard surface.
M.9.3	Congratulations! You correctly follow your instructions for a month.	Bravo! You go great! You correctly follow your instructions for a month. Keep measure your body weight once per week 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. Be sure the scale is on a flat, hard surface.
M.10.1	Please follow your instructions: Measure body weight once per month (morning)	You haven't taken body weight measurement for a month! Please measure your body weight once per month 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. Be sure the scale is on a flat, hard surface.
M.10.2	You haven't taken measurement for body weight 2 months, please measure body weight once per month	You haven't taken body weight measurement for 2 months. Please measure your body weight once per month 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. Be sure the scale is on a flat, hard surface.
M.10.3	Congratulations! You correctly follow your instructions for 2 months.	Bravo! You go great! You correctly follow your instructions for 2 months. Keep measure your body weight once per month 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. Be sure the scale is on a flat, hard surface.
M.11.1	Please follow your instructions: Measure blood glucose three times per day (before breakfast,	You haven't taken measurement blood glucose for a day! Please measure your blood glucose three times per day; take the first blood glucose measurement in the morning before breakfast or taking any medications, the

	lunch & dinner)	second before lunch and the third before dinner. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.11.2	You have high risk, please measure your blood glucose at least three times per day.	You haven't taken measurement blood glucose for 3 day! Please measure your blood glucose at least three times per day; take the first blood glucose measurement in the morning before breakfast or taking any medications, the second before lunch and the third before dinner. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.11.3	You haven't taken measurement for blood glucose 5 days, please measure blood glucose three times per day.	You haven't taken measurement blood glucose for 5 day! Please measure your blood glucose three times per day; take the first blood glucose measurement in the morning before breakfast or taking any medications, the second before lunch and the third before dinner. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.11.4	You haven't taken a measurement for blood glucose for 7 days, please measure blood glucose three times per day.	You haven't taken measurement blood glucose for 7 day! You are at high risk! Please measure your blood glucose three times per day; take the first blood glucose measurement in the morning before breakfast or taking any medications, the second before lunch and the third before dinner. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.

M.11.5	Congratulations! You correctly follow your instructions for 7 days.	Congratulations! You correctly follow your instructions for the last 7 days. Keep measure your blood glucose three times per day; take the first blood glucose measurement in the morning before breakfast or taking any medications, the second before lunch and the third before dinner. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip.
M.13.1	Please follow your instructions: Measure blood glucose once per month (before breakfast)	You haven't taken measurement blood glucose for a month! Please measure your blood glucose once per month; take the blood glucose measurement in the morning before breakfast or taking any medications. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.13.2	You haven't taken measurement for blood glucose 2 months, please measure blood glucose at least once per month	You haven't taken measurement blood glucose for 2 months! Please measure your blood glucose once per month; take the blood glucose measurement in the morning before breakfast or taking any medications. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip. REMEMBER! If your blood glucose is ≤ 70 mg/dL, please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.13.3	Congratulations! You correctly follow your instructions for 2 months.	Congratulations! You correctly follow your instructions for 2 months. Keep measure your blood glucose once per month; take the blood glucose measurement in the morning before breakfast or taking any medications. In order to take a measurement, please follow the next steps: (1) wash your hands and dry them well before doing the test, (2) use an alcohol pad to clean the area that you're going to prick, (3) insert the test strip into your glucose meter, (4) prick yourself with a sterile lancet to get a drop of blood, and (5) place the drop of blood on the test strip.
M.14.1	Please be careful!!! Don't overdo it when exercising.	Please be careful!!! Don't overdo it when exercising. Please walk only as long as you feel comfortable. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.

M.15.1	Congratulations! You reached your goal for today!	Congratulations! You reached your goal for today! You walked ≥ 3000 steps! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.15.2	You already have 4 days this week with 3000 steps per day.	Good job! You already have 4 days this week with 3000 steps per day. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.15.3	You only walked **cnt** days (with 3000 steps) this week. Next week, please try to walk a bit more.	You only walked **cnt** days (with 3000 steps) this week. Next week, please try to walk a bit more. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.15.4	Congratulations! You reached your goal this week (3000 steps **cnt** times this week).	Congratulations! You reached your goal! You walked 3000 steps **cnt** times this week! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.15.5	No need to walk more than 3-4 times per week.	No need to walk 3000 steps more than 3-4 times per week. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.16.1	Congratulation! You reached your daily goal!	Congratulations! You reached your goal! You walked ≥ 3000 steps today! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.16.2	Great! You already have **cnt** high active days this month. Please try more!	Great! You already have **cnt** high active days this month. Please try more! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.16.3	Great! You already have **X** steps today. Please try more! You have **Y** hours to achieve your goal.	Great! You already have **X** steps today. Please try more! You have **Y** hours to achieve your goal! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.16.4	Bravo! You already have **cnt** high active days this month. Please try little more!	Bravo! You already have **cnt** high active days this month. Please try little more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.16.5	You already have **X** steps and you are not so far from your goal.	You already have **X** steps and you are not so far from your goal. Please try little more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.16.6	Congratulation! You were high active (**cnt** high active days) this month.	Congratulation! You were high active (**cnt** high active days) this month. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.1	Congratulation! You reached your daily goal!	Congratulation! You reached your daily goal! You walked ≥ 6000 steps today! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.2	Bravo! You already have **X** steps	Bravo! You already have **X** steps today. Please try little

	today. Please try little more!	more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.3	Great! You already have **cnt** high active days this month. Please try more!	Great! You already have **cnt** high active days this month. Please try more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.4	Great! You already have **X** steps today. Please try more! You have **Y** hours to achieve your goal.	Great! You already have **X** steps today. Please try more! You have **Y** hours to achieve your goal! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.5	Bravo! You already have **cnt** high active days this month. Please try little more!	Bravo! You already have **cnt** high active days this month. Please try little more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.6	You already have **X** steps and you are not so far from your goal.	You already have **X** steps and you are not so far from your goal. Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.17.7	Congratulation! You were high active (**cnt** high active days) this month.	Congratulation! You were high active (**cnt** high active days) this month. Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.1	Congratulations! You reached your daily goal!	Congratulations! You reached your daily goal! You walked ≥ 9000 steps today! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.2	Congratulations! You already have **X** steps today. Please try little more!	Congratulations! You already have **X** steps today. Please try little more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.3	Great! You already have **cnt** high active days this month. Please try more!	Great! You already have **cnt** high active days this month. Please try more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.4	Great! You already have **X** steps today. Please try more! You have **Y** hours to achieve your goal.	Great! You already have **X** steps today. Please try more! You have **Y** hours to achieve your goal. Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.5	Congratulations! You already have **cnt** high active days this month. Please try little more!	Congratulations! You already have **cnt** high active days this month. Please try little more! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.6	You already have **X** steps - you are not so far from your goal.	You already have **X** steps - you are not so far from your goal! Do not give up! Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.18.7	Congratulations! You were high active (**cnt** high active days) this	Congratulations! You were high active (**cnt** high active days) this month.

	month.	Please remember: Don't forget to use your activity meter in order to monitor your physical activity.
M.19.1	ATTENTION! Take another blood pressure measurement and if it is still high, please go to hospital immediately.	Attention! Your last systolic blood pressure was > 180 mmHg, or your last diastolic blood pressure was > 120 mmHg. Please take another blood pressure measurement in a quiet room, in the seated position, back and arm supported. **If it is still high**, please go to hospital immediately.
M.20.1	Check your ankles for fluid detention.	Your systolic blood pressure average per week was ≥ 135 mmHg and **≤** 145 mmHg, or your diastolic blood pressure average per week was ≥ 85 mmHg and **≤** 90 mmHg. Please check your ankles for fluid detention.
M.20.2	Please call your doctor and reduce salt intake.	Are your ankles swollen? **If yes**, please call your doctor and reduce salt intake.
M.20.3	Please visit your doctor and reduce salt intake.	Your systolic blood pressure average per week was > 145 mmHg, or your diastolic blood pressure average per week was > 90 mmHg. Please visit your doctor and reduce salt intake.
M.20.4	Please visit your doctor.	Your systolic blood pressure average per week was < 100 mmHg, or your diastolic blood pressure average per week was < 60 mmHg. Please visit your doctor!
M.20.5	ATTENTION! Take another blood pressure measurement and if it is still high, go to the nearest hospital.	Attention! Your last systolic blood pressure was > 160 mmHg, or your last diastolic blood pressure was > 110 mmHg. Please take another blood pressure measurement in a quiet room, in the seated position, back and arm supported. **If it is still high**, please go to nearest hospital.
M.21.2	Start walking more than half an hour (over 3000 steps) per day, reduce salt intake and increase vegetables intake.	Your systolic blood pressure average per week was > 120 mmHg and ≤ 140 mmHg, or your diastolic blood pressure average per week was > 80 mmHg and ≤ 90 mmHg. Please start walking more than half an hour (over 3000 steps) per day, reduce the salt intake and increase the vegetables intake.
M.21.3	Please increase fruits intake.	Your systolic blood pressure average per week was > 120 mmHg and ≤ 140 mmHg, or your diastolic blood pressure average per week was > 80 mmHg and ≤ 90 mmHg. Please increase the fruits intake.
M.21.4	Please increase your daily activity, at least half an hour walking (over 3000 steps) per day.	Your systolic blood pressure average per week was > 120 mmHg and ≤ 140 mmHg, or your diastolic blood pressure average per week was > 80 mmHg and ≤ 90 mmHg. Your steps average per day for one week was < 3000! Please increase your daily activity, at least half an hour walking (over 3000 steps) per day.

M.22.2	Start walking more than half an hour (over 3000 steps) per day, reduce salt intake and increase vegetables and fruits intake.	Your systolic blood pressure average per 3 months was > 120 mmHg and ≤ 140 mmHg, or your diastolic blood pressure average per 3 months was > 80 mmHg and ≤ 90 mmHg. Please start walking more than half an hour (over 3000 steps) per day, reduce salt intake and increase vegetables and fruits intake.
M.23.1	Check your ankles for fluid detention.	Your body weight has increased during last day (≥ 1 Kg), this may mean that your body is retaining fluid! Please check your ankles for fluid detention.
M.23.2	Call your doctor and reduce salt intake.	Your body weight has increased in last three days (≥ 2 Kg)! Please call your doctor and reduce salt intake.
M.23.3	Please urgently go to hospital.	Do you have dyspnea? **If yes**, please urgently go to hospital!!!
M.23.4	Reduce salt intake.	Are your ankles swollen? **If no**, please reduce salt intake.
M.23.5	Please call your doctor	Are your ankles swollen? **If yes**, please call your doctor.
M.24.1	• Start walking about an hour (e.g. 6000 steps) per day. • Reduce the amount of food. • Change your diet.	Your body weight has increased during last week (≥ 1 Kg)! Please have in mind the followings: (1) start walking about an hour (e.g. 6000 steps) per day, (2) reduce the amount of food and (3) change your diet.
M.24.2	Please increase your daily activity, at least an hour walking (e.g. 6000 steps) per day.	Your body weight has increased during last week (≥ 1 Kg) and your steps average per day for 3 days was < 6000! Please increase your daily activity, at least an hour walking (e.g. 6000 steps) per day.
M.25.1	• Start walking about an hour (e.g. 6000 steps) per day. • Reduce the amount of food. • Change your diet.	Your body weight has increased during last week (≥you seem to have gained about 2 Kg or more)! Please have in mind the followings: (1) start walking about an hour (e.g. 6000 steps) per day, (2) reduce the amount of food and (3) change your diet.
M.25.2	Please increase your daily activity, at least an hour walking (e.g. 6000 steps) per day.	Your body weight has increased during last month (≥ 2 Kg) and your steps average per day for one week was < 6000! Please increase your daily activity, at least an hour walking (e.g. 6000 steps) per day.
M.26.1	• Consume 15-20 grams of glucose or simple carbohydrates. • Call an ambulance.	Attention! Your last blood glucose was ≤ 70 mg/dL. Please consume 15-20 grams of glucose or simple carbohydrates and call an ambulance.
M.26.2	• Change your diet. • Do you take your pills? • Start walking about an hour (e.g. 6000 steps) per day.	Your blood glucose maximum per day was > 140 mg/dL and **≤** 200 mg/dL. Please have in mind the followings: (1) change your diet, (2) do you take your pills? and (3) start walking about an hour (e.g. 6000 steps) per day.
M.26.3	Please call your doctor.	Attention! Your blood glucose maximum per day was >

		200 mg/dL. Please call your doctor!
M.28.1	• Change your diet. • Start walking about half an hour (e.g. 3000 steps) per day.	Your blood glucose maximum per month was > 100 mg/dL and ≤ 126 mg/dL. Please have in mind the followings: (1) change your diet, and (2) start walking about an hour (e.g. 3000 steps) per day.
M.28.2	Please visit your doctor.	Your blood glucose maximum per month was > 126 mg/dL. Please visit your doctor!
M.28.3	Please visit your doctor.	There is no reduction of blood glucose after two months! Your blood glucose maximum per month continues to be > 100 mg/dL and ≤ 126 mg/dL. Please visit your doctor!
M.29.1	Please call your doctor. You may need ECG monitoring.	Your heart rate average for the last 3 days was > 90 pulse/min. Your body weight or your blood pressure is increased. Please call your doctor. You may need ECG monitoring!
M.30.1	Attention! There is an increase in risk factor **List_RF**[i].	Attention! There is an increase in risk factor **List_RF**[i] as regards the last month.
M.30.2	Detected a new risk factor **List_RF**[i]. Please contact with your doctor.	Detected a new risk factor **List_RF**[i] as regards the last month. Please contact with your doctor!
M.30.3	Great! There is a decrease in risk factor **List_RF**[i].	Great! There is a decrease in risk factor **List_RF**[i] as regards the last month.
M.30.4	Congratulations! There is no more the risk factor **List_RF**[i].	Congratulations! There is no more the risk factor **List_RF**[i].