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Remote monitoring and telemedicine

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Telemedicine and remote monitoring represent more than the communication of health data via a 'remote connection'. Modern systems can be stand-alone and can be equipped with the ability to acquire and summarize data in order to inform the patient, carer or health care giver. The information can be held locally or be shared with a health care centre. Contemporary telemedicine and telemonitoring solutions have shifted their focus, trying to work on a system which is ubiquitous, efficient and sustainable. Along with devices that collect and elaborate data, a new generation of plug and play sensors has also come to life, which with standardization can lower management costs and make introduction into practice more feasible. Multiple trials (TIM-HF, TEN-HMS and BEAT.HF) have reported varying outcomes, depending on the monitoring system and the background health care process. A special mention is necessary for home tele-rehabilitation programmes for patients with heart failure. Despite the progress obstacles remain, including adequate training, data ownership and handling and applicability to larger populations. This article will review contemporary advances in this area.

Telemedicine and remote monitoring represent far more than more communication of health data via a 'remote connection'. In the past, through often bulky and expensive devices, simple observations of patients' clinical variables were recorded and subsequently sent to the specialist physician's office. A necessary subsequent step was the collection and storage of these data in a cloud system which the physician, at any subsequent point in time, could consult remotely possibility modifying treatment recommendations based on the results.

Today's stand-alone systems are frequently equipped with self-intelligence and are able to acquire and elaborate data in order to inform the patient, who has previously been instructed and therefore is capable of responding appropriately to the notifications, and the physician of the need for therapeutic modification, hospitalization or access to the emergency room. Along with this technology maturation process, the device market has also gone through significant changes.[1-3] A few years ago, systems were too expensive and their wide-spread dissemination was quite difficult. Each system was linked to its own platform and was not able to interoperate with other systems in use by the physician or hospital. Devices were 'secured' and impossible to customize in order to meet the requests of end-users. In addition, these devices were conceived to function only in selected environments, with a very limited range of actions. Contemporary telemedicine and telemonitoring offerings have shifted the focus, trying to work towards a system which is ubiquitous, efficient and sustainable.

In order to achieve this new focus, a new generation of less expensive devices that can be used in different settings with a scalable approach has been conceived. These devices give the possibility to monitor different biological and haemodynamic parameters and, above all, interact with Electronic Personal Health Records already in place. Along with devices that collect and elaborate data, a new generation of 'plug and play' sensors has also come to life. Self-configuration and self-calibration in sensors now make them able to create autonomously an interconnected constellation of signal processors that are managed by a self-learning algorithm. The standardization of platforms and their interaction with different

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systems lower the management costs and facilitate end-users' educational needs for interacting with the new system elements, as well as reducing the system-specific training needs of technicians and specialists, who still have not been adequately educated in the use of remote monitoring systems to date.

To all the above, the important step forward of connectivity of systems to the Net and to ubiquitous mobile systems must be also added. As an example, the number of medical devices that have an internet connection has doubled in the past 5 years and is presently growing at double this speed. Many last generation sensors/devices are able to detect, register and suggest the actions that should be carried out in relation to the patient's physical condition[4] and are often also present in smartphones, as well as in apps that, as an example, can calculate the calories of a dish by taking a simple photo or detect the heart rhythm through a very high-resolution camera. In light of this new opportunity that monitors more and more closely our health condition, some insurance companies have begun to apply discounts to those who use such systems or that regularly use 'illness prevention Apps'.

It is difficult to quantify, manage and above all, protect, the amount of data collected in this way, because the trade of personal data is one of the most profitable businesses of our times. This is the reason why the most recent European Privacy Directive deals exhaustively with the issue of the management of health data that are sent or accessible or remotely processed, introducing very specific strict regulations which must be taken into consideration in case a patient telemedicine and remote monitoring system is built or simply utilized.

A large Italian database to which eight regions have participated has shown how in 2017 the number of readmissions to hospital 1 year after the first discharge for heart failure was around 48% with a mortality rate, also after 1 year, almost reaching 19%. In a scenario that traces transmissible diseases in an epidemic stage, the use of new technologies that monitor biological and haemodynamic parameters is particularly useful in order to increase the speed with which instability can be detected and make possible earlier interventions.

For this reason, the 2016 European Heart Failure Guidelines[5] indicated the need to include patients with heart failure in educational programmes as well as in multi-disciplinary programmes that include an adequate training on compliance and self-care, thank to the involvement of the same patient in self-monitoring and therapeutic control (such as the diuretic one; class II, evidence level B). Several studies have given seesawing results, but a meta-analysis of 2015 shows how a simple phone support associated with a telemonitoring system significantly reduced hospitalizations and mortality for all causes.[6]

The sometimes differing results of large randomized trials (TIM-HF, TIM-HF2, TEN-HMS and BEAT.HF)[7–11] are the result of the different basic characteristics of the patients enrolled, the different conditions of application of the programmes into practice within the trial setting, all building on the base on devices that have different specificities being applied place in varying settings, with dissimilar endpoints and types of follow-up. This relative lack of standardization makes differences between trials difficult to interpret.

A special mention is necessary for home telerehabilitation programmes for patients with heart failure. In 2015, Frederix *et al.*[12] showed how compliance to exercise training was significantly superior and maintained a high percentage for at least 12 months if patients participated in a home-based remote monitoring rehabilitation programme-centred on the exercise training, and the number of re-hospitalizations also was reduced.

In 2017, our group published the results of a home-based integrated project of telesurveillance and remote monitoring of exercise training maintenance in patients with chronic heart failure and pulmonary comorbidities (chronic obstructive pulmonary disease), which have proven feasibility and safety but, above all, the efficacy in reducing hospitalizations, increase of functional capacity, quality of life and mortality.[13]

Despite advances there are still many obstacles that prevent the use of telematic systems for the assistance of care and remote monitoring; from the limited, if present at all, reimbursement of the costs of healthcare provided, up to the need of patients to believe that the remote clinical assessment is as reliable as the traditional 'face to face' method. From the healthcare professional's point of view, there is the need for adequate training and courses that teach how to use these systems, as well as a greater ability to share duties and tasks. Data collected until the present moment have proven that probably this kind of approach is not suitable for all patients with heart failure, highlighting greater benefits in those at higher risk. Furthermore, we cannot exclude the possibility that promoting increased access to health care through these systems may increase the number of users with a resulting rise in costs.

Therefore, today it seems ever more necessary to find the most relevant biological parameters to monitor, the process clinical profile of the HF patient with most to gain, and in which specific healthcare setting the intervention should be implemented.[14] To date, we could describe the benefits of such a system most likely to be of benefit to HF patients who have been repeatedly hospitalized, usually those in NYYA classes II and III, for a period of 12 months after discharge and after a well-designed educational programme. There are no certainties as to which is the best system or strategy, but we know that remote monitoring associated with a precise nursing management and scheduled visits are the elements of a winning programme.

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