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The changing landscape of cardiac rehabilitation; *from early mobilisation and reduced mortality to chronic multi-morbidity management*

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ABSTRACT

Aim: This paper aims to demonstrate how the rationale and delivery of cardiac rehabilitation (CR), in those countries with long term established standards of practice, has changed over the past eight decades.

Methods: A narrative report based on the evolution of key published guidelines, systematic reviews and medical policies since the 1940s.

Results: Case reports of the value of exercise in cardiac disease can be dated back to 1772. Formative groundwork for exercise-based CR was published between 1940 and 1970. However, it was not until the late 1980s that a large enough data set of controlled trials was available to show significant reductions in premature all-cause and cardiac mortality. Since the mid 1990s, cardiac mortality has been greatly reduced due to enhanced public health, emergency care and more sensitive diagnostic techniques and aggressive treatments. As a result, there appears to be an associated reduced potency of CR to affect mortality. New rationales for why, how and where CR is delivered have emerged including: adapting to a longer surviving ageing multi-morbid population, where healthcare cost savings and quality of life have become increasingly important.

Conclusions: In light of these results, an emerging focus for CR, and in some cases "pre-habilitation", is that of a chronic disability management programme increasingly delivered in community and home settings. Within this delivery model, the use of remote personalised technologies is now emerging, especially with new needs accelerated by the pandemic of COVID-19.

➤ IMPLICATIONS FOR REHABILITATION

- With continued advances in medical science and better long term survival, the nature of cardiac rehabilitation has evolved over the past eight decades. It was originally an exercise-focused intervention on short term recovery and reducing cardiac and all-cause mortality, to now being one part of a multi-factor lifestyle, behavioural, and medical chronic disease management programme.
- Throughout history, the important influence of psycho-social well-being and human behaviour has, however, always been of key importance to patients.
- The location of rehabilitation can now be suited to patient need, both medically and socially, where the same components can be delivered in either a traditional outpatient clinic, community settings, at home and more recently all of these being supported or augmented with the advent of mobile technology.

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Introduction

This report provides a narrative review of the multidimensional changing historical landscape of cardiac rehabilitation (CR). The landscape includes *the how, the where, the what is included, the when, the why and for whom* CR is offered. The essence of CR started with a reported case almost 250 years ago, of exercise being associated with the first known relief of anginal symptoms and related disability [1]. To contextualise this discussion of a "changing landscape" of CR, this not only includes the how, the what type, and the where exercise is delivered but the changes to and integration of all multiple patient-care components of CR [2] as illustrated in Figure 1. Debates in the past decade have arisen, especially in the United Kingdom, on the exercise-centric model of CR being outdated [9,10]. This was not stating that exercise is not an important element, but its priority and value needs to be re-determined at both service level and at the individualised patient risk factor management level with full respect to all care components. In amongst all the debate, the one emerging consensus on CR or any other updated or nuanced name it is now given (e.g., preventive cardiology), is that every patient deserves advice and support physically, psychologically, socially, behaviourally and medically. As this review is written mainly for those working in physical rehabilitation, the discussion aims to inform this group of professionals of the "changing landscape of CR" upon which they will likely be expected to work in the future. It would be remiss not to mention how the COVID-19 pandemic has accelerated the value

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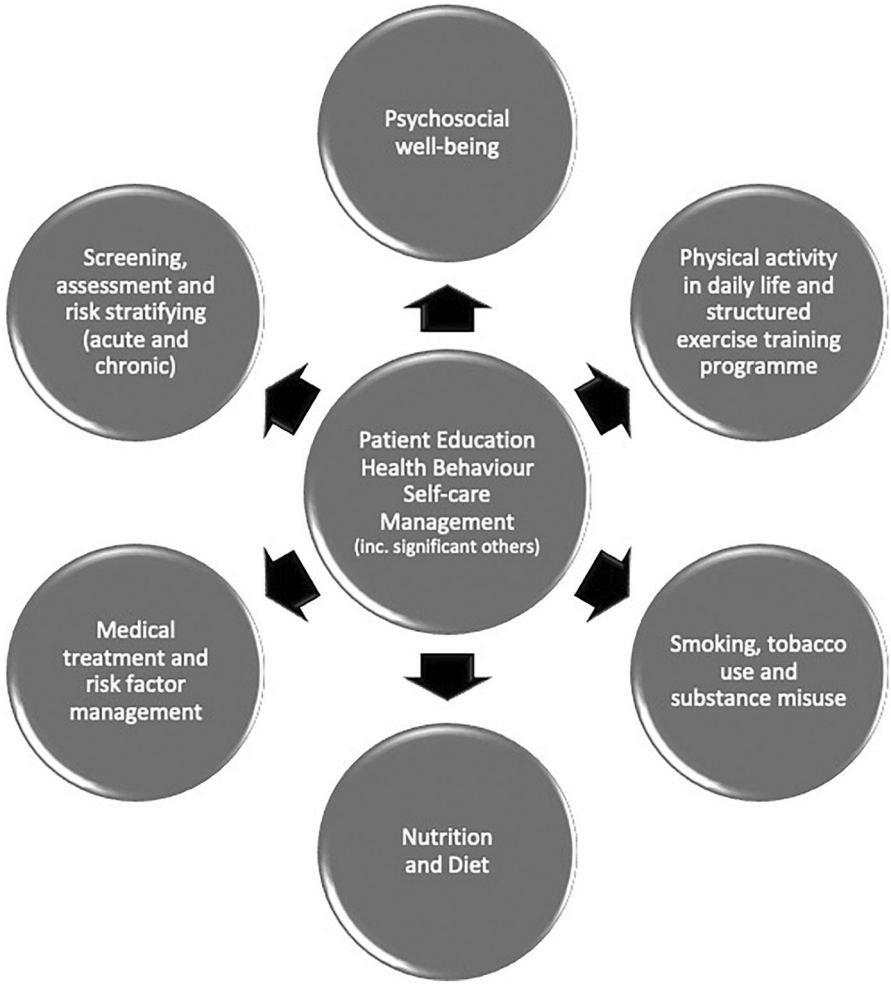

Figure 1. The core components of a cardiovascular disease prevention and rehabilitation; common to the Associations of Australia, Canada, Europe, UK, USA and recognised by the International Council for Cardiovascular Prevention and Rehabilitation towards adaptation in developing countries [3–8].

of personalised remote home-based care, and thus its influence on the landscape of CR will also be featured. Therefore, the objectives of this report are to first discuss the historically evolving elements of CR and then reflect on the common themes and individual nuances of the more recent guidelines, standards and evidence-base that have been led by the CR societies of the U.S, Canada, the U.K., Australia and Europe. Encouragingly, in more recent times, these guidelines and standards are now being adapted in developing countries where cardiology has had a recent rapid growth with the important goal to include rehabilitation as an obligatory, not optional, part of the standard care package [11,12].

Overview of the evolving history of cardiac rehabilitation

The first known benefit of exercise-based rehabilitation in someone with alleged coronary heart disease [angina] symptoms was reported by Dr William Heberden in 1768 to the Royal College of Physicians in his *Account of a Disorder of the Breast*. It was later published in 1772 (Medical Transactions of The Royal College of Physicians of London, 2, 1772, pp. 59–67), where he stated …

> I knew one who set himself a task of sawing wood for half an hour every day, and was nearly cured.

It was in this paper that the term *Angina Pectoris* was defined for the first time. Furthermore, it was not only linked to the physical symptoms in the chest, throat and/or arm typically brought on by exertion, but it was also reported to trigger *disturbances of the mind*. Heberden had clearly noted that Angina caused psychological symptoms of *anxiety* showing from this first reported case the importance of helping patients with both the physical and the psychological components of their condition. The account of 30 min manual exertion per day as a means of cure, is also uncanny as this is directly relates to current International recommendations for health promoting physical activity [13].

In 1854, Professor William Stokes' wrote similarly about the benefits of exercise in his book on The Diseases of the Heart and the Aorta, where he stated … *symptoms of debility of the heart are often removable by a regulated course of gymnastics, or by pedestrian exercise* (Hodges and Smith, Grafton Street, Book sellers to the University, Dublin, 1854). And yet from this point up until 1961, prolonged bed rest and emotional rest following myocardial infarction were the widely recommended form of care [1]. There were, however, a handful of pioneers in the 1940s and 1950s starting to demonstrate that early in-patient mobilisation and exercise aided physical and emotional recovery and led to an earlier return to work [14–17]. As a result of these early publications, Herman Hellerstein in the United States was regarded as a father of the modern exercise-based formula for cardiac rehabilitation. His aim focused on getting patients back to work as early as possible. Coincidently, it was also during the 1950s and 1960s that

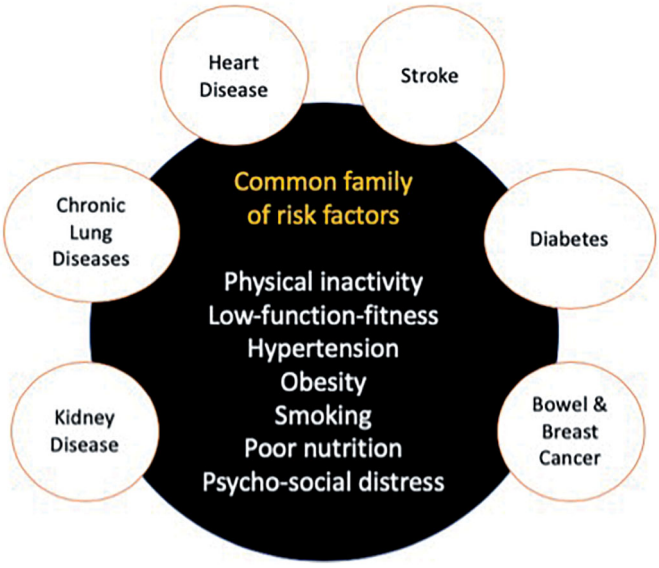

Figure 2. Generic model for delivering rehabilitation where there is a common family of risk factors requiring the same care-support.

Morris and Paffenbarger provided the first reported evidence on the links between physical activity and heart disease [18–20]. After almost 250 and 170 years since Heberden and Stokes, respectively reported on the value of exercise for the heart, there was finally emerging evidence in the 1970s to catalyse its promotion and development in preventing and managing heart disease [21]. Most of the trials focused on an "exercise" centric model but there were also groups investigating the domain of psycho-social care influenced by how patients responded to and managed life following diagnosis and treatment of heart disease [22,23]. By the end of the 1980s there was a critical mass of randomised trial evidence to demonstrate that exercise-based cardiac rehabilitation was cost-effective, enhanced quality of life and reduced premature mortality following myocardial infarction and/or revascularisation treatment [24,25]. Over the 30-year period between 1960 and 1990, where rehabilitation evidence emerged and grew, the WHO followed suit in recognising its value in its series of publications on cardiovascular disease in 1964, 1969, 1989 and 1993 [26].

In 1993 the World Health Organisation clearly defined cardiac rehabilitation in the context of not only physical outcomes but also a patient-centred psycho-social and behavioural context:

> The sum of activities required to influence favourably the underlying cause of cardiovascular disease, as well as to provide the best possible physical, mental and social conditions, so that the patients may, by their own efforts, preserve or resume optimal functioning in their community and through improved health behaviour, slow or reverse progression of disease [26]

Intuitively, one may regard the "exercise component" at the heart of cardiac rehabilitation but there is a broader challenge in helping patients, which includes supporting other lifestyle behaviours (smoking and poor nutrition) and self-management skills linked with medical treatments and the psychological and social challenges that typically follow a diagnosis or cardiac event (Figure 1). In many ways, suffering a myocardial infarction and/or having significant cardio-pulmonary dysfunction is akin to any other disability (physically and psycho-socially) [27]. It is also important to recognise that those with a physical disability such as spinal-cord injury are 2.5 – 3.5 times more likely to develop cardiovascular disease [28]. The events the patient experiences cannot only afflict their own behaviour and quality-of-life but it likely places demands on the lives of others (relatives, friends, co-workers) [29–31].

Contemporary CR has thus evolved to a point of bridging the earlier mid-twentieth century concepts into the twenty-first century. There is now the need for a broadened focus on patient education and self-management of medical and lifestyle risk factors whilst accommodating for an ageing/surviving multi-morbid population [32,33]. Some of the mortality reducing potency of exercise-based CR has recently been rigorously challenged as will be later discussed. As a result there has been a re-focussing on other prominent outcomes such as psychosocial well-being, chronic disease management and reduced rehospitlisation (reduced healthcare costs) linked to early post-acute programmes delivered beyond the clinic in the community and in the home [34,35].

Transitioning into the twenty first century with diminishing effects on mortality

In acknowledging the previously discussed seminal reports on exercise ameliorating cardiac symptoms by Heberden and Stokes in the seventeenth and eighteenth centuries, it was not until the early twenty first century that the physiological mechanisms of why exercise could improve coronary blood flow would be revealed [36]. Along with this improved understanding of exercise mechanisms in cardiac health, there were rapid improvements in medical cardiac care that led to a more aggressive approach to pharmaceutical prescriptions and invasive elective or emergency revascularisation procedures [37–40]. On one hand this heightened the need for cardiac rehabilitation within the secondary prevention care package but on the other hand, the benefit of exercise on cardiovascular health, morbidity and mortality was being potentially reduced. In 2000 the first Cochrane systematic review was published on exercise-based cardiac rehabilitation including the earliest randomised trials from the 1970s and 1980s. Until 2011, these reviews clearly showed the value of exercise having a significant influence on reducing premature mortality by up to 25% [41]. There was however a growing appreciation to independently assess the evidence after the year 2000, in light of the growing aggressive medical treatments being offered and the ensuing reductions in the incidence of myocardial infarctions and related mortality across Europe [42]. Heran et al. in 2011[41] seemed to be anticipating this and concluded that there was the need for more trials to include health-related quality of life outcomes, hospital re-admissions, and cost savings and cost-effectiveness analyses. As a result, the leading Commonwealth societies from Australia, Britain and Canada began to highlight more the psycho-social and health-economic value of cardiac rehabilitation [8,32] (Figure 1). By 2016 this reduced effect of exercise on cardiovascular and all-cause mortality was indeed becoming apparent [34]. Whilst Heran et al.'s 2011 Cochrane review showed diminished effects on all-cause mortality following cardiac rehabilitation compared to the previously reported 25% reduction in 2000, an important outcome on the rise was an 18% reduction in hospital re-admissions; showing a significant cost saving to health services. Future services would thus need to change their focus to adapt to the new reasons for "why, who, when, where & how?" rehabilitation programmes would be best delivered. The discussion to follow therefore examines the "why, who, when, where & how of the emerging post-2010 landscape of cardiac rehabilitation.

The new landscape of cardiovascular disease prevention and rehabilitation programmes

In response to the global burden of key non-communicable diseases, including cardiovascular disease, the WHO in 2012 set specific targets for reducing the productive loss to society when morbidity and mortality occurs in those under the age of 75 years

Table 1. Cardiovascular diseases, comorbidity prevalence [49] and subsequent cardiac events needing either adapted or further rehabilitation.

Coronary heart disease [50]	Heart Failure [51,52]	Stroke [53]	Peripheral arterial disease [54]
25–30% diabetes	40–50% Atrial fibrillation	33% have >50% coronary stenosis	12.4% have significant coronary disease
18% Arthritis	43% Osteoarthritis	3% myocardial infarction in < 12 months	
10% Cancer	25–40% Kidney disease	Greatest mortality from coronary disease	
10% Chronic back pain	24% Diabetes		
	17% Chronic lung disease		

[43]. With specific relevance to cardiovascular disease and the role of cardiac rehabilitation within these WHO initiatives, an International Council of Cardiovascular Prevention and Rehabilitation (ICCPR) was established in 2012 as an associate group of the World Heart Federation [11,12,44–47]. The ICCPR has grown to a membership of 40 societies from around the world with the aim to provide advocacy and guidance for enhancing the provision and utilization of CR globally [30] (www.globalcardiacrehab.com).

Why and who?

In addition to the typical group of people (aged 50 – 65 years) attending rehabilitation following symptomatic or medically treated coronary disease, there are two growing groups of people who can greatly benefit from participating in the same multi-component programme (Figure 1). Those who are asymptomatic but have significant cardiovascular disease risk factors (Figure 2) [48] and those (typically older) living with a more chronic state of cardiovascular-metabolic conditions and multiple morbidities (Table 1).

With the combined prominence of increasing survival rates from coronary heart disease occurring in the twenty first century [55], there has been a corresponding increase in the incidence and prevalence of subsequent heart failure [51,52,56]. This evidence also demonstrates the onset of symptomatic disease diagnosis at an older age. The common co-morbidities prevalent among coronary heart disease patients typically include: diabetes, heart failure, stroke, peripheral arterial disease, and arthritis (Table 1) [51], all of which can individually and collectively benefit from a lifestyle management and prevention programme. Exercise adaptations for those with diabetes is now a key consideration as they make up 25% (and increasing) of patients attending CR [57]. The National Audit for Cardiac Rehabilitation in the UK, reports that those attending rehabilitation typically have at least two co-morbidities [50]. With programmes increasingly having to adapt to these co-morbidities, it may be both clinically- and cost-effective to combine rehabilitation and prevention with other key chronic diseases illustrated in Figure 2. Examples including lower functioning or older patients with heart failure, pulmonary disease, peripheral arterial disease and falls prevention could participate in the same exercise sessions as they will likely be working at similar intensities with similar symptoms, and where combined endurance, strength and balance activities are becoming more prominent; they have been shown to better enhance function and endurance compared to only aerobic endurance activities [58].

When? The case for early rehabilitation and prehabilitation

As noted earlier, up until to the mid twentieth century, prolonged bed-rest was recommended following myocardial infarction. The advancement and proven safety of exercise rehabilitation eventually grew in the 1980s and 1990s where the practice was to commence rehabilitation after 4 – 6 weeks from hospital discharge [22,25]. Since 2011, for stable patients the earliest possible commencement of exercise has proven to provide the best outcomes for longer-term myocardial recovery and improved programme uptake and adherence [30,32,59].

In the past decade there has been a growing value on pre-surgery programmes (prehabilitation). The aims are to improve physical functional capacity, nutritional and psychological status so as to reduce post-surgical complications and enhance the rate of recovery [60,61]. Favourable outcomes in cardiac surgery have been demonstrated, especially in those more frail, from programmes which include three elements using the acronym "NEW" (nutrition, exercise and worry (anxiety) reduction) [62–64].

Where, how and the COVID-19 accelerator?

In the past decade there has been a shift to delivering cardiac rehabilitation programmes in community settings and at home, with equal cost efficacy to clinical/hospital-based programmes [35,65–67]. These results also highlight that community and home-based programmes increase the likelihood of longer-term adherence. For almost four decades, the UK has led on the evidence-base and policy implementation of community and home-based rehabilitation [68,69], and up to 2020 40% and 8% of cardiac rehabilitation programmes are delivered in community and home-based settings, respectively [50]. Home-based rehabilitation was validated and implemented in the UK in the early 1990s, with follow-up applications in preventive angina management in the early 2000s [70,71]. Whilst equal efficacy of home-based programmes compared to clinic/centre-based programmes was confirmed in 2007 [65], it was not until 2019 when it became a practice policy in the US [72] and is now being considered more seriously by the European Association of Preventive Cardiology [33] in light of the COVID-19 pandemic [73].

Remote patient monitoring and advances in technology have enabled rehabilitation in more significant rural locations such as in Australia. These are promising results for developing countries where specialist clinicians can now more easily communicate (visually and orally) from there clinics to patients at home and this is certain to increase in the future [74–77] As noted in the statement by the EAPC above, the need for home-based rehabilitation across all care sectors was forced into the spot-light with the global pandemic of COVID-19. For cardiac rehabilitation, it was encouraging to already have an evidence-base and underpinning policy statements *in situ* [8,72]. However, there still remain three challenges to effective implementation: (i) the availability of CR staff for whom many were re-deployed because their skills are directly linked to managing those in-hospital with COVID-19; (ii) the logistics of shifting the work-force of rehabilitators (mind-set and skills) to use tele-medical technology, given that <10% of participants receiving CR were home-based compared to 90% who attended a centre where the staff and facilities were located [78,79], and iii. once many of these challenges had been overcome, there is one main hurdle remaining, which was the performing of remote and safe exercise assessments for the purposes of pre-programme risk stratification, physical activity guidance

Table 2. Historical summary of cardiac rehabilitation (1772–2020).

Period	Events
1772	Heberden defines "Angina" and reports to Royal College of Physicians its first cure as 30 mins/day of exercise in the form of sawing wood
1854	Stokes describes exercise as a means of removing debilities of the heart
1940s–1950s	Prolonged bed-rest questioned following myocardial infarction, with inpatient mobilisation for a number of physical and emotional benefits noted
	Hellerstein creates a a framework for exercise -based rehabilitation especially to aid the return to work
	Morris presents first paper on heart disease and exercise to the World Congress of Cardiology in Washington that shows strong links between daily levels of activity and cardiac morbidity and mortality
1970s–1980s	Randomised controlled trials performed to show beneficial morbidity and mortality outcomes from exercise-based rehabilitation following myocardial infarction and bypass surgery, and commentaries on the value of including educational and psycho-social elements to programmes
Early-to-mid 1990s	Meta-analyses confirming significant morality reductions
	World Health Organisation defines cardiac rehabilitation with a focus on patients becoming self-managed and returning to a psycho-socially productive life
	Proliferation of guidelines and standards for cardiac rehabilitation in in Australia, Canada, Europe, UK and US
Late 1990s	Growing evidence on how exercise independently influences myocardial and coronary health
	Initiation of aggressive public health, emergency care, and medical/pharmaceutical strategies in secondary prevention of heart disease established in Australia, Canada, Europe, UK and US
2000 – 2010	Cardiac rehabilitation grows internationally with many countries adopting and creating a hybrid of guidelines based on standards from Australia, Canada, Europe, UK and US
	Preventive cardiology aggressively promoted in Europe and advocated internationally
2011–present	International Council of Cardiovascular Prevention and Rehabilitation established within the World Heart Federation, as an advocate and advisor to developing countries
	Mortality as an outcome being challenged, due to advances in medical treatment; leads to a refocussing on chronic disease management and healthcare cost savings through reduced re-hospitalisation
	Promotion of generic programmes that cater for similar lifestyle risk factor management goals (e.g., diabetes, cancer, pulmonary disease, heart failure, falls prevention)
	Advances in telehealth and remote monitoring
	COVID-19 accelerates the need to greatly increase provision of remote/virtually supported home-based programmes, underpinned by 30 years of evidence that favours rehabilitation at home

and service outcome evaluations[73,79,80]. Up until COVID-19, even those receiving home-based programmes will have attended for initial rehabilitation assessments at an established clinic or centre or *via* home visit; however, the risks associated with being infected greatly outweighed attendance or visits for these assessments. Therefore, the challenge and opportunity COVID-19 has accelerated for future is the need for scaling-up the use of more easily useable virtual and remote technology, and policies and procedures for remote assessment and monitoring. Such innovations in technology and service will have the benefit of increasing "the reach" to patients in regions and countries who are currently in remote and/or poorer resourced locations [30,44]. Overall Table 2 provides a brief summary of the key historical changes that have occurred since 1772, when Heberden reported exercise as the first effective treatment for what was seemingly coronary artery disease to which he named *angina pectoris.*

Continued need for psycho-social care, in light of medical and technological advances

At the heart of cardiac rehabilitation, even with medical and technological advances, there is still the basic need to help patients change their behaviour and their social environment to live a healthier lifestyle. As recently highlighted by the COVID-19 pandemic, the need for skilled caring practitioners who are able to interact, educate, motivate, support and promote self-management skills in patients, remains a vital component of CR as was highlighted by the WHO in 1993 and others since [8,26,32,74].

Summary

Cardiac rehabilitation has evolved over three centuries from observed hypotheses in the eighteenth and nineteenth century, to an exercise-based programme in the mid twentieth century, and now to a multi-faceted, multi-morbidity chronic disease management programme. The key clinical outcomes have shifted from achieving unnecessary prolonged bed-rest and sooner return to work, to reduced mortality and more recently to healthcare cost savings. Throughout this history, however, the enduring common thread from the patient's perspective has been the influence of rehabilitation and prevention on helping them have the best possible state of psychological and social functioning and quality of life. With both medical and personal care technology advancing and aiding in the preservation of life, it is important to always be mindful of what this means in relation to the each patient's quality of psycho-social life.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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