ESC Heart Failure

Digital Health in Older Adults for the Prevention and Management of Cardiovascular Diseases and Frailty

--Manuscript Draft--

Manuscript Number:	ESCHF-21-01118R1
Full Title:	Digital Health in Older Adults for the Prevention and Management of Cardiovascular Diseases and Frailty
Article Type:	Review
Corresponding Author:	Luigina Guasti, MD PhD Universita degli Studi dell'Insubria Varese, VARESE ITALY
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universita degli Studi dell'Insubria
Corresponding Author's Secondary Institution:	
Corresponding Author E-Mail:	Luigina.Guasti@uninsubria.it
First Author:	Luigina Guasti, MD PhD
First Author Secondary Information:	
Order of Authors:	Luigina Guasti, MD PhD
	Polychronis Dilaveris
	Mamas A Mamas
	Dimitrios Richter
	Ruxandra Christodorescu
	Joost Lumens
	Mark Schuuring
	Stefano Carugo
	Jonathan Afilalo
	Marc Ferrini
	Riccardo Asteggiano
	Martin R Cowie
Order of Authors Secondary Information:	
Abstract:	Digital health technology is receiving increasing attention in cardiology. The rise of accessibility of digital health tools including wearable technologies and smart phone applications used in medical practice has created a new era in healthcare. The coronavirus pandemic has provided a new impetus for changes in delivering medical assistance across the world. This Consensus document discusses the potential implementation of digital health technology in older adults, suggesting a practical approach to general cardiologists working in an ambulatory outpatient clinic, highlighting the potential benefit and challenges of digital health in older patients with, or at risk of, cardiovascular disease. Advancing age may lead to a progressive loss of independence, to frailty, and to increasing degrees of disability. In Geriatric Cardiology digital health technology may serve as an additional tool both in cardiovascular prevention and treatment that may help by 1) supporting self-caring patients with cardiovascular disease to maintain their independence and improve the management of their cardiovascular disease 2) improving the prevention, detection and management of frailty and supporting

	collaboration with caregivers. Digital health technology has the potential to be useful for every field of cardiology, but notably in an office-based setting with frequent contact with ambulatory older adults who may be pre-frail or frail but who are still able to live at home. Cardiologists and other healthcare professionals should increase their digital health skills and learn how best to apply and integrate new technologies into daily practice and how to engage older people and their caregivers in a tailored program of care.
Response to Reviewers:	Reply to Reviewers: PLEASE SEE THE REPLY TO REVIEWERS LETTER (IN BLACK REFEREES'COMMENTS, IN BLUE RESPONSES TO REFEREES, IN RED CHANGES MADE ON THE MANUSCIPT) We thank all the referees for providing comments and suggestions as to how we might further improve the manuscript. Reviewer #1: General comments 1. We have modified some sentences that were too similar to the referenced papers; the following sentences or references were corrected as suggested by referee #1: Previous page 6, line 54: DH technologies may offer various potential improvements in the care of older adult including a closer relationship between patients and medical staff, empowerment of the patients, more frequent measures to tailor therapy, and the chance of avoiding transportation needs, particularly distressing in the oldest and frail patients (27-35). Previous page 8, line 44-49 ....However, since snapshot ECG recordings are unable to capture infrequent paroxysmal AF, new algorithms based on more frequent sampling are needed (58). And previous page 8, line 56-61, “(57)”citation has been added. Section specific comments Hypertension and dyslipidemia 2. The authors mention that DH improves BP control compared to standard care. It would be best if this could be quantified based on the available evidence ...... and 3. The authors have emphasized on BP telemonitoring as the key DH element for the management of hypertension. However, it should also be noted that patient education, behavioral and lifestyle consultations...... The following sentences have been added; accordingly, references from 36 to 44 were matched as appropriate. Although data are highly heterogenous regarding both the DH methodology used for telemonitoring, the clinical setting of the patients studied, and the presence of co-morbidities, most reviews and metanalyses tend to show an improvement in blood pressure control (35-38). In addition to the use of telemonitoring, many DH trials include other interventions leading to a comprehensive approach to hypertension, including patient education, behavioural and motivational support, close follow-up and focus on medication adherence, probably all contributing to optimization of clinical outcomes. Moreover, with a new DH intervention combining self-monitoring of blood pressure with guided self-management in patients with poorly controlled hypertension, the drop in blood pressure was larger in the DH-managed groupwhen compared with the usual care group (follow-up 12 months: mean difference of -3.4 mm Hg in systolic blood pressure, 95% confidence interval -6.1 to -0.8 mm Hg, and mean difference of -0.5 mm Hg in diastolic blood pressure, -1.9 to 0.9 mm Hg).However, the benefit was observed to be larger in patients aged less than 67 years (39). Atrial fibrillation 4. The authors have emphasized on the importance of AF screening and its benefits among the elderly. However, there are different methods for screening of AF..... The following sentences have been added: Patients with non-valvular AF and left ventricular hypertrophy are often older and with a higher prevalence of multimorbidity (56). Different mHealth–based modalities for arrhythmia monitoring may be used in different settings and to address different questions. Recording electrocardiogram (ECG) tracings (single or multi-lead, in intermittent or continuous format, of various durations) and non-ECG technologies such as pulse photoplethysmography are two different

modalities to approach mHealth signal monitoring (57).

And
According to the Apple Heart Study, notification of irregular pulse is very low in participants without self-reported arrhythmias. However, once notification was received, the probability of confirmation of AF after returning an ECG patch was about 84%, thus supporting the ability of the algorithmto correctly identify AF in users whom it notifies of an irregular pulse (59).
Accordingy, the new ref 56 and 59 have been added and the numbers of references corrected.

5. It should be further emphasized that a definitive diagnosis of AF in a positively screened patient is established only after physicians confirm AF on ECG (2020 ESC AF guideline)
The following sentences have been added:
However, according to 2020 AF ESC Guidelines, ECG documentation is required to establish the diagnosis of AF (Class I) (67). When screening for AF, definite diagnosis in screen-positive cases is established only after the physician reviews the single-lead ECG recording of >30 s or 12-lead ECG and confirms that it shows AF. Moreover, it is recommended to consider systematic ECG screening for those ≥75 years, or those at high risk of stroke (Class IIa) (67), thus emphasising the relevance for screening in the older patient.
Accordingy, the new ref 67 has been added and the numbers of references corrected.

Heart failure
6. Page 9, line 40-42 (benefit with telehealth in HF) contradicts page 10, line 14-16 (lack of benefit with telehealth in HF). Please modify these based on the current pool of evidence, which seems to be mainly toward benefit with telemonitoring in HF patients.
The following sentence was misleading and it has been removed:
“Despite promise, most large, multi-centre randomized trials have failed to demonstrate improved outcomes for remote monitoring in HF patients”

7. Telemonitoring in heart failure can also include invasive methods such as implantable hemodynamic monitoring devices for remote surveillance and drug titration (e.g. wearable cardiac defibrillator, CardioMEMS for monitoring pulmonary artery pressure). This aspect of DH interventions for HF patients is better to be discussed along the mentioned non-invasive measures.
We have added a short section on HF remote monitoring using cardiac electronic implantable devices, and haemodynamic monitoring – bearing in mind that the most recent ESC HF guideline makes a recommendation only for CardioMEMSand even then as only a “may be considered” Class 2 B level of evidence. Accordingly, new references from #79 to 87 have been added:

Patients with an implantable cardiac device such as an implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy (CRT) require regular checks to monitor device performance, battery longevity and detection of arrhythmia, but most modern devices can wirelessly connect with home monitors that transmit relevant data and alerts, allowing a device check to be performed remotely (79). Home monitoring is safe and effective for routine device checks, with earlier detection of arrhythmia and technical issues (80). Centres using home monitoring of implanted devices have reported reduced face-to-face contact (81). Such devices can also collect physiological data that may correlate with HF status. Multiparametric monitoring, incorporating intrathoracic impedance with other variables such as heart rate, heart rate variability, physical activity and heart sounds, has shown potential, but requires consideration of the workflow issues such as what actions should be taken in response to “alerts” being raised, and the need to persuade patients to change therapy (or be more adherent to lifestyle and drug therapies) despite them feeling well (82).
Implantable haemodynamic monitors have shown promise at preventing HF hospitalisation. Pulmonary artery pressure (PAP) increases in response to increasing intracardiac pressure or fluid volume, with rises in pressure typically preceding symptoms by some weeks (83). A randomised trial showed that remote daily PAP monitoring, (via a CardioMEMSdevice;Abbott) and titration of medications in response to rises in pressure, reduced subsequent HF hospitalisation by 30% in NYHA Class III patients who had been admitted for HF in the previous year (84). Data from NYHA

Class III patients outside the US confirm this benefit (85,86). The GUIDE HF study recently reported benefit in a pre-specified pre-covid19 subgroup analysis of a broader spectrum of symptomatic severity (87) leading to FDA support of the use of CardioMEMS in patients with HF and a recent hospitalisation or raised natriuretic peptides.
ESC HF guidelines make a recommendation only for CardioMEMS and as only a “may be considered” Class 2 B level of evidence (71).

Added references:

79. Wilkoff BL, Auricchio A, Brugada J, Cowie M, Ellenbogen KA, Gillis AM, Hayes DL, Howlett JG, Kautzner J, Love CJ, Morgan JM, Priori SG, Reynolds DW, Schoenfeld MH, Vardas PE; Heart Rhythm Society; European Heart Rhythm Association; American College of Cardiology; American Heart Association; European Society of Cardiology; Heart Failure Association of ESC; Heart Failure Society of America. HRS/EHRA expert consensus on the monitoring of cardiovascular implantable electronic devices (CIEDs): description of techniques, indications, personnel, frequency and ethical considerations. Heart Rhythm. 2008;5:907-925.

80. Varma N, Epstein AE, Irimpen A, Schweikert R, Love C; TRUST Investigators. Efficacy and safety of automatic remote monitoring for implantable cardioverter-defibrillator follow-up: the Lumos-T Safely Reduces Routine Office Device Follow-up (TRUST) trial. Circulation. 2010;122:325-332.

81. Hernández-Madrid A, Lewalter T, Proclemer A, Pison L, Lip GY, Blomstrom-Lundqvist C; Scientific Initiatives Committee, European Heart Rhythm Association. Remote monitoring of cardiac implantable electronic devices in Europe: results of the European Heart Rhythm Association survey. Europace. 2014;16:129-132.

82. Singhal A, Cowie MR. Digital Health: Implications for Heart Failure Management. Card Fail Rev. 2021;7:e08.

83 Adamson PB, Gold MR, Bennett T, Bourge RC, Stevenson LW, Trupp R, Stromberg K, Wilkoff BL, Costanzo MR, Luby A, Aranda JM, Heywood JT, Baldwin HA, Aaron M, Smith A, Zile M. Continuous hemodynamic monitoring in patients with mild to moderate heart failure: results of The Reducing Decompensation Events Utilizing Intracardiac Pressures in Patients With Chronic Heart Failure (REDUCEhf) trial. Congest Heart Fail. 2011;17:248-254.

84. Abraham WT, Stevenson LW, Bourge RC, Lindenfeld JA, Bauman JG, Adamson PB; CHAMPION Trial Study Group. Sustained efficacy of pulmonary artery pressure to guide adjustment of chronic heart failure therapy: complete follow-up results from the CHAMPION randomised trial. Lancet. 2016;387(10017):453-461.

85. Angermann CE, Assmus B, Anker SD, Asselbergs FW, Brachmann J, Brett ME, Brugts JJ, Ertl G, Ginn G, Hilker L, Koehler F, Rosenkranz S, Zhou Q, Adamson PB, Böhm M; MEMS-HF Investigators. Pulmonary artery pressure-guided therapy in ambulatory patients with symptomatic heart failure: the CardioMEMS European Monitoring Study for Heart Failure (MEMS-HF). Eur J Heart Fail. 2020;22:1891-1901.

86. Cowie MR, Flett A, Cowburn P, Foley P, Chandrasekaran B, Loke I, Critoph C, Gardner RS, Guha K, Betts TR, Carr-White G, Zaidi A, Lim HS, Hayward C, Patwala A, Rogers D, Pettit S, Gazzola C, Henderson J, Adamson PB. Real-world evidence in a national health service: results of the UK CardioMEMS HF System Post-Market Study. ESC Heart Fail. 2022;9:48-56.

87. Lindenfeld J, Zile MR, Desai AS, Bhatt K, Ducharme A, Horstmanshof D, Krim SR, Maisel A, Mehra MR, Paul S, Sears SF, Sauer AJ, Smart F, Zughaib M, Castaneda P, Kelly J, Johnson N, Sood P, Ginn G, Henderson J, Adamson PB, Costanzo MR. Haemodynamic-guided management of heart failure (GUIDE-HF): a randomised controlled trial. Lancet. 2021;398(10304):991-1001.

Nutrition
8. Page 12, line 38-44: the reference #104 should be mentioned in the text as Krznaric and colleagues (the 1st author).

	The name of the first author has been corrected. Reviewer #2: Minor issues Comment 1: The manuscript entitled"Digital Health in Community-Dwelling Older Adults for the Prevention / Management of Cardiovascular Diseases and Frailty".Please assess the trustworthiness of the implementation of digital health technology in older adults with cognitive impairment and frailty, and evaluate the extent to which Digital health technology are applicable to older adults with frailty in their real-world practice setting. A sentence have been addedin "LIMITATIONS FACED BY OLDER ADULTS IN USING DIGITAL HEALTH TECHNOLOGY" section Although patients with cognitive impairment and high degree of frailty are probably less likely to direct benefit from DH approaches to disease management and care, DH technology may provide support to their caregivers. Comment 2: Page 6, line 53: "Cardiovascular disease prevention: hypertension and dyslipidaemias". It would be better if the author could change "prevention" to "prevention and management". Comment 3 and 4: Page 7, line 44: "Cardiovascular disease prevention: diabetes". It would be better if the author could change "prevention" to "prevention and management". Subtitles have been changed, according to both referee #2 and referee #4 suggestions to: Arterial hypertension and dyslipidaemias And Diabetes Mellitus Reviewer #3: An apt and timely consensus document from the ESC Council. I feel it may be useful to add a paragraph mentioning the clinical situations where treatment relying on DH technologies should be avoided. A sentence has been added to acknowledge further limitation in DH technology use and the opportunity for caregivers in those clinical conditions Although patients with cognitive impairment and high degree of frailty are probably less likely to direct benefit from DH approaches to disease management and care, DH technology may provide support to their caregivers. Reviewer #4: minor adjustments to be made before publication: 1. The title is misleading for me: The title has been changed as suggested by referee #4 to: Digital Health in Older Adults for the Prevention and Management of Cardiovascular Diseases and Frailty 2. Please adjust the titles.....In my opinion, these could also be left away andjust being called "arterial hypertension and dyslipidemias" and "Diabetes Mellitus" . Subtitles have been changed, according to both referee #2 and referee #4 suggestions to: Arterial hypertension and dyslipidaemias And Diabetes Mellitus 3. please add a sentence for CardioMEMS HF in adequate patients for home monitoring for difficult HF patients.

	As mentioned in response to Reviewer#1 we have added a short section on CardioMEMS with the addition of the appropriate references: Implantable haemodynamic monitors have shown promise at preventing HF hospitalisation. Pulmonary artery pressure (PAP) increases in response to increasing intracardiac pressure or fluid volume, with rises in pressure typically preceding symptoms by some weeks (83). A randomised trial showed that remote daily PAP monitoring, (via a CardioMEMSdevice;Abbott) and titration of medications in response to rises in pressure, reduced subsequent HF hospitalisation by 30% in NYHA Class III patients who had been admitted for HF in the previous year (84). Data from NYHA Class III patients outside the US confirm this benefit (85,86). The GUIDE HF study recently reported benefit in a pre-specified pre-covid19 subgroup analysis of a broader spectrum of symptomatic severity (87) leading to FDA support of the use of CardioMEMS in patients with HF and a recent hospitalisation or raised natriuretic peptides. ESC HF guidelines make a recommendation only for CardioMEMS and as only a “may be considered” Class 2 B level of evidence (71). 4. Please write mobile Apps or add mApps to the dictionary. Mobile Applications (mApps)has been added and the sentence has been modified to: “Applications (Apps). Computer software programs that operate on computer, tablets andother mobile devices such as smartphones and smartwatches (Mobile-Apps – mApps-). To the Editor: 1.In addition to the changes underlined above in Reply to Reviewers, the following sentences have been removed in the revised version of the paper: ...The promise of improving CV care (in particular for hypertensive and dyslipidaemic patients) in older adults by utilization of DH technologies is based on providing more frequent measurements to tailor therapy and circumventing barriers to transportation, limited geographical access, lack of community-based programmes, and limited staffing....(in “hypertension and dyslipidaemias” section) ... however, it is likely that longitudinal sampling algorithms would be necessary to capture infrequent paroxysmal AF since daily “snapshot” ECG monitoring may miss half of AF episodes..(in “Atrial Fibrillation”) ... . Despite promise, most large, multi-centre randomized trials have failed to demonstrate improved outcomes for remote monitoring in HF patients... (in “Heart Failure” section) 2.The following references have been added; the numbers of references have been corrected accordingly: 56. Proietti M, Marra AM, Tassone EJ, De Vuono S, Corrao S, Gobbi P, Perticone F, Corazza GR, Basili S, Lip GY, Violi F, Raparelli V; ARAPACIS Study Investigators; GIS Group. Frequency of Left Ventricular Hypertrophy in Non-Valvular Atrial Fibrillation. Am J Cardiol. 2015;116:877-882. 59. Perez MV, Mahaffey KW, Hedlin H, Rumsfeld JS, Garcia A, Ferris T, Balasubramanian V, Russo AM, Rajmane A, Cheung L, Hung G, Lee J, Kowey P, Talati N, Nag D, Gummidipundi SE, Beatty A, Hills MT, Desai S, Granger CB, Desai M, Turakhia MP; Apple Heart Study Investigators. Large-Scale Assessment of a Smartwatch to Identify Atrial Fibrillation. N Engl J Med. 2019;381:1909-1917.

67. Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomström-Lundqvist C, Boriani G, Castella M, Dan GA, Dilaveris PE, Fauchier L, Filippatos G, Kalman JM, La Meir M, Lane DA, Lebeau JP, Lettino M, Lip GYH, Pinto FJ, Thomas GN, Valgimigli M, Van Gelder IC, Van Putte BP, Watkins CL; ESC Scientific Document Group. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): The Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. Eur Heart J. 2021;42:373-498.

79. Wilkoff BL, Auricchio A, Brugada J, Cowie M, Ellenbogen KA, Gillis AM, Hayes DL, Howlett JG, Kautzner J, Love CJ, Morgan JM, Priori SG, Reynolds DW, Schoenfeld MH, Vardas PE; Heart Rhythm Society; European Heart Rhythm Association; American College of Cardiology; American Heart Association; European Society of Cardiology; Heart Failure Association of ESC; Heart Failure Society of America. HRS/EHRA expert consensus on the monitoring of cardiovascular implantable electronic devices (CIEDs): description of techniques, indications, personnel, frequency and ethical considerations. Heart Rhythm. 2008;5:907-925.

80. Varma N, Epstein AE, Irimpen A, Schweikert R, Love C; TRUST Investigators. Efficacy and safety of automatic remote monitoring for implantable cardioverter-defibrillator follow-up: the Lumos-T Safely Reduces Routine Office Device Follow-up (TRUST) trial. Circulation. 2010;122:325-332.

81. Hernández-Madrid A, Lewalter T, Proclemer A, Pison L, Lip GY, Blomstrom-Lundqvist C; Scientific Initiatives Committee, European Heart Rhythm Association. Remote monitoring of cardiac implantable electronic devices in Europe: results of the European Heart Rhythm Association survey. Europace. 2014;16:129-132.

82. Singhal A, Cowie MR. Digital Health: Implications for Heart Failure Management. Card Fail Rev. 2021;7:e08.

83 Adamson PB, Gold MR, Bennett T, Bourge RC, Stevenson LW, Trupp R, Stromberg K, Wilkoff BL, Costanzo MR, Luby A, Aranda JM, Heywood JT, Baldwin HA, Aaron M, Smith A, Zile M. Continuous hemodynamic monitoring in patients with mild to moderate heart failure: results of The Reducing Decompensation Events Utilizing Intracardiac Pressures in Patients With Chronic Heart Failure (REDUCEhf) trial. Congest Heart Fail. 2011;17:248-254.

84. Abraham WT, Stevenson LW, Bourge RC, Lindenfeld JA, Bauman JG, Adamson PB; CHAMPION Trial Study Group. Sustained efficacy of pulmonary artery pressure to guide adjustment of chronic heart failure therapy: complete follow-up results from the CHAMPION randomised trial. Lancet. 2016;387(10017):453-461.

85. Angermann CE, Assmus B, Anker SD, Asselbergs FW, Brachmann J, Brett ME, Brugts JJ, Ertl G, Ginn G, Hilker L, Koehler F, Rosenkranz S, Zhou Q, Adamson PB, Böhm M; MEMS-HF Investigators. Pulmonary artery pressure-guided therapy in ambulatory patients with symptomatic heart failure: the CardioMEMS European Monitoring Study for Heart Failure (MEMS-HF). Eur J Heart Fail. 2020;22:1891-1901.

86. Cowie MR, Flett A, Cowburn P, Foley P, Chandrasekaran B, Loke I, Critoph C, Gardner RS, Guha K, Betts TR, Carr-White G, Zaidi A, Lim HS, Hayward C, Patwala A, Rogers D, Pettit S, Gazzola C, Henderson J, Adamson PB. Real-world evidence in a national health service: results of the UK CardioMEMS HF System Post-Market Study. ESC Heart Fail. 2022;9:48-56.

87. Lindenfeld J, Zile MR, Desai AS, Bhatt K, Ducharme A, Horstmanshof D, Krim SR, Maisel A, Mehra MR, Paul S, Sears SF, Sauer AJ, Smart F, Zughaib M, Castaneda P, Kelly J, Johnson N, Sood P, Ginn G, Henderson J, Adamson PB, Costanzo MR. Haemodynamic-guided management of heart failure (GUIDE-HF): a randomised controlled trial. Lancet. 2021;398(10304):991-1001.

Author Comments:

This Consensus document (from the ESC Council for Cardiology Practice/Taskforce on Geriatric Cardiology, the ESC Digital Health Committee and the ESC Working Group

	on e-Cardiology) is the first ESC official document on Digital Health in Older Adults and Frailty and it has been approved by the Clinical Practice Guidelines Committee -CPG-. It discusses the potential implementation of Digital Health technology in older adults -being heart failure one of the major determinant of frailty in this patient population- suggesting a practical approach to clinical cardiologists working in an ambulatory outpatient clinic. The document has been created to be a primer for general cardiologists and it highlights the potential benefit and challenges of Digital Health in older patients with, or at risk of, cardiovascular disease.

Reply to Reviewers:

We thank all the referees for providing comments and suggestions as to how we might further improve the manuscript.

Reviewer #1:

General comments
1. We have modified some sentences that were too similar to the referenced papers; the following sentences or references were corrected as suggested by referee #1:

Previous page 6, line 54: DH technologies may offer various potential improvements in the care of older adult including a closer relationship between patients and medical staff, empowerment of the patients, more frequent measures to tailor therapy, and the chance of avoiding transportation needs, particularly distressing in the oldest and frail patients (27-35).
Previous page 8, line 44-49
........However, since snapshot ECG recordings are unable to capture infrequent paroxysmal AF, new algorithms based on more frequent sampling are needed (58).
And previous page 8, line 56-61, "(57)"citation has been added.

Section specific comments
Hypertension and dyslipidemia
2. The authors mention that DH improves BP control compared to standard care. It would be best if this could be quantified based on the available evidence ...... and
3. The authors have emphasized on BP telemonitoring as the key DH element for the management of hypertension. However, it should also be noted that patient education, behavioral and lifestyle consultations......
The following sentences have been added; accordingly, references from 36 to 44 were matched as appropriate.
Although data are highly heterogenous regarding both the DH methodology used for telemonitoring, the clinical setting of the patients studied, and the presence of co-morbidities, most reviews and metanalyses tend to show an improvement in blood pressure control (35-38). In addition to the use of telemonitoring, many DH trials include other interventions leading to a comprehensive approach to hypertension, including patient education, behavioural and motivational support, close follow-up and focus on medication adherence, probably all contributing to optimization of clinical outcomes. Moreover, with a new DH intervention combining self-monitoring of blood pressure with guided self-management in patients with poorly controlled hypertension, the drop in blood pressure was larger in the DH-managed groupwhen compared with the usual care group (follow-up 12 months: mean difference of -3.4 mm Hg in systolic blood pressure, 95% confidence interval -6.1 to -0.8 mm Hg, and mean difference of -0.5 mm Hg in diastolic blood pressure, -1.9 to 0.9 mm Hg).However, the benefit was observed to be larger in patients aged less than 67 years (39).

Atrial fibrillation
4. The authors have emphasized on the importance of AF screening and its benefits among the elderly. However, there are different methods for screening of AF.....
The following sentences have been added:
Patients with non-valvular AF and left ventricular hypertrophy are often older and with a higher prevalence of multimorbidity (56).

Different mHealth–based modalities for arrhythmia monitoring may be used in different settings and to address different questions. Recording electrocardiogram (ECG) tracings (single or multi-lead, in intermittent or continuous format, of various durations) and non-ECG technologies such as pulse photoplethysmography are two different modalities to approach mHealth signal monitoring (57).

And

According to the Apple Heart Study, notification of irregular pulse is very low in participants without self-reported arrhythmias. However, once notification was received, the probability of confirmation of AF after returning an ECG patch was about 84%, thus supporting the ability of the algorithmto correctly identify AF in users whom it notifies of an irregular pulse (59).

Accordingy, the new ref 56 and 59 have been added and the numbers of references corrected.

5. It should be further emphasized that a definitive diagnosis of AF in a positively screened patient is established only after physicians confirm AF on ECG (2020 ESC AF guideline)

The following sentences have been added:

However, according to 2020 AF ESC Guidelines, ECG documentation is required to establish the diagnosis of AF (Class I) (67). When screening for AF, definite diagnosis in screen-positive cases is established only after the physician reviews the single-lead ECG recording of ≥30 s or 12-lead ECG and confirms that it shows AF. Moreover, it is recommended to consider systematic ECG screening for those ≥75 years, or those at high risk of stroke (Class IIa) (67), thus emphasising the relevance for screening in the older patient.

Accordingy, the new ref 67 has been added and the numbers of references corrected.

Heart failure

6. Page 9, line 40-42 (benefit with telehealth in HF) contradicts page 10, line 14-16 (lack of benefit with telehealth in HF). Please modify these based on the current pool of evidence, which seems to be mainly toward benefit with telemonitoring in HF patients.

The following sentence was misleading and it has been removed:

"Despite promise, most large, multi-centre randomized trials have failed to demonstrate improved outcomes for remote monitoring in HF patients"

7. Telemonitoring in heart failure can also include invasive methods such as implantable hemodynamic monitoring devices for remote surveillance and drug titration (e.g. wearable cardiac defibrillator, CardioMEMS for monitoring pulmonary artery pressure). This aspect of DH interventions for HF patients is better to be discussed along the mentioned non-invasive measures.

We have added a short section on HF remote monitoring using cardiac electronic implantable devices, and haemodynamic monitoring – bearing in mind that the most recent ESC HF guideline makes a recommendation only for CardioMEMSand even then as only a "may be considered" Class 2 B level of evidence. Accordingly, new references from #79 to 87 have been added:

Patients with an implantable cardiac device such as an implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy (CRT) require regular checks to monitor device performance, battery longevity and detection of arrhythmia, but most modern devices can wirelessly connect with home monitors that transmit relevant data and alerts, allowing a device check to be performed remotely (79). Home monitoring is safe and effective for routine device checks, with earlier detection of arrhythmia and technical issues (80). Centres using home monitoring of implanted devices have reported reduced face-to-face contact (81). Such devices can also collect physiological data that may correlate with HF status. Multiparametric monitoring, incorporating intrathoracic impedance with other variables such as heart rate, heart rate variability, physical activity and heart sounds, has shown potential, but requires consideration of the workflow issues such as what actions should be taken in response to “alerts” being raised, and the need to persuade patients to change therapy (or be more adherent to lifestyle and drug therapies) despite them feeling well (82).

Implantable haemodynamic monitors have shown promise at preventing HF hospitalisation. Pulmonary artery pressure (PAP) increases in response to increasing intracardiac pressure or fluid volume, with rises in pressure typically preceding symptoms by some weeks (83). A randomised trial showed that remote daily PAP monitoring, (via a CardioMEMSdevice;Abbott) and titration of medications in response to rises in pressure, reduced subsequent HF hospitalisation by 30% in NYHA Class III patients who had been admitted for HF in the previous year (84). Data from NYHA Class III patients outside the US confirm this benefit (85,86). The GUIDE HF study recently reported benefit in a pre-specified pre-covid19 subgroup analysis of a broader spectrum of symptomatic severity (87) leading to FDA support of the use of CardioMEMS in patients with HF and a recent hospitalisation or raised natriuretic peptides.

ESC HF guidelines make a recommendation only for CardioMEMS and as only a “may be considered” Class 2 B level of evidence (71).

Added references:

79. Wilkoff BL, Auricchio A, Brugada J, Cowie M, Ellenbogen KA, Gillis AM, Hayes DL, Howlett JG, Kautzner J, Love CJ, Morgan JM, Priori SG, Reynolds DW, Schoenfeld MH, Vardas PE; Heart Rhythm Society; European Heart Rhythm Association; American College of Cardiology; American Heart Association; European Society of Cardiology; Heart Failure Association of ESC; Heart Failure Society of America. HRS/EHRA expert consensus on the monitoring of cardiovascular implantable electronic devices (CIEDs): description of techniques, indications, personnel, frequency and ethical considerations. Heart Rhythm. 2008;5:907-925.

80. Varma N, Epstein AE, Irimpen A, Schweikert R, Love C; TRUST Investigators. Efficacy and safety of automatic remote monitoring for implantable cardioverter-defibrillator follow-up: the Lumos-T Safely Reduces Routine Office Device Follow-up (TRUST) trial. Circulation. 2010;122:325-332.

81. Hernández-Madrid A, Lewalter T, Proclemer A, Pison L, Lip GY, Blomstrom-Lundqvist C; Scientific Initiatives Committee, European Heart Rhythm Association. Remote monitoring of cardiac implantable electronic devices in Europe: results of the European Heart Rhythm Association survey. Europace. 2014;16:129-132.

82. Singhal A, Cowie MR. Digital Health: Implications for Heart Failure Management. Card Fail Rev. 2021;7:e08.

83 Adamson PB, Gold MR, Bennett T, Bourge RC, Stevenson LW, Trupp R, Stromberg K, Wilkoff BL, Costanzo MR, Luby A, Aranda JM, Heywood JT, Baldwin HA, Aaron M, Smith A, Zile M. Continuous hemodynamic monitoring in patients with mild to moderate heart failure: results of The Reducing Decompensation Events Utilizing Intracardiac Pressures in

Patients With Chronic Heart Failure (REDUCEhf) trial. Congest Heart Fail. 2011;17:248-254.

84. Abraham WT, Stevenson LW, Bourge RC, Lindenfeld JA, Bauman JG, Adamson PB; CHAMPION Trial Study Group. Sustained efficacy of pulmonary artery pressure to guide adjustment of chronic heart failure therapy: complete follow-up results from the CHAMPION randomised trial. Lancet. 2016;387(10017):453-461.

85. Angermann CE, Assmus B, Anker SD, Asselbergs FW, Brachmann J, Brett ME, Brugts JJ, Ertl G, Ginn G, Hilker L, Koehler F, Rosenkranz S, Zhou Q, Adamson PB, Böhm M; MEMS-HF Investigators. Pulmonary artery pressure-guided therapy in ambulatory patients with symptomatic heart failure: the CardioMEMS European Monitoring Study for Heart Failure (MEMS-HF). Eur J Heart Fail. 2020;22:1891-1901.

86. Cowie MR, Flett A, Cowburn P, Foley P, Chandrasekaran B, Loke I, Critoph C, Gardner RS, Guha K, Betts TR, Carr-White G, Zaidi A, Lim HS, Hayward C, Patwala A, Rogers D, Pettit S, Gazzola C, Henderson J, Adamson PB. Real-world evidence in a national health service: results of the UK CardioMEMS HF System Post-Market Study. ESC Heart Fail. 2022;9:48-56.

87. Lindenfeld J, Zile MR, Desai AS, Bhatt K, Ducharme A, Horstmanshof D, Krim SR, Maisel A, Mehra MR, Paul S, Sears SF, Sauer AJ, Smart F, Zughaib M, Castaneda P, Kelly J, Johnson N, Sood P, Ginn G, Henderson J, Adamson PB, Costanzo MR. Haemodynamic-guided management of heart failure (GUIDE-HF): a randomised controlled trial. Lancet. 2021;398(10304):991-1001.

Nutrition
8. Page 12, line 38-44: the reference #104 should be mentioned in the text as Krznaric and colleagues (the 1st author).
The name of the first author has been corrected.

Reviewer #2:

Minor issues

Comment 1:
The manuscript entitled"Digital Health in Community-Dwelling Older Adults for the Prevention / Management of Cardiovascular Diseases and Frailty".Please assess the trustworthiness of the implementation of digital health technology in older adults with cognitive impairment and frailty, and evaluate the extent to which Digital health technology are applicable to older adults with frailty in their real-world practice setting.
A sentence have been added in **"LIMITATIONS FACED BY OLDER ADULTS IN USING DIGITAL HEALTH TECHNOLOGY" section**
Although patients with cognitive impairment and high degree of frailty are probably less likely to direct benefit from DH approaches to disease management and care, DH technology may provide support to their caregivers.

Comment 2:
Page 6, line 53: "Cardiovascular disease prevention: hypertension and dyslipidaemias". It would be better if the author could change "prevention" to "prevention and management".

Comment 3 and 4:
Page 7, line 44: "Cardiovascular disease prevention: diabetes". It would be better if the author could change "prevention" to "prevention and management".
Subtitles have been changed, according to both referee #2 and referee #4 suggestions to:
Arterial hypertension and dyslipidaemias
And
Diabetes Mellitus

Reviewer #3:

An apt and timely consensus document from the ESC Council.
I feel it may be useful to add a paragraph mentioning the clinical situations where treatment relying on DH technologies should be avoided.
A sentence has been added to acknowledge further limitation in DH technology use and the opportunity for caregivers in those clinical conditions
Although patients with cognitive impairment and high degree of frailty are probably less likely to direct benefit from DH approaches to disease management and care, DH technology may provide support to their caregivers.

Reviewer #4:

minor adjustments to be made before publication:

1. The title is misleading for me:
The title has been changed as suggested by referee #4 to: Digital Health in Older Adults for the Prevention and Management of Cardiovascular Diseases and Frailty

2. Please adjust the titles.....In my opinion, these could also be left away andjust being called "arterial hypertension and dyslipidemias" and "Diabetes Mellitus" .
Subtitles have been changed, according to both referee #2 and referee #4 suggestions to:
Arterial hypertension and dyslipidaemias
And
Diabetes Mellitus

3. please add a sentence for CardioMEMS HF in adequate patients for home monitoring for difficult HF patients.

As mentioned in response to Reviewer#1 we have added a short section on CardioMEMS with the addition of the appropriate references:
Implantable haemodynamic monitors have shown promise at preventing HF hospitalisation. Pulmonary artery pressure (PAP) increases in response to increasing intracardiac pressure or fluid volume, with rises in pressure typically preceding symptoms by some weeks (83). A randomised trial showed that remote daily PAP monitoring, (via a CardioMEMSdevice;Abbott) and titration of medications in response to rises in pressure, reduced subsequent HF hospitalisation by 30% in NYHA Class III patients who had been admitted for HF in the previous year (84). Data from NYHA Class III patients outside the US confirm this benefit (85,86). The GUIDE HF study recently reported benefit in a pre-specified pre-covid19 subgroup analysis of a broader spectrum of symptomatic severity

(87) leading to FDA support of the use of CardioMEMS in patients with HF and a recent hospitalisation or raised natriuretic peptides.
ESC HF guidelines make a recommendation only for CardioMEMS and as only a “may be considered” Class 2 B level of evidence (71).

4. Please write mobile Apps or add mApps to the dictionary.
Mobile Applications (mApps)has been added and the sentence has been modified to:
“**Applications (Apps).** Computer software programs that operate on computer, tablets andother mobile devices such as smartphones and smartwatches (M**obile-Apps – mApps-**).

To the Editor:

1. In addition to the changes underlined above in Reply to Reviewers, the following sentences have been removed in the revised version of the paper:

...The promise of improving CV care (in particular for hypertensive and dyslipidaemic patients) in older adults by utilization of DH technologies is based on providing more frequent measurements to tailor therapy and circumventing barriers to transportation, limited geographical access, lack of community-based programmes, and limited staffing....(in “hypertension and dyslipidaemias” section)

... however, it is likely that longitudinal sampling algorithms would be necessary to capture infrequent paroxysmal AF since daily “snapshot” ECG monitoring may miss half of AF episodes..(in “Atrial Fibrillation”)

... . Despite promise, most large, multi-centre randomized trials have failed to demonstrate improved outcomes for remote monitoring in HF patients... (in “Heart Failure” section)

2. The following references have been added; the numbers of references have been corrected accordingly:

56. Proietti M, Marra AM, Tassone EJ, De Vuono S, Corrao S, Gobbi P, Perticone F, Corazza GR, Basili S, Lip GY, Violi F, Raparelli V; ARAPACIS Study Investigators; GIS Group. Frequency of Left Ventricular Hypertrophy in Non-Valvular Atrial Fibrillation. Am J Cardiol. 2015;116:877-882.

59. Perez MV, Mahaffey KW, Hedlin H, Rumsfeld JS, Garcia A, Ferris T, Balasubramanian V, Russo AM, Rajmane A, Cheung L, Hung G, Lee J, Kowey P, Talati N, Nag D, Gummidipundi SE, Beatty A, Hills MT, Desai S, Granger CB, Desai M, Turakhia MP; Apple Heart Study Investigators. Large-Scale Assessment of a Smartwatch to Identify Atrial Fibrillation. N Engl J Med. 2019;381:1909-1917.

67. Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomström-Lundqvist C, Boriani G, Castella M, Dan GA, Dilaveris PE, Fauchier L, Filippatos G, Kalman JM, La Meir M, Lane DA, Lebeau JP, Lettino M, Lip GYH, Pinto FJ, Thomas GN, Valgimigli M, Van Gelder IC, Van Putte BP, Watkins CL; ESC Scientific Document Group. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): The Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. Eur Heart J. 2021;42:373-498.

79. Wilkoff BL, Auricchio A, Brugada J, Cowie M, Ellenbogen KA, Gillis AM, Hayes DL, Howlett JG, Kautzner J, Love CJ, Morgan JM, Priori SG, Reynolds DW, Schoenfeld MH, Vardas PE; Heart Rhythm Society; European Heart Rhythm Association; American College of Cardiology; American Heart Association; European Society of Cardiology; Heart Failure Association of ESC; Heart Failure Society of America. HRS/EHRA expert consensus on the monitoring of cardiovascular implantable electronic devices (CIEDs): description of techniques, indications, personnel, frequency and ethical considerations. Heart Rhythm. 2008;5:907-925.

80. Varma N, Epstein AE, Irimpen A, Schweikert R, Love C; TRUST Investigators. Efficacy and safety of automatic remote monitoring for implantable cardioverter-defibrillator follow-up: the Lumos-T Safely Reduces Routine Office Device Follow-up (TRUST) trial. Circulation. 2010;122:325-332.

81. Hernández-Madrid A, Lewalter T, Proclemer A, Pison L, Lip GY, Blomstrom-Lundqvist C; Scientific Initiatives Committee, European Heart Rhythm Association. Remote monitoring of cardiac implantable electronic devices in Europe: results of the European Heart Rhythm Association survey. Europace. 2014;16:129-132.

82. Singhal A, Cowie MR. Digital Health: Implications for Heart Failure Management. Card Fail Rev. 2021;7:e08.

83 Adamson PB, Gold MR, Bennett T, Bourge RC, Stevenson LW, Trupp R, Stromberg K, Wilkoff BL, Costanzo MR, Luby A, Aranda JM, Heywood JT, Baldwin HA, Aaron M, Smith A, Zile M. Continuous hemodynamic monitoring in patients with mild to moderate heart failure: results of The Reducing Decompensation Events Utilizing Intracardiac Pressures in Patients With Chronic Heart Failure (REDUCEhf) trial. Congest Heart Fail. 2011;17:248-254.

84. Abraham WT, Stevenson LW, Bourge RC, Lindenfeld JA, Bauman JG, Adamson PB; CHAMPION Trial Study Group. Sustained efficacy of pulmonary artery pressure to guide adjustment of chronic heart failure therapy: complete follow-up results from the CHAMPION randomised trial. Lancet. 2016;387(10017):453-461.

85. Angermann CE, Assmus B, Anker SD, Asselbergs FW, Brachmann J, Brett ME, Brugts JJ, Ertl G, Ginn G, Hilker L, Koehler F, Rosenkranz S, Zhou Q, Adamson PB, Böhm M; MEMS-HF Investigators. Pulmonary artery pressure-guided therapy in ambulatory patients with symptomatic heart failure: the CardioMEMS European Monitoring Study for Heart Failure (MEMS-HF). Eur J Heart Fail. 2020;22:1891-1901.

86. Cowie MR, Flett A, Cowburn P, Foley P, Chandrasekaran B, Loke I, Critoph C, Gardner RS, Guha K, Betts TR, Carr-White G, Zaidi A, Lim HS, Hayward C, Patwala A, Rogers D, Pettit S, Gazzola C, Henderson J, Adamson PB. Real-world evidence in a national health service: results of the UK CardioMEMS HF System Post-Market Study. ESC Heart Fail. 2022;9:48-56.

87. Lindenfeld J, Zile MR, Desai AS, Bhatt K, Ducharme A, Horstmanshof D, Krim SR, Maisel A, Mehra MR, Paul S, Sears SF, Sauer AJ, Smart F, Zughaib M, Castaneda P, Kelly J, Johnson N, Sood P, Ginn G, Henderson J, Adamson PB, Costanzo MR. Haemodynamic-guided management of heart failure (GUIDE-HF): a randomised controlled trial. Lancet. 2021;398(10304):991-1001.

Digital Health in Older Adults for the Prevention and Management of Cardiovascular Diseases and Frailty

Consensus document from the ESC Council for Cardiology Practice/Taskforce on Geriatric Cardiology, the ESC Digital Health Committee and the ESC Working Group on e-Cardiology

Luigina Guasti[1], Polychronis Dilaveris[2], Mamas A. Mamas[3], Dimitrios Richter[4], Ruxandra Christodorescu[5], Joost Lumens[6], Mark J Schuuring[7], Stefano Carugo[8], Jonathan Afilalo[9], Marc Ferrini[10], Riccardo Asteggiano[1,11], Martin R Cowie[12].

1) University of Insubria, ASST-settelaghi, Varese, Italy

2) First Department of Cardiology, Hippokration Hospital, National and Kapodistrian University of Athens, Athens, Greece

3) Keele Cardiovascular Research Group, Centre for Prognosis Research, Keele University, UK

4) Euroclinic Hospital, Athens, Greece

5) University of Medicine and Pharmacy V.Babes, Timisoara, Romania

6) CARIM School for Cardiovascular Diseases, Maastricht University Medical Center, Duboisdomein 30, 6229 GT Maastricht, the Netherlands

7) Department of Cardiology, Amsterdam UMC location AMC, University of Amsterdam, the Netherlands

8) University of Milan, Cardiology, Policlinico di Milano, Italy

9) Division of Experimental Medicine, McGill University; Centre for Clinical Epidemiology, Jewish General Hospital; Division of Cardiology, Jewish General Hospital, McGill University; Research Institute, McGill University Health Centre, Montreal, Qc, Canada

10) CH Saint Joseph et Saint Luc. Lyon, France

11) LARC (Laboratorio Analisi e Ricerca Clinica), Turin, Italy

12) Royal Brompton Hospital (Guy's& St Thomas' NHS Foundation Trust) & Faculty of Lifesciences & Medicine, King's College London, London, UK.

Address for correspondence:

Luigina Guasti, MD, PhD

Internal Medicine, Department of Medicine and Surgery, University of Insubria, Geriatric Unit, ASST settelaghi, Via Guicciardini 5, Varese, Italy

luigina.guasti@uninsubria.it

ABSTRACT

Digital health technology is receiving increasing attention in cardiology. The rise of accessibility of digital health tools including wearable technologies and smart phone applications used in medical practice has created a new era in healthcare. The coronavirus pandemic has provided a new impetus for changes in delivering medical assistance across the world.

This Consensus document discusses the potential implementation of digital health technology in older adults, suggesting a practical approach to general cardiologists working in an ambulatory outpatient clinic, highlighting the potential benefit and challenges of digital health in older patients with, or at risk of, cardiovascular disease.

Advancing age may lead to a progressive loss of independence, to frailty, and to increasing degrees of disability. In Geriatric Cardiology digital health technology may serve as an additional tool both in cardiovascular prevention and treatment that may help by 1) supporting self-caring patients with cardiovascular disease to maintain their independence and improve the management of their cardiovascular disease 2) improving the prevention, detection and management of frailty and supporting collaboration with caregivers.

Digital health technology has the potential to be useful for every field of cardiology, but notably in an office-based setting with frequent contact with ambulatory older adults who may be pre-frail or frail but who are still able to live at home. Cardiologists and other healthcare professionals should increase their digital health skills and learn how best to apply and integrate new technologies into daily practice and how to engage older people and their caregivers in a tailored program of care.

Keywords: Digital Health, Digital technology, eHealth, older adults, frailty, cardiovascular disease, cardiovascular prevention, geriatric cardiology

Digital Health (DH) technology is increasingly adopted in cardiovascular (CV) medicine, although its implementation has been slow, and quality standards focused around improvements in clinical practice are still lacking (1,2). The increased accessibility of wearable technologies and mobile applications (mApps) has created a new era in health tracking, with the coronavirus disease-2019 (COVID-19) pandemic providing the impetus for changes in delivering healthcare across the world and in building a more comprehensive picture of a patient during follow-up (3-6).

The potential support of DH technology may have a special role in patients living with health status limitations due to ageing. Ageing is a natural process that poses several challenges and threats to the preservation of independence (7). In healthy older adults the maintenance of healthy ageing, defined as developing and maintaining the functional ability that enables well-being in older age, has become a principal goal worldwide (8,9). Moreover, advancing age may lead to frailty, which has been increasingly recognized to be central to health and outcomes in an ageing population and, more generally, in patients with CV diseases (10-12). This is a multisystem/multidomain complex condition characterized by reduced functional reserves and increased vulnerability to adverse stress and health events, often associated with multimorbidity. Frailty can contribute to an accelerated clinical decline (Figure 1a) which may lead to progressive loss of independence and disability, defined as difficulty or dependency in carrying out activities essential for daily living, including tasks needed for self-care and living (10-12). The frail condition is the result of deficits in various domains: physical, medical, psychological, cognitive, and social. Better consideration of these specific domains allows better identification of specific needs, which can then be targeted (Figure 1b) (11,13). Since frailty may be, at least in part, reversible, early identification and characterisation of the frailty, along with interventions on frailty components, together with the general management of frailty (including support for physical activity, nutrition, medical optimization, and social interaction) may improve the degree of frailty, or at least slow down the frailty trajectory (11,14).

Though these terms are not synonymous, ageing, frailty and disability are clearly interconnected (11). Considering the impact of increasing population ageing on health care systems, the older population is therefore a prime target for new technologies and interventions (10).

This Consensus document highlights the potential benefit and challenges of DH in older adults with, or at risk of, CV disease, providing a practical approach to general cardiologists working in an ambulatory (outpatients) setting by 1) providing suggestions for DH in the management of common age-associated CV diseases so as to foster self-care and independence, and 2) providing suggestions for DH in the prevention, detection, and management of frailty.

TECHNICAL INNOVATIONS FOR THE CARE OF OLDER ADULTS

Although DH technologies (Box –definitions-) (15-17) have become increasingly common place, their utility, feasibility, and roles may differ by age group. Gerontology studies on digital technology include applications to physical and mental health, mobility, social connectedness, loneliness, communication, leisure and safety (18). In relation to older adults, DH technology holds the potential to improve well-being, optimize healthcare delivery and monitoring particularly in individuals with limited mobility, and to support ageing people in a safe and independent environment (19,20).

Digital tools may vary from simple text messaging platforms (short message service: SMS) to mApps, or more complex algorithms including information obtained by biological sensors. Text messages are simple, instant, and popular. They offer a widely available medium for delivery of health-related communication and can be sent remotely to large numbers of people in an unobtrusive manner. Apps are computer software programs that operate on smartphones, tablets, and other mobile devices such as smartwatches (17). Apps are generally readily available – for those that have a mobile device – and relatively easy to use via touchscreen interfaces. Examples of more complex DH technology based on sensors are algorithms that can detect physical instability and predict the risk of falls. A number of studies have utilized camera and sensor-based systems to assess gait and developed predictive algorithms with the formation of novel digital fall risk assessment protocols, thus allowing early preventive intervention (21). Since falls are the main cause of accidental death and disability (and the related healthcare costs) within the European Union in older adults (22,23), the development of new technical solutions is receiving much attention.

DIGITAL HEALTH INSTRUMENTS THAT MAY BE USEFUL IN COMMON AGE-ASSOCIATED CARDIOVASCULAR DISEASES

Use of text message programs has been shown to support the management of chronic disease and CV risk factors. These include smoking cessation, weight loss, physical activity, blood pressure lowering, and diabetes care (see below) (24). Since the prevention, detection and treatment of CV disease (including atrial fibrillation –AF- and heart failure –HF-) are closely related to improving health decline in older subjects (11) DH technology management of these diseases is becoming part of the routine CV care in older adults (Figure 2).

Historical underutilization of DH technologies, such as video visits and remote patient monitoring, reflects an incomplete understanding of their value and applications across the chronological and physiological spectrum of older age. This is related to various factors including (a) healthcare workers' incomplete understanding and inertia in old methods of care delivery, (b) older patients' lower rates of digital device usage and comprehension, (c) manufacturers' lack of attention to adapted needs of older adults e.g. simple devices with large screens and text sizes, etc.

During the COVID-19 pandemic, the use of DH technology has been accelerated to preserve and optimize the health of older adults with regard to CV prevention and treatment of CV disease. Restrictions on the use of DH technology have been modified to increase flexibility for clinicians to conduct non–face-to-face visits and to improve patient access to healthcare. Several hospitals and commercial insurance companies currently reimburse telehealth similarly to in–person visits, thus supporting increased telehealth utilization. How this will play out as the pandemic precautions are withdrawn, is unclear and may differ geographically.

In the past decade there has been a proliferation of Web sites and mApps that claim to support secondary prevention of heart disease. A systematic review and meta-analysis of telehealth (phone, Internet, and videoconference communication between patient and health care provider) found that such interventions were not associated with lower all-cause mortality but resulted in significantly lower re-hospitalization or cardiac events compared with non-intervention groups (25,26).

Arterial hypertension and dyslipidaemias

DH technologies may offer various potential improvements in the care of older adult including a closer relationship between patients and medical staff, empowerment of the patients, more frequent measures to tailor therapy, and the chance of avoiding transportation needs, particularly distressing in the oldest and frail patients (27-35).

Remote monitoring and telehealth models of care are important for older adult patients with chronic diseases because they allow acquisition of physiological data from home locations.

Hypertension is a good target for telemedicine, and in particular, for telemonitoring, as it is the most common and important risk factor for CV disease worldwide (35,36). Although data are highly heterogenous regarding both the DH methodology used for telemonitoring, the clinical setting of the patients studied, and the presence of co-morbidities, most reviews and metanalyses tend to show an improvement in blood pressure control (35-38). In addition to the use of telemonitoring, many DH trials include other interventions leading to a comprehensive approach to hypertension, including patient education, behavioural and motivational support, close follow-up and focus on medication adherence, probably all contributing to optimization of clinical outcomes. Moreover, with a new DH intervention combining self-monitoring of blood pressure with guided self-management in patients with poorly controlled hypertension, the drop in blood pressure was larger in the DH-managed groupwhen compared with the usual care group (follow-up 12 months: mean difference of -3.4 mm Hg in systolic blood pressure, 95% confidence interval -6.1 to -0.8 mm Hg, and mean difference of -0.5 mm Hg in diastolic blood pressure, -1.9 to 0.9 mm Hg). However, the benefit was observed to be larger in patients aged less than 67 years (39).

Although telemedicine has been shown to improve blood pressure control as compared with standard care, its place in daily clinical practice is not yet clear. While most guidelines refer to it in the context of excluding white coat or masked hypertension, there are no current specific recommendations on the place of telemedicine in general hypertension management, with the partial exception of the 2018 Hypertension Clinical Practice Guidelines, which suggest that telehealth strategies can be useful adjuncts to interventions shown to reduce blood pressure for adults with hypertension (40).

Several barriers still limit the implementation of telemedicine in the routine clinical management of CV risk factors, including the fact that telemedicine is considered as an add-on to existing care rather than an indispensable tool to be blended in current care delivery (41).

Nevertheless, adopters of DH activity trackers tend to adhere more to hypertension and dyslipidemia medications, and adherence increases with tracking frequency and smartphone-associated blood pressure controls (34, 38,39, 41-44). Digital interventions in the presence of multimorbidity, in patients with difficult-to-treat hypertension or with poor adherence to medication management seem to be clinically relevant.

Diabetes Mellitus

Diabetes mellitus is an important risk factor for the development of CV morbidity and mortality. Self-management with DH technologies was recommended recently by the European Society of Cardiology (ESC) guidelines on diabetes and CV diseases (45). mApps can facilitate self-management by providing reminders for regular measurement of the required parameters and medication adherence, and may support education and motivational support. Improved glycaemic control may improve other aspects of CV health such as reducing AF incidence and recurrence (46,47). Regular transmission of blood glucose levels from patients to their physicians can be based on SMS, e-mail, or various web-based services. Bluetooth-enabled glucose meters are frequently used (48,49). BlueStar™ (Welldoc, Columbia, MD), was the first to receive US FDA clearance for diabetes mellitus management: it comes with an App which requires a physician prescription and enables patients to titrate insulin dosing by using the proprietary insulin calculator. The Freestyle™LibreLink™ app (Abbott Laboratories, Abbott Park, IL) links with an associated continuous glucose monitoring patch and displays trends (50).
Stand-alone diabetes management mApps have recently been reviewed (51). Efficacy for improving glycaemic control in randomized controlled trials has shown varied results (52). Meta-analyses indicate that mobile phone interventions for self-management reduced haemoglobin (Hb)A1c modestly by 0.2-0.5% over a median of 6-months' follow-up, with a greater reduction in patients with type 2 compared to type 1 diabetes (53). A significant impact on clinical outcomes may affect healthcare expenditures by reducing the need for in-person contact with healthcare providers, preventing hospital admissions, and improving prognosis. In a retrospective study, the use of DH technologies was associated with a 21.9% reduction in medical spending than a control group during the first year (54). Key determinants to successful uptake of decision-support mApps will likely be their user-friendliness, simplicity, delivery of electronic communications, and feedback to the patient.

Atrial fibrillation

Although opportunistic tools for AF diagnosis are widely used, the key to making AF identification clinically valuable is the selection of patients with an increased likelihood of harbouring undiagnosed AF (55) and an increased risk of stroke that may qualify for anticoagulation. Patients with non-valvular AF and left ventricular hypertrophy are often older and with a higher prevalence of multimorbidity (56).

Different mHealth–based modalities for arrhythmia monitoring may be used in different settings and to address different questions. Recording electrocardiogram (ECG) tracings (single or multi-lead, in intermittent or continuous format, of various durations) and non-ECG technologies such as pulse photoplethysmography are two different modalities to approach mHealth signal monitoring (57).

Mobile recorders are increasingly used to facilitate frequent brief (e.g. 30s) recordings over prolonged periods of time by the ubiquity of such devices (including smartphone-based mApps or watches) (57). These devices are particularly well suited to capture intermittent or non-persistent arrhythmias. However, since snapshot ECG recordings are unable to capture infrequent paroxysmal AF, new algorithms based on more frequent sampling are needed (58). Such algorithms include repetitive verifications of pulse rate regularity through plethysmography sensors followed by periodic verifications of ECG rhythm when irregularity is detected. According to the Apple Heart Study, notification of irregular pulse is very low in participants without self-reported arrhythmias. However, once notification was received, the chance to confirm AF after returning an ECG patch was about 84%, thus supporting the ability of the algorithm to correctly identify AF in users whom it notifies of irregular pulses (59).

AF burden is increasingly recognized as a powerful independent predictor of stroke and (60,61). Formal screening with mobile ECG recordings has yielded higher incidence of newly diagnosed AF compared with diagnosis relying only on the office ECG (57). The yield generally is enhanced by the presence of risk factors, such as older age and higher CHA2DS2-VASc scores. By focusing on older patients (75-76 years of age) at greater risk, Swedish studies identified new AF in 3% of study participants, and up to 7.4% when additional risk factors beyond age were required (62-64). A recent meta-analysis found that new AF detection rate increased progressively with age from 0.34% for <60 years to 2.73% ≥85 years (65). Importantly, the number of subjects needed to screen to discover AF meeting indications for anticoagulation was 1089 for subjects < 60 years but only 83 for ≥ 65 years.

While subclinical device-detected AF is associated with heightened stroke risk, there is insufficient data and ongoing debate about the minimum duration which would be associated with heightened risk of stroke warranting anticoagulation therapy. One key study suggested that decisions to anticoagulate should not be based on a single cutoff but rather consideration of AF duration relative to CHA2DS2-VASc score (i.e.AF≥6 minutes/day if CHA2DS2-VASc scores 3 or more or AF ≥23.5 hours/day if CHA2DS2-VASc score is 2) (66).

However, according to 2020 AF ESC Guidelines, ECG documentation is required to establish the diagnosis of AF (Class I) (67). When screening for AF, definite diagnosis in screen-positive cases is established only after the physician reviews the single-lead ECG recording of ≥30 s or 12-lead ECG and confirms that it shows AF. Moreover, it is recommended to consider systematic ECG screening for those ≥75 years, or those at high risk of stroke (Class IIa) (67), thus emphasising the relevance for screening in the older patient.

In addition to the role of ECG for arrhythmia detection, recent studies have shown promising results for detecting undiagnosed left ventricular dysfunction, hypertrophy, and ischaemic heart disease (68).

Heart Failure

The prevalence of HF is ≥ 10 % among those 70 years and older. It is associated with comorbidities, poor quality of life, high healthcare utilisation, and increased mortality (11,12). People living with HF may often be geographically separated from specialized healthcare providers, making symptom monitoring and disease control more difficult. Telehealth programmes for HF patients at home have been suggested to have positive impacts on both mortality and morbidity (69). However, adoption is limited by the fact that most often programmes require the patients' ability to use a computer, a tablet or a mobile phone together with other medical equipment (70). The most recent ESC HF guideline (71) made a "Level 2b" ("may be considered") recommendation for the use of home-based telemonitoring, based on a meta-analysis published in 2017 (72).

Clinical guidelines and national organizations have recently recommended the integration of palliative care into standard HF care (73). The Educate, Nurture, Advise, Before Life Ends (ENABLE) Comprehensive Heartcare For Patient and Caregivers (CHF-PC) Study (74) has been designed to implement behavioural support in advanced HF patients. The study includes a series of 30- to 60-minute, weekly telehealth coaching sessions with a nurse addressing palliative care topics (74).

Remote monitoring in HF patients may monitor symptom and activity levels, sleep disordered breathing, changes in heart rate (as a marker of autonomic activity), arrhythmia, and support dietary and medication adherence. Such monitoring can be achieved using stand-alone equipment and/or wearables, or cardiac implantable electronic devices (if present). Such systems may enable remote adjustment of medication, and other earlier interventions to reduce the need for emergency department visits and unplanned HF-related hospitalizations. If scalable, remote monitoring coupled with mobile communication may reduce costs associated with HF, although the evidence to date is not conclusive (75-78). Careful patient selection, more rapid and locally-integrated responses to evidence of deterioration, and reimbursement support are likely success factors (78).

Patients with an implantable cardiac device such as an implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy (CRT) require regular checks to monitor device performance, battery longevity and detection of arrhythmia, but most modern devices can wirelessly connect with home monitors that transmit relevant data and alerts, allowing a device check to be performed remotely (79). Home monitoring is safe and effective for routine device checks, with earlier detection of arrhythmia and technical issues (80). Centres using home monitoring of implanted devices have reported reduced face-to-face contact (81). Such devices can also collect physiological data that may correlate with HF status. Multiparametric monitoring, incorporating intrathoracic impedance with other variables such as heart rate, heart rate variability, physical activity and heart sounds, has shown potential, but requires consideration of the workflow issues such as what actions should be taken in response to "alerts" being raised, and the need to persuade patients to change therapy (or be more adherent to lifestyle and drug therapies) despite them feeling well (82).

Implantable haemodynamic monitors have shown promise at preventing HF hospitalisation. Pulmonary artery pressure (PAP) increases in response to increasing intracardiac pressure or fluid volume, with rises in pressure typically preceding symptoms by some weeks (83). A randomised trial showed that remote daily PAP monitoring, (via a CardioMEMSdevice;Abbott) and titration of medications in response to rises in pressure, reduced subsequent HF hospitalisation by 30% in NYHA Class III patients who had been admitted for HF in the previous year (84). Data from NYHA Class III patients outside the US confirm this benefit (85,86). The GUIDE HF study recently reported benefit in a pre-specified pre-covid19 subgroup analysis of a broader spectrum of symptomatic severity (87) leading to FDA support of the use of CardioMEMS in patients with HF and a recent hospitalisation or raised natriuretic peptides.

ESC HF guidelines make a recommendation only for CardioMEMS and as only a "may be considered" Class 2 B level of evidence (71).

DIGITAL TOOLS ABLE TO PREVENT AND MANAGE FRAILTY

DH tools and mApps have been developed to assess and monitor frailty status in patients with CV disease, and are being studied to target therapeutically the various components of frailty (11). Certain mApps have integrated assessments of frailty alongside CV risk scores to provide global estimates of post-procedural risk or poor outcomes. One example is the Frailty Tool mApp (frailtytool.com) that integrates the Essential Frailty Toolset (EFT) alongside the Society of Thoracic Surgeons risk score to guide decision making in older adults referred for transcatheter aortic valve replacement (TAVR) or cardiac surgery. In addition to prognostic value (88,89), therapeutic value has been demonstrated by de-frailing patients with high EFT score using prehabilitation and multicomponent geriatric intervention (90,91).

In daily clinical practice, general cardiologists are increasingly using DH tools for the management of deficits associated with older-age (Figure 2). The progression of health decline and frailty may be usefully opposed by DH-supported management of medication adherence, physical and nutritional needs, and the specific requirements after acute events. Moreover DH assistance may help to enhance the collaboration with family caregivers and health personnel who are supporting older adults living at home (Figure 2). Since major cognitive impairment or poor social support often limit the ambulatory access to an outpatient clinic, DH-based management focused on the physical and medical domains deficits may be particularly relevant to frail patients with CV disease who are seen in office-based practice (11).

Drug adherence and persistence

Poor adherence to medical therapy is frequent in older patients (92,93) resulting in poorer clinical outcomes and increased healthcare costs (94); forgetfulness, communication barriers, socio-economic factors, and lack of motivation represent the main causes of poor adherence. Interventions to assess and improve medication adherence within a home setting based on mHealth techniques have been investigated. The assessment of drug adherence may rely on self-report methods, visual confirmation by smartphone, digital pills dispenser or a Quick Response code (95-97).

Drug adherence may be improved by two broad categories of strategies: behavioural (e.g. “smart” pill boxes, follow-up telephone calls, SMSs, Apps) and educational (e.g. Web-based e-learning). A systematic review including 10 trials reported that mHealth interventions improved medication adherence in CV patients, though the magnitude of benefit was not consistently large (98). A recent review, evaluating drug adherence in older adults identified 50 studies (14,269 participants) comparing interventions versus usual care (99). Behavioural-only (RR 1.22, 95% CI 1.07 to 1.38) and mixed interventions (RR 1.22, 95% CI 1.08 to 1.37) may increase adherence, while educational-only interventions (SMD 0.16, 95% CI -0.12 to 0.43-) may have little or no impact. Globally, the quality of evidence is low, due to heterogeneity and methodological limitations of studies included in the review. Further studies are required.

Greater progress is expected with better co-designed smartphone mApps that take into account age-related factors that limit optimal use by elderly and/or frail patients, with more optimal user friendliness obtained with appropriate levels of training and support (100, 101). Voice and visual interfaces could be useful by recognizing vocal biomarkers of change in neurological or mental health status (4,102). Potential concerns on privacy and security regarding medications may be overcome for instance by using biometrics during authentication (103,104). A patient-centred approach is encouraged to assist patients construct their own individualized adherence strategies (105). Machine learning and Artificial Intelligence may help in personalized patients experiences, taking into account socio-economic, cultural and personal characteristics (106). Current evidence suggests that DH tools can improve medication adherence in older patients with, or at risk of, CV disease.

Nutrition

Malnutrition is one of the important determinants of physical frailty and sarcopenia – defined as the progressive loss of muscle mass and strength associated with aging– and an actionable target for its improvement. Several studies have demonstrated the high prevalence and negative impact of malnutrition in older adults with CV diseases (11, 107-110). Most mApps for multidomain assessment of frailty include malnutrition screening (11,111) and many DH technologies have been employed to identify hospital malnutrition (112).

Nutritional therapy should be individualized for each patient according to their needs and consider both food sources and pharmacological supplements such as vitamin D and calcium (107). A systematic review on nutrition in older adults reported a negative association between lower intake of specific micronutrients and frailty, and a protective association between higher intake of protein and dietary antioxidant and frailty (108).

Calculation of energy, protein, micronutrient needs should be performed in consultation with qualified nutritionists in line with the appropriate guidelines, while taking into account the specific requirements of the older adult given their relevant comorbidities such as cancer, gastroenterologic, neurologic and renal diseases (113).

Telemedicine can be used in the monitoring of patients with parenteral nutrition at home, even though there is limited literature that has focussed in this space (114,115). Elderly and frail patients must have access to nutritional care as a part of primary and secondary healthcare services (115). Recently, Krznaric and colleagues proposed a simple remote nutritional screening tool and practical guidance for nutritional care in primary care, along with their implementation into telemedicine processes and digital platforms suitable for healthcare providers (116). The intervention consisted of practical guidance on nutritional interventions for family physicians after identification of nutritional risk and loss of muscle mass and function by validated tools.

Movement and fitness

Physical frailty is characterized by diminished strength and endurance (11,107). Early detection of health transitions towards a frail condition is often challenging, particularly in the pre-frailty state where changes may be subtle. Screening to diagnose frailty syndrome in older adults with subtle or no overt clinical manifestations of frailty can be achieved by employing DH technologies that incorporate physical performance-based screening, such as gait speed and assessments of gait, “sit-to-stand” tests, grip strength, or using recently developed Apps to quickly perform a multidomain screening for frailty (11,117). Digital biomarkers when applied to the identification of the frailty phenotype are objective, quantifiable, physiological and behavioural data that are collected and measured by means of digital devices such as sensors or wearables, enabling remote data collection and processing of large amounts of real-life, continuous and long-term health-related data (118). Examples of such digital biomarkers include waist-worn accelerometer sensors that allow digital monitoring of walking speed – they have been shown to be able to accurately measure continuous gait speed in frail, older patients - (119). Wrist-worn sensor-derived frailty indices have also been validated in comparison with other established measures of frailty such as gait, timed “up and go” and “sit-to-stand” assessments (120). Sit-to-stand tests can be undertaken remotely through measures of hip and knee angular velocity range, weakness, and exhaustion (coefficient of variation of angular velocity range of hip and knee, and vertical power range) from sensors attached to the trunk and thighs thereby providing remote assessment of this traditional measure of physical frailty (121).

Other sensor based digital solutions provide data to populate risk scores for frailty. For example, wrist-worn fitness trackers used before TAVR have been used to develop a Fitness-tracker assisted Frailty-Assessment Score (FIFA score) that has greater predictive performance for in-hospital mortality compared to that of the 6-minute walk test and the Edmonton Frail Scale classification (122).

Physical support and rehabilitation

Telerehabilitation is the supervision and performance of comprehensive cardiac rehabilitation at a distance, typically including video-consulting, tele-monitoring, tele-assessment (active remote assessment), tele-support (supportive tele-visits by nurses, psychological support), tele-therapy (actual interactive therapy), tele-coaching (support and instruction for therapy), and teleconsulting and tele-supervision of exercise training (25,26,123).

Home-based tele-rehabilitation has been demonstrated to be safe and effective, with high adherence among people living with HF. It improves physical and psychological status, 6-minute walk distance, and Quality of Life (123-125). The recent Scientific Statement from the American Association of Cardiovascular and Pulmonary Rehabilitation, the American Heart Association, and the American College of Cardiology highlights that home-based rehabilitation using telemedicine is a promising new service model (126).

Moreover, such technologies may provide support focused on nutrition and fitness before scheduled procedures, and DH technology have been used after interventional TAVR procedures and to guide rehabilitation after lower limbs revascularization (11,127,128).

Home stay and interaction with health personnel

The collaboration between caregivers (family members, nurses and health personnel for home support) and medical personnel is central in the management of older people who have lost some degree of independence but are still living at home. DH technology has the potential to improve the connection and exchange of medical information.

Older adults are considered to be at the highest risk for poor communication with healthcare providers (129). This is due to the presence of a multiple comorbidities, poly-pharmacy, functional impairment, affective disorders, cognitive decline and sensory impairment (130). Compared to younger patients, older adults in general are frequently less proactive and ask fewer and less in-depth questions which may result in poor memory retention of medical information (131). This is problematic because adequate information recall positively contributes to patient treatment adherence, disease management, quality of life and health outcomes (129,132,133). To increase the likelihood that health information will be understood, processed and applied by older adults, it is critical to provide instructions in a variety of ways (129). Both interpersonal communication (e.g., patient-provider communication through video consulting) and digital communication (e.g., mHealth Apps) provide opportunities to improve information processing, self-management and health outcomes in older adults. One important reason to use interpersonal communication during consultations with health communication technologies is their synergistic effect (134). The combination of multiple communication media exceeds the sum of their individual effects (135). Moreover, use of online interventions among older adults can be associated with increased social activity, decreased loneliness, increased perceived social support, improved self-competence, and enhanced wellbeing (136,137). As people with frailty have distinct informational, social and health-management needs, they might derive unique benefit from accessing relevant health information and from interacting with others with similar health issues through online group interventions or through social media (138).

LIMITATIONS FACED BY OLDER ADULTS IN USING DIGITAL HEALTH TECHNOLOGY

Although the familiarity of older adults with technology is increasing, barriers to wider adoption include very old age, lower disposable income, and higher comorbidity (139-141). Although patients with cognitive impairment and high degree of frailty are probably less likely to direct benefit from DH approaches to disease management and care, DH technology may provide support to their caregivers. Whilst it has been shown that older adults are less likely to use new technology compared with younger adults, there is ample evidence that they also desire interaction with new technologies to remain active and engaged with society (142). Several challenges that older adults face when adopting digital technology include the poor confidence in their ability to learn and use technology devices, in part because of their perception that the technology is too complicated, and physical or functional barriers in using technology devices not designed with their needs in mind (139,142). For example, touchscreen devices may be challenging in the case of visual impairment or when hearing defects may impair verbal tele-communications. Larger font sizes, bigger icons, magnification and volume amplification or earphones might be helpful in this population. Furthermore, elderly patients with cognitive decline may struggle to use technology that requires active interaction rather than more passive monitoring functionality such as the wearing of a sensor or a smart watch. While DH developments may increase access to care for older adults we should be aware of the need to avoid increasing inequality by ageism or geographical or socioeconomic biases (143). Co-designing the new technical supports taking into account the specific ageing-associated needs of those who will use the technology would appear essential.

CONCLUSIONS

DH is changing daily practice in general cardiology. Although recent results from an ESC survey developed to assess the knowledge of cardiologists about DH technologies showed interest from cardiologists, the experience of (and knowledge about) DH tools were lower in ‘general’ office-based cardiologists compared with hospital-based cardiologist (144). DH technology has potential to be useful for every field of cardiology, but notably in an office-based setting with frequent contact with ambulatory older adults who may be pre-frail or frail but who are still able to live at home.

DH technology may enhance the characterization of older adults’ health status and increase the personalisation of clinical follow-up, and help in the prevention and the general management of frailty, while supporting specific age-related CV diseases with dedicated tools. However health personnel should not consider DH as a replacement for face-to-face clinic visits, but rather as an additional tool to help support better outcome and experience of care. To fully benefit from the potential of DH, cardiologists and other healthcare professionals should increase their DH skills and learn how best to apply and integrate new technologies. The ESC actively supports improved multi-stakeholder interaction, co-design and education in DH as a key element of its mission to reduce the burden of CV disease.

DECLARATIONS

L Guasti, P Dilaveris, M A. Mamas, D Richter, R Christodorescu, J Lumens, M J Schuuring, S Carugo, J Afilalo, M Ferrini, R Asteggiano, M R Cowie declare no conflict of interest and declare that the submitted work is original and has not been published before (neither in English nor in any other language) and that the work is not under consideration for publication elsewhere.

Box. Definitions

FIGURES

Figure 1a. Ageing and frailty-related health decline

Figure 1b. Frailty domains and components

Figure 2. DH interventions in older adults with, or at risk of, CV disease

REFERENCES (annexe: in data supplement on-line only)

Figure

Digital Health in Community-Dwelling Older Adults for the Prevention and Management of Cardiovascular Diseases and Frailty

Consensus document from the ESC Council for Cardiology Practice/Taskforce on Geriatric Cardiology, the ESC Digital Health Committee and the ESC Working Group on e-Cardiology

Box. Definitions

Electronic-Health (eHealth). The use of information and communications technology in support of health and health-related fields, including health care services, health surveillance, health literature, and health education, knowledge and research.

Mobile-Health (mHealth). The use of mobile and wireless technologies to support health objective; the application of sensors, mobile apps, social media, and location-tracking technology to obtain data pertinent to wellness and disease diagnosis, prevention, and management . mHealth is a component of eHealth.

Digital Health. An overarching term that comprises eHealth (which includes mHealth), and emerging areas, such as the use of computing sciences in the fields of artificial intelligence, big data and genomics.

Applications (Apps). Computer software programs that operate on computer, tablets and other mobile devices such as smartphones and smartwatches (**Mobile-Apps – mApps-**).

Client-to-provider telemedicine. Provision of health services at a distance; delivery of health care services where clients/patients and health workers are separated by distance.

Digital biomarkers. Physiological and behavioral measures collected by means of digital devices such as portables, wearables, implantables, or digestibles that characterize, influence, or predict health-related outcomes.

Digital diagnostics. The application of wearable and ambient sensors, mobile apps, social media, and location-tracking technology singly or in combination to diagnose medical conditions.

Digital therapeutics. Interventions that use wearable and ambient sensors, mobile apps, social media, and location-tracking technology independently or in conjunction with medications, devices, or other therapies to improve patient care and health outcomes.

FIGURES

Figure 1a. Ageing and frailty-related health decline

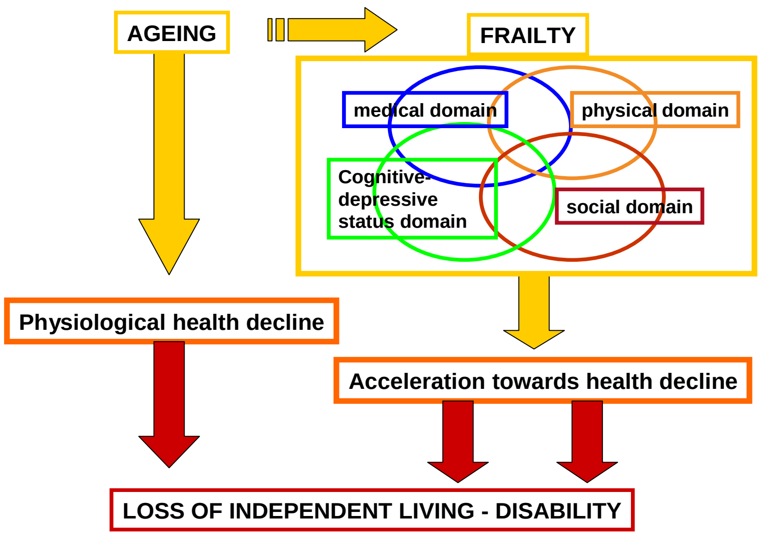

Figure 1b. Frailty domains and components

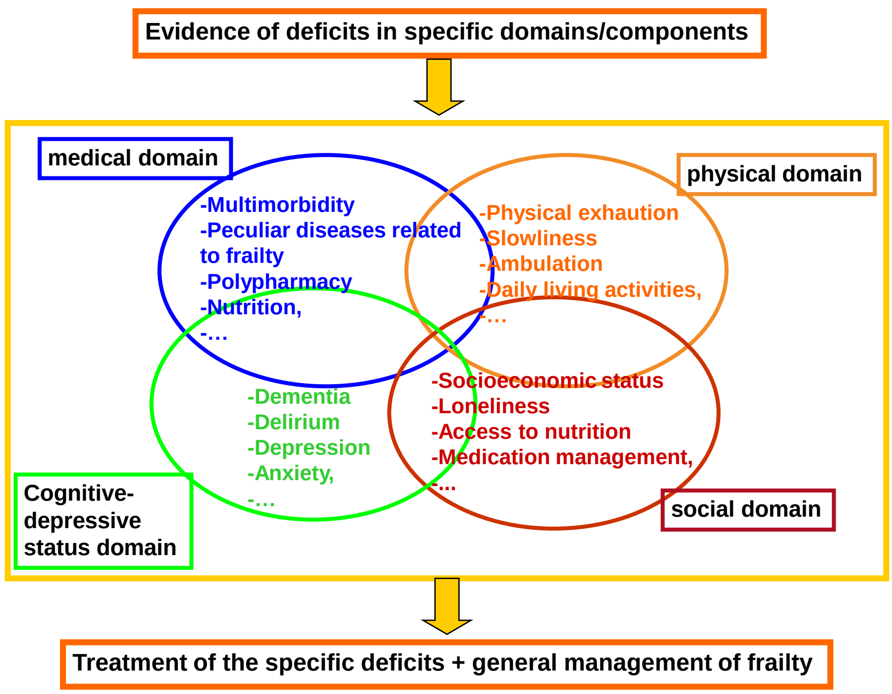

Figure 2. DH interventions in older adults with, or at risk of, CV disease