

HerzMobil Tirol network: rationale for and design of a collaborative heart failure disease management program in Austria

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Summary Heart failure (HF) is approaching epidemic proportions worldwide and is the leading cause of hospitalization in the elderly population. High rates of readmission contribute substantially to excessive health care costs and highlight the fragmented nature of care available to HF patients. Disease management programs (DMPs) have been implemented to improve health outcomes, patient satisfaction, and quality of life, and to reduce health care costs. Telemonitoring systems appear to be effective in the vulnerable phase after discharge from hospital to prevent early readmissions. DMPs that emphasize comprehensive patient education and guideline-adjusted therapy have shown great promise to result

in beneficial long-term effects. It can be speculated that combining core elements of the aforementioned programs may substantially improve long-term cost-effectiveness of patient management.

We introduce a collaborative post-discharge HF disease management program (HerzMobil Tirol network) that incorporates physician-controlled telemonitoring and nurse-led care in a multidisciplinary network approach.

Keywords Telemonitoring · Disease management program · Chronic heart failure · HerzMobil Tirol network

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HerzMobil Tirol Netzwerk: Rationale und Design eines sektorenübergreifenden Betreuungsnetzwerks mit Telemonitoring für Patienten mit Herzinsuffizienz in Österreich

Zusammenfassung Herzinsuffizienz ist der häufigste Grund für Krankenhausaufnahmen bei älteren Patienten. Die hohe Anzahl rascher Wiederaufnahmen nach Entlassung sind mit hohen Kosten verbunden und widerspiegeln die bislang unzureichende Versorgung dieser Patienten. Disease-Management-Programme (DMPs) sollen die Schnittstellenproblematik zwischen Krankenhaus und niedergelassenem Bereich sowie Lebensqualität und klinischem Langzeitverlauf verbessern, die Eigenkompetenz von Patienten stärken und langfristig die Kosteneffektivität der Versorgung erhöhen. Mit Hilfe von telemedizinischen Einrichtungen können die häufigen Wiederaufnahmen in der vulnerablen Phase nach Krankenhausentlassung reduziert werden. Eine langfristige Stabilisierung ist allerdings nur mit DMPs möglich, welche eine umfassende Schulung von betroffenen Patienten sowie eine konsequente Therapieoptimierung zum Ziel haben. Es ist wahrscheinlich, dass die Kombination derartiger DMPs mit telemedizinischen Systemen sowohl die Effizienz als auch die Kosten-Effektivität der Patientenversorgung verbessert.

Wir berichten über ein integratives Versorgungsprojekt für Patienten nach akuter kardialer Dekompensation, bei dem ein nicht-invasives Telemonitoringsystem in ein umfassendes, sektorenübergreifendes Betreuungsnetzwerk eingebunden ist.

Schlüsselwörter Telemonitoring · Disease Management Programm · Chronische Herzinsuffizienz · HerzMobil Tirol Netzwerk

Introduction

Heart failure (HF) is approaching epidemic proportions worldwide. Its prevalence extends from 0.7% in the younger population to more than 10% in individuals >75 years of age [1]. HF is the leading cause of hospitalization among elderly patients [2]. Rates of death and readmission after hospitalization for acute HF remain high despite considerable advances in evidence-based therapy. Mortality rate within the first year approaches 40%, and up to 50% of patients are readmitted within 6 months of discharge [3–5]. Given that approximately two-thirds of HF health care expenses are due to in-hospital treatment, repeat hospitalizations contribute substantially to the enormous overall economic burden of the disease [6]. It is estimated that up to two-thirds of readmissions for acute HF are triggered by potentially remediable factors, including poor discharge planning, nonadherence to recommendations regarding diet and medical treatment, inadequate follow-up, poor social support, and delays in seeking medical attention [7].

Post-discharge disease management programs have been established to prevent readmission and reduce mortality and health care costs. These programs vary widely in their specific content and focus, including specialized HF clinics [8], nurse-led interventions [9], and telephone support models or telemedical monitoring systems [10–13]. Pooled data from 18 predominantly small, single-center studies demonstrated a 25% reduction in the rates of all-cause hospital readmission and a statistically nonsignificant trend toward reduced mortality [14]. Benefits were achieved without an increment in overall health care costs. These promising results, however, contrast with findings from recent studies that provided post-discharge support to HF patients via remote monitoring involving a telephone-based interactive voice-response system (Tele-HF) [15], nurse telephone support [10], or more intensive monitoring intervention (TEN-HMS) [10]. No incremental benefit of home monitoring over standard HF care can be derived from these large, prospective, multicenter clinical trials. Similarly, no substantial benefit of remote monitoring over usual care was recorded in the German Telemedical Interventional Monitoring in Heart Failure (TIM-HF) study that included 710 patients with mild-moderate HF [11].

Overall, available evidence suggests that remote surveillance of HF symptoms and physiological data by telephone or using telemonitoring systems may facilitate early detection of clinical deterioration and direct corrective intervention to avert adverse clinical outcomes in the early, vulnerable phase after discharge from hospital [7, 13, 16]. By contrast, mid- to long-term benefits may be better achieved with strategies that target sustained therapeutic modifications and patient self-efficacy through education to promote self-management and adherence to treatment plans [7, 16]. From this, it can be speculated that improvement of long-term cost-effectiveness of patient management may be achieved by combining core elements of the aforementioned programs. We here introduce a multidimensional post-discharge disease management program for HF patients, HerzMobil Tirol network, with a telemedical monitoring system incorporated in a comprehensive network that includes specialized HF nurses, private practice physicians, and primary and tertiary referral centers.

Methods

mHealth-based closed-loop health care monitoring

Mobile health monitoring offers new opportunities to improve the management of HF patients at home and to increase patient compliance with medical therapy [17]. Mobile phone applications are available that enhance patient empowerment and facilitate reliable and efficient data transfer of measured physiological data [18, 19]. Desai and Stevenson [20] defined a sequence of steps needed to successfully implement home monitoring in a comprehensive HF management approach: (a) transmis-

sion of physiological data by the patient; (b) data retrieval and analysis, and to close the loop; (c) patient contact to implement the prescription; and finally, (d) continued monitoring for response and revised intervention. Such a closed-loop health care approach is shown in Fig. 1.

In the HerzMobil Tirol network, patients are provided with a blood pressure and heart rate monitor and a scale. From lessons learned from the Austrian MOBITELE trial [12], an integrated system called Keep-In-Touch (KIT) was developed to facilitate efficient and reliable data transfer and to document drug intake and well-being based on Near Field Communication (NFC)-enabled mobile phones and medical devices [21].

Signal processing and analyzing algorithms filter the relevant signals from the noise of physiological data and thereby support timely identification of upcoming adverse events. Automatic event detection in terms of missing values and off-limit measurements, where limits are individually defined, signals the need for therapeutic decisions and facilitates optimized allocation of attention to those patients who might need early intervention [19]. Physicians are empowered to timely react on patient clinical deterioration, noncompliance, or the need for dose adjustment of existing medication.

Collaborative heart failure network

Although automated home monitoring can identify clinical deterioration or impending decompensation, additional steps are necessary to effectively close the circle of HF management and prevent hospitalization events [7, 20]. Comprehensive HF management requires multidisciplinary collaborative care, in particular with respect to longitudinal care across venues. During the transition after hospitalization, information is often lost in the handoff from the discharging hospital to the next venue of care and vice versa. Gaps in transition of care in HF are

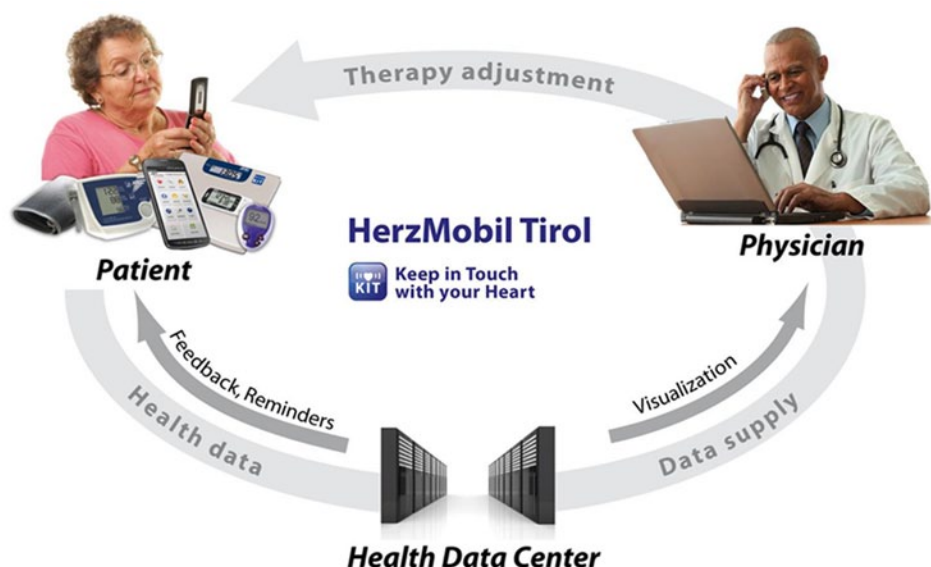
found in the fields of medication errors, handoff communication, and discharge planning [22]. After discharge, complex medical, social, and economic factors as well as intermittent worsening of HF call for an integrated team-based approach [23]. Patients, relatives, physicians in private practice and in hospitals, as well as HF nurses can provide valuable contributions. HF outpatient clinics have been established, where a team of HF cardiologists, HF nurses, and other HF-related experts provide diagnostic services, comprehensive patient education, and counseling and treatment according to prevailing guidelines [24, 25]. Beyond that, structured post-discharge management is barely established in Austria. Physicians in general practice, including cardiologists, specialists in internal medicine, and general practitioners, however, are important partners in managing HF patients, and close and ongoing cooperation between these stakeholders and HF outpatient clinics is needed [26].

HF nurses play an important role in mHealth telemonitoring-based collaborative HF networks, being the direct link to the patient at almost all levels of care. Besides patient education and counseling, the agenda comprises home visits and adjustments of medical therapy according to instructions from network physicians. To meet the comprehensive tasks, in-service training in HF nursing care for graduated nursing staff that is supported by the Austrian Working Group on HF as well as the Board of the Austrian Society of Cardiology was recently introduced in Austria [27].

HerzMobil Tirol network project

Based on evidence from published trials and lessons learned from a previous project [12], a collaborative HF network, the HerzMobil Tirol network, was implemented by the health care provider TILAK in 2012 [12, 14, 28]. The project was approved by the local ethics committees. All

Fig. 1 In the HerzMobil Tirol network, information on blood pressure, heart rate, weight, health status, and drug intake is transmitted daily by the patient via the NFC-enabled mobile phone to a health data center. Processed and visualized data are provided to stakeholders, who are thereby enabled to react by adjusting therapy. Continuous monitoring allows reassessment of response to therapeutic modifications



patients provided informed written consent. This hybrid network model incorporates core elements of different HF management programs as physician-controlled telemonitoring and nurse-led care into a multidisciplinary network approach. Participating physicians are located within and outside the hospital. Communication between the HF management stakeholders encircles the patient and ensures optimal treatment without delay (Fig. 2).

All relevant information can be shared on web-based TMScardio telemonitoring software and instantly reviewed by anyone with conferred access to the system. The TMScardio telemonitoring system serves as the IT backbone. The HerzMobil Tirol network incorporates one tertiary and three primary referral centers in the greater Innsbruck area, two dedicated HF outpatient clinics, three HF nurses, nine internists in private practice, one general practitioner, and one medical coordinator.

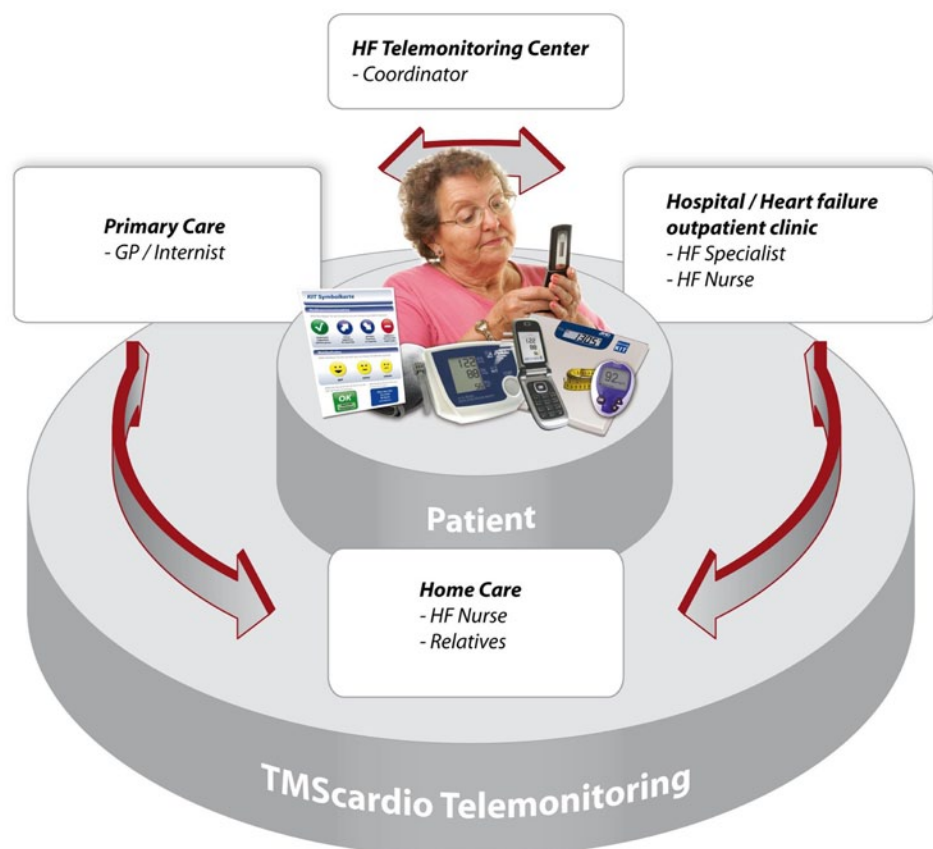
Patients hospitalized for acute HF are assigned to the program irrespective of the underlying heart disease. Patients with end-stage HF and/or comorbidities associated with a life expectancy of less than 6 months or patients who are not capable of using the provided devices are excluded from the program. Specially trained HF nurses provide patient education on self-management and a better understanding of their disease before discharge. In addition, patients are trained in the use of the mHealth-based telemonitoring equipment, including blood pressure and heart rate monitor, scale, and

NFC-enabled mobile phone. The patient is assigned to one of the network physicians in private practice, who is designated to supervise HF management and adjust therapy according to prevailing guidelines. Extensive discharge information is communicated from the hospital to the assigned physician at time of discharge via the web-based TMScardio telemonitoring software. The allocated network physician reviews telemedical patient data at least once a week. Out-of-limit data that are detected automatically by the telemonitoring system are reviewed immediately so that timely interventions, e.g., adjustment of diuretics, can be made (Fig. 3). In-hospital HF specialists serve as back-up in case of serious problems.

A home visit by the HF nurse is scheduled within 1 week after discharge to complete disease- and equipment-related education and to make sure that prescribed medication is available to the patient. Patients are requested to provide daily information on blood pressure, heart rate, weight, well-being, and drug intake via the NFC-enabled mobile phone. Patients are followed for 6 months under supervision of all stakeholders of the collaborative HerzMobil Tirol Network. During this phase, patients will learn how to adhere to treatment and improve self-management abilities. A medical coordinator orchestrates all stakeholders and manages efficient co-operation of the involved partners.

Following a pilot study, a proof-of-concept project was started in December 2013. By the end of the recruitment period in April 2014, 63 patients had been enrolled

Fig. 2 The collaborative HerzMobil network includes physicians in hospital and in private practice, specially trained heart failure nurses, and a telemonitoring system. Information between stakeholders is shared on web-based TMScardio telemonitoring software and orchestrated by a coordinator. Thereby, patients are embedded in a close-meshed network of stakeholders to ensure disease stability



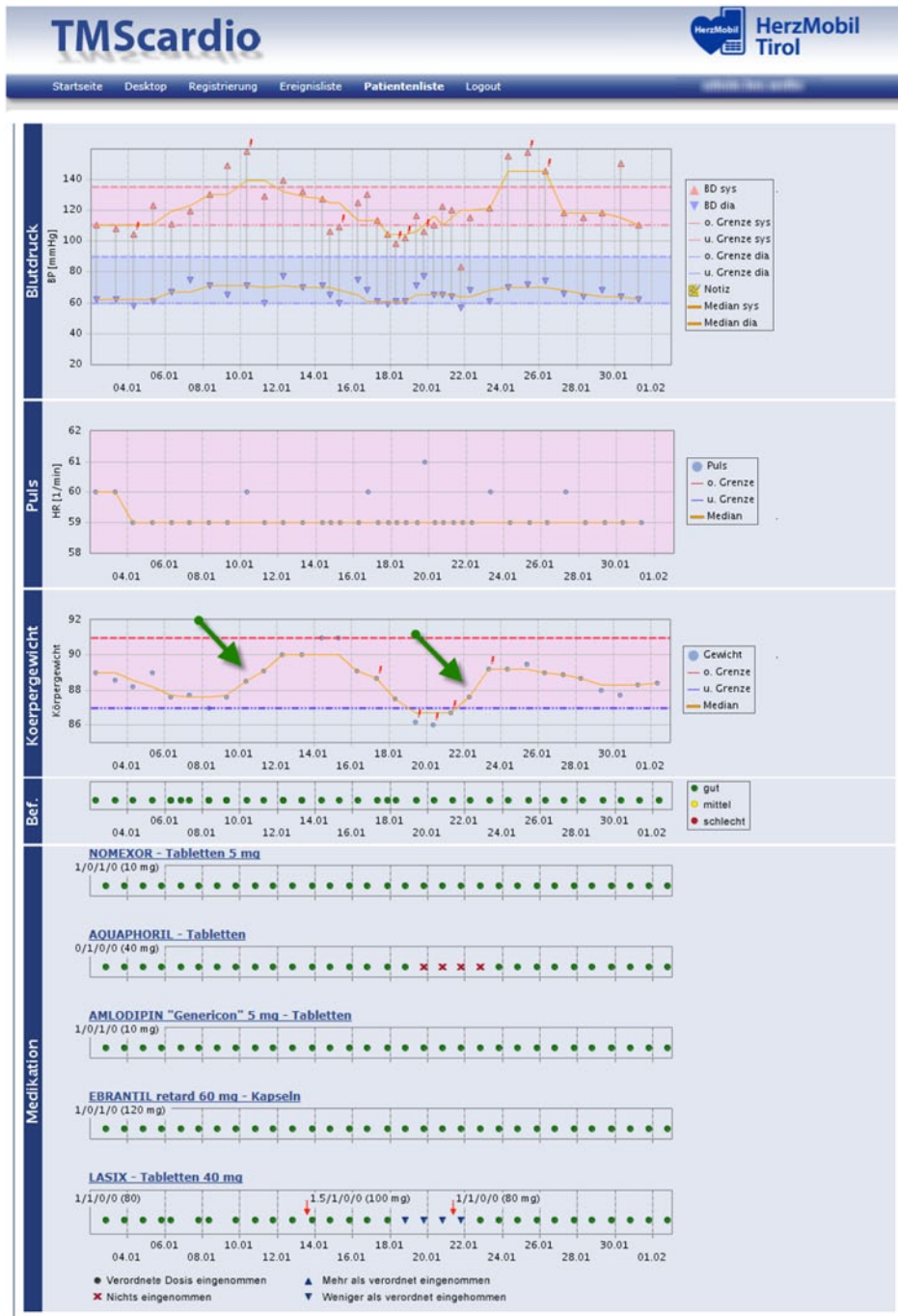


Fig. 3 In the HerzMobil Tirol network, transmitted data are depicted graphically by the TMScardio telemonitoring system and provided to the assigned stakeholders. The figure shows graphically displayed data transmitted by a 71-year-old woman, who was included in the program while hospitalized for acute heart failure due to hypertensive cardiomyopathy with preserved left ventricular function 2 months earlier. Starting on January 8, weight gradually increased by nearly 4 kg within 5 days (arrow). The trend to weight increase became obvious on day 3. After telephone contact with the patient to catch up on her condition, dosage of furosemide was increased from 80 to 100 mg daily. This intervention resulted in a rapid decrease in weight, and the previous dosage was reintroduced within 7 days. A second peak in weight on January

23 (arrow) was due to the patient's decision to temporarily stop xipamide. After restarting therapy, her weight leveled out to her "dry weight" of 88 kg. This demonstrates how the HerzMobil Tirol network enables timely corrective interventions on early signs of disease worsening and hence can prevent acute exacerbation of HF in the vulnerable post-discharge period. Also, continuous monitoring allows reassessment of response to therapeutic modifications and subsequent adjustments, if needed. Thereby, the HerzMobil Tirol network acts as a closed-loop health care approach, where the circle of HF management starts with data collection and interpretation followed by adequate corrective interventions and reassessment for response

in the program. Analysis of disease-related data, data on hospital readmissions and mortality as well as on quality of life, acceptance of the program by patients and stakeholders, and feasibility of the program is conducted by the Department of Electrical and Biomedical Engineering and the Department of Biomedical Informatics at UMIT - University for Health Sciences, Medical Informatics and Technology. Final results will be presented after the last patient has completed the 6-month follow-up period in October 2014.

Discussion

Dedicated disease management and telemonitoring programs have been established to comply with the comprehensive patient care needs following discharge from hospitalization for acute HF. However, efficiency of isolated home-monitoring programs with regard to patient outcome is still under debate [7, 29]. Also, optimal level and intensity of care for which kind of patient and the volume of reasonable costs are still unclear [7, 30].

Close monitoring of signs and symptoms of congestion and gaps in transitions of care are critical in the post-discharge period. Poor adherence to medication and poor recognition of early signs of cardiac decompensation on the patient's side as well as insufficient collaboration among care providers may be efficiently addressed by integrating a closed-loop telemonitoring program in a comprehensive multidisciplinary disease management program. Such a hybrid program as established by the HerzMobil Tirol network can cope with crucial issues like adherence, behavior changes, monitoring, and timely interventions.

Mobile communication devices such as mobile phones together with Internet and other wireless devices can improve disease management by extending health interventions beyond the reach of traditional care—an approach referred to as mHealth [31]. In addition, mobile phone applications have been designed to enhance patient empowerment and patient self-efficacy.

It is an open question, though, how to combine these mHealth applications and disease management programs to an effective HF disease management network that timely and efficiently closes the feedback loop between patients and their providers and thus supports continuity of care. Also, what is the best approach to implement these concepts in clinical practice for a wide range of patients—from low-risk to high-risk patients and from patients supervised by HF specialists to patients out of reach of specialized HF centers?

The risk of readmission after hospital discharge as well as the number of avoidable readmissions varies according to the patient's location along the overall trajectory of illness [32, 33]. The risk is high in the early post-discharge interval (transition phase), falls off to a lower plateau after 2–3 months (plateau phase), and then reaccelerates as patients approach the end of life (phase of palliation and priorities) [32]. Likewise, the number of avoidable hospitalizations is high in the transition phase, whereas in the plateau phase, disease stability might be disrupted by unavoidable readmissions due to complications like atrial fibrillation or infection. In the phase of palliation and priorities, the number of avoidable hospital admissions increases again and might be prevented if appropriate support for palliative care is available. Thus, to obtain the optimal trade-off between costs (efforts of care, manpower) and benefits (increase in quality of life, reduction of re-hospitalization and mortality), the level

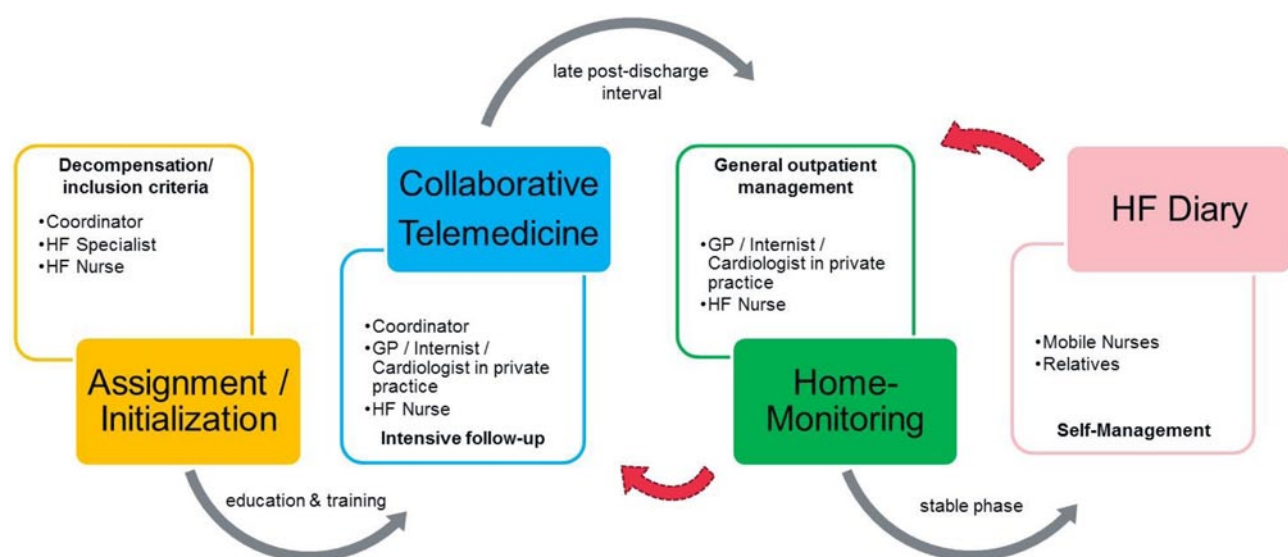


Fig. 4 Following inclusion in the HerzMobil Tirol network, intensity of care provided by a network of various stakeholders is gradually reduced as patient empowerment and HF stability

increase along the trajectory of disease. Intensity of care is increased again in case of recurrent instability

of care and monitoring of HF patients should be adapted according to the patient's location along the overall trajectory of the illness [34].

Fig. 4 illustrates how the level of HF care may be gradually adjusted within an mHealth telemonitoring-based collaborative HF network, such as the HerzMobil Tirol network: eligible patients are enrolled in the program during acute HF hospitalization. Comprehensive patient education is provided by specially-trained HF nurses.

Patients are also trained in the use of mHealth-based telemonitoring equipment. Adequate discharge information is communicated to the assigned network physician in private practice at discharge, and the patient is followed for 6 months by the stakeholders of the collaborative HF network, which is considered the most vulnerable phase. Prevention of disease progression is promoted by gradual adjustment of medication according to prevailing guidelines. During this phase, patients will learn how to adhere to treatment and improve self-management abilities.

As patient empowerment and stability of the disease status increase (plateau phase), the level of care can be reduced, switching from close-meshed medical supervision for a limited time to lifetime home care (i.e., assistance by mobile nurses and/or relatives). Intensity of care might be increased again in case of worsening HF (indicated by red arrows in Fig. 3) or in the phase of palliation and priorities, but with more focus on palliative care.

HerzMobil Tirol is a collaborative HF network that integrates hospital- and private practice-based physicians along with HF nurses and telemonitoring facilities. A data-protected Internet platform facilitates efficient and timely communication among stakeholders. Communication between stakeholders and patients is primarily based on mHealth-based telemonitoring and home-based nurse contacts. Office visits with physicians are reduced to an inevitable minimum. Thereby, severely ill patients are enabled to enjoy life to a better part at home according to the principle: move the information, not the patient.

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Conflict of interest

All authors declare they have no conflicts of interest.

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