

Tele-Ophthalmology in the 21st Century: Innovation or Necessity for Global Eye Health?

Introduction

Despite progress in the practice of global health, stark differentials remain in the health outcomes experienced between countries depending on their economic status. These are typically separated into Higher Income Countries (HICs), and the grouped category of Low-Income and Middle-Income Countries (LMICs), and will be referred to by this nomenclature throughout this essay. Such stark differentials are especially striking when considering global eye health in particular, as it is estimated that up to 90% of sight loss is preventable¹. Good vision, and the prevention of sight loss where possible, are important Sustainable Development Goals according to work by the United Nations, established to promote flourishing and development in LMICs. However, should a LMIC be unable to provide optimum eye healthcare, citizens' productivity for their nation's development is inhibited by sight loss, which further impedes their ability to work. This forms a vicious cycle, trapping LMICs in situations where their economic development, itself a tool to improving their nation's health, is stifled by avoidable health inequalities.

With initiatives from HICs, efforts are underway to improve global eye health and break this cycle. The impressive development of tele-ophthalmology, the delivery of eye healthcare using telecommunication technology, is often cited as a landmark achievement in global health development and may herald new possibilities in improving global eye health². This essay will aim to explore how tele-ophthalmology has developed, what its present uses are, and how it may prove to be an important development for the improvement of global eye health.

When discussing global eye health research, it is important to consider that the practice of 'global health' itself is not undertaken without criticism. Theorists who criticise 'global health' argue that due to a history of racism and imperialism permeating through contemporary practice, 'global health' is a practice which can be perceived as white supremacist and neo-colonial. This is, of course, despite the best intentions of those aiming to optimise global eye health³. This essay will therefore engage interdisciplinary insights from critical theorists and decolonial perspectives to understand wider social contexts around 'global health' and incorporate these into its exploration of the innovation and necessity of tele-ophthalmology.

The Impact of Eye Disease across the Globe

According to figures from the World Health Organisation, at least 2.2 billion people worldwide experience visual impairment, of which at least 1 billion are due to preventable causes or are unaddressed⁴. Yet, visual impairment is not just a medical condition. To truly explore its multifactorial causes and impacts, vision impairment must be viewed holistically as a multifaceted phenomenon.

There are many causes of vision impairment, ranging in severity from mild (such as mild myopia, where an inability of the eye to focus on distant objects results in blurriness, colloquially known as 'short-sightedness') to total blindness (in which the eye does not perceive any light at all). Across the globe, the WHO's most common causes are primarily slowly developing conditions such as 'uncorrected refractive errors, cataracts, age-related macular degeneration, glaucoma, and diabetic retinopathy'⁴. Many of these are preventable with adequate health promotion efforts or treatable through refractive correction, such as glasses, contact lenses, or surgical procedures. Despite these conditions' preventability and treatability, resource deficiencies in LMICs are resulting in health inequalities, in which patients who require healthcare to improve their eye health cannot access it⁴.

Aside from widespread resource deficiencies, there are also a multitude of social determinants of eye health that contribute to this situation. Factors determining this include poor coverage of universal health initiatives and inequitable resource

distribution^{5,6}. In terms of broader social factors, gender inequities, racism, educational inequalities, social deprivation and unemployment are all found to exacerbate and cause health inequalities¹. When these inequalities arise in the first place, they markedly increase the likelihood a patient will experience untreated or poorly-treated eye disease. This demonstrates the complex interrelationship between socioeconomic determinants of health and medical conditions.

There are particular medical determinants which also play a role in influencing eye health. To an extent, these are also related to socioeconomic determinants. Vision impairment can be caused by low birth weight, maternal smoking and alcohol use⁷. In the example of low birth weight, this in itself is related to poverty and malnutrition, thereby forming a link between the socioeconomic and medical precipitants of vision impairment in children. Furthermore, exposure to infections *in utero* can cause congenital structural ocular pathologies. Some infections are endemic in some countries yet not in others, producing a heightened effect when combined with resource deficiencies in LMICs. Examples of this include Zika virus, rubella, toxoplasmosis, herpes and cytomegalovirus, all of which can cause damage to the eye before a baby is even born, which may be irreversible⁸.

The subsequent social impact of visual impairments in young people cannot be understated. Children experiencing vision impairment are at risk of poorer educational outcomes and are often less likely to attend their schools, a particular concern for global development as improved education is strongly linked to reductions in poverty and unemployment⁹. As a person progresses through their life with vision impairment, their access to work is limited and thereby their individual income and productivity is reduced, preventing social mobility and trapping the individual in poverty⁴. This also has a major impact on a nation-wide level, as economic productivity, gender inequality and inequity per capita are all found to be linked to worse ophthalmic health. These conditions and risk factors beyond eye health are all intricately and complicatedly linked, as explored in Figure 1.

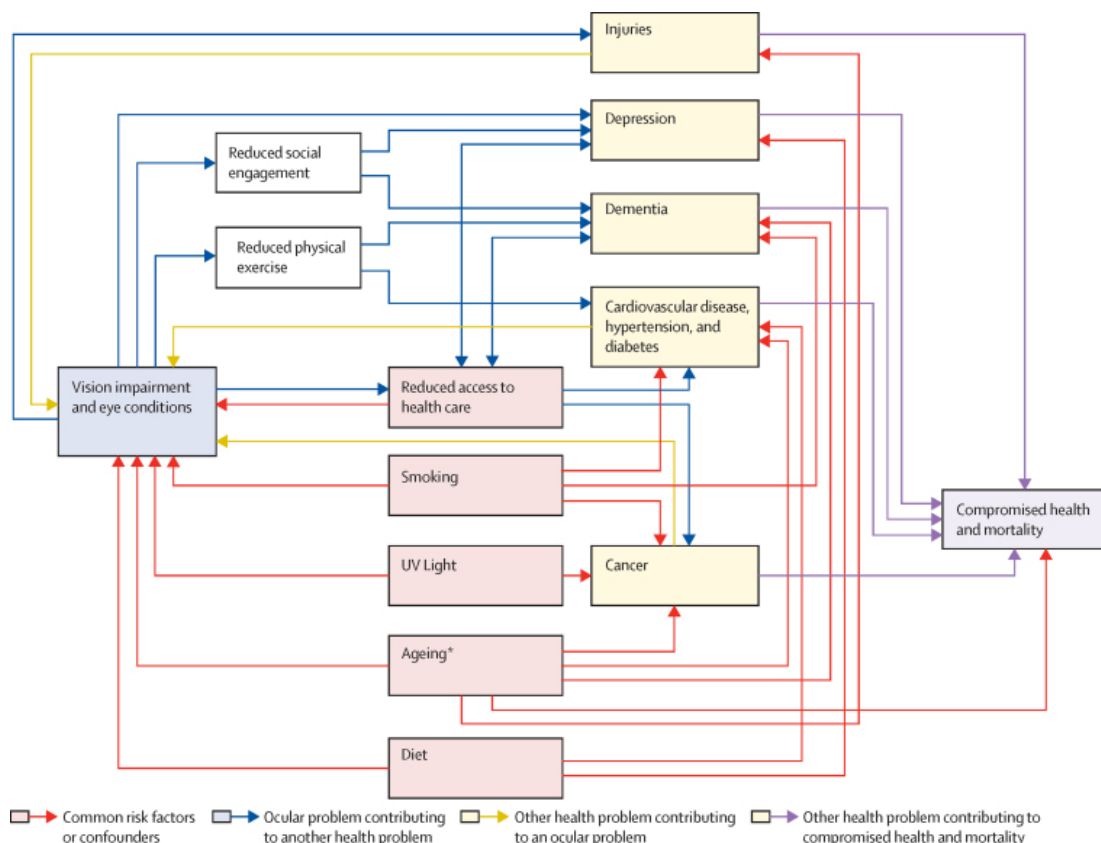


Figure 1. A diagram demonstrating the interrelations of social determinants of eye health with other risk factors and diseases⁴.

The worldwide inequalities in these health outcomes are marked and concerning. At present, 92% of people diagnosed as being blind and 88% of people diagnosed with a moderate to severe vision impairment live in a LMIC, with these statistics expected to rise without intervention¹⁰. Figure 2 demonstrates the projected increases in cases in LMICs compared to MICs based on data from the Global Burden of Disease Blindness and Vision Impairment Collaborators¹⁰.

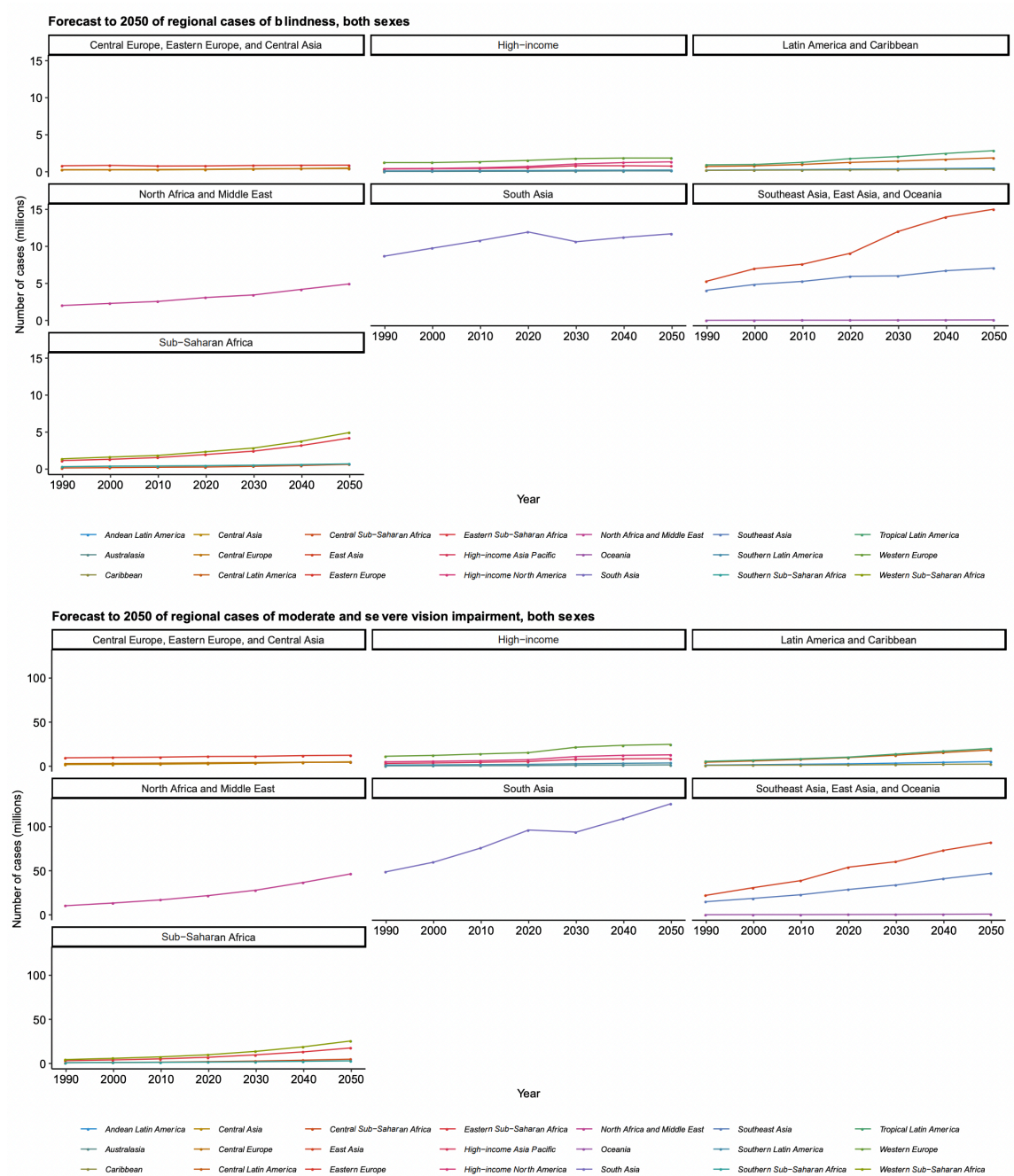


Figure 2. Predicted increases in cases of blindness, severe vision impairment and moderate vision impairment globally¹⁰.

The Creation of Tele-Ophthalmology

The definition of ‘tele-ophthalmology’ has developed over time as technological advances have progressed. In the present day, tele-ophthalmology is primarily an internet-based tool which is fundamentally based around the sending of images from ophthalmological investigations from a source near to a patient to a clinician

elsewhere². Yet, before the 'internet revolution', tele-ophthalmology still existed. The use of radio and telecommunications technologies to deliver collaborative care between an on-site technician and an off-site ophthalmologist can be dated back to at least 1975². By modern standards, this was fairly primitive, but developments such as these set in motion the possibilities for future innovations in tele-ophthalmology.

Today, smartphones attached to slit lamps are capable of collecting high-quality images of a fundus (the interior surface of the back of the eye), and relaying these on to ophthalmologists elsewhere for consultation. This constitutes an example of 'colour fundus photography' (CFP), in which trained technicians take images of the fundus. With technological advances, this is not even an asynchronous process in which a single image (or multiple) is taken and reviewed by an ophthalmologist elsewhere. With the advent of 5G technologies and faster WiFi speeds, live-streamed video footage in real-time can be seen by a supervising ophthalmologist². Indeed, further developments in tele-ophthalmology have allowed for remote-controlled slit lamps to be utilised in real-time by an off-site ophthalmologist, thereby enabling assessment to be undertaken by one clinician only and saving costs². This has remarkable implications for a potential revolution in global eye health; CFP can be taken to monitor disease progression in diabetic retinopathy, cataracts and in age-related macular degeneration in patients who might otherwise lack access to eye health screening. Similarly, modern technologies are allowing for optical coherence tomography (OCT) to be taken remotely, with telecommunications utilised to review the images and discussing management plans, transforming care for patients with glaucoma².

However, it is yet to be fully explored how tele-ophthalmology can develop in the future. As 2025 progresses, the 'AI age' is dawning and technologies previously thought impossible are rapidly being developed. There are monumental ethical challenges faced by those who seek to integrate AI's capabilities into medicine, such as data protection, confidentiality, and ensuring diagnostic accuracy can be assured when using AI¹. However, should these be navigated successfully, AI may hold the keys to the challenges posed by global eye health inequalities, as it may be capable of diagnostic reasoning and image interpretation¹. In conjunction with tele-ophthalmology technologies, patients can have their remotely-taken scans assessed

in mere minutes by an AI system, though it is likely that an ophthalmologist's verification will be required to ensure the AI's judgements are correct¹.

The Necessity of Tele-Ophthalmology

Beyond the exciting possibilities of tele-ophthalmological technologies, there remains a case to be made for why this is a necessity rather than simply an impressive innovation. There are opportunities for tele-ophthalmology to form a key role in many developing health systems, but literature is scarce on how tele-ophthalmology may be a necessity for developing global eye health.

There are, however, many potential ways in which tele-ophthalmology's need can be proven. Sharma et al. suggest that, beyond its ability to reach rural communities in LMICs which may have less access to high-quality ophthalmic care, tele-ophthalmology may be able to offer more timely care for acute ophthalmic concerns¹¹. This is of particular importance in LMICs, as although screening for more insidious conditions is important, the delivery of timely healthcare is equally as important to promote optimum health. Sharma et al. further suggest that the implementation of tele-ophthalmology presents a further advantage to populations living in LMICs as it can save 'cost, time and effort' for health systems. This is particularly relevant in the provision of screening services, where tele-ophthalmology carries the potential to widen access to screening and thereby reduce overall burdens on health systems through timely detection and treatment of developing conditions.

Barriers to implementing tele-ophthalmology

Despite the interesting potential that tele-ophthalmology may have for global eye health, it is not necessarily the case that implementing it into systems internationally will be a successful endeavour. Many potential barriers exist to its expansion¹². Expanding tele-ophthalmology systems requires resource and time-intensive deployment of computer systems which LMICs may struggle to afford, and may

therefore require assistance from MICs. Indeed, to enable rapid assessment and treatment, fast internet connectivity is required at all points in the system which may not be in place where it is needed most, especially in the most rural areas. Furthermore, the implementation of new systems and technologies can be prone to resistance to change, hampering efforts to expand tele-ophthalmology¹².

To explore an example of a barrier to implementing tele-ophthalmology in detail, we can look to the detection and treatment of uveitis. This is a condition in which the uvea (a triad of structures: the iris, the ciliary bodies and the choroid), becomes inflamed due to infection or autoimmune causes (Figure 2).

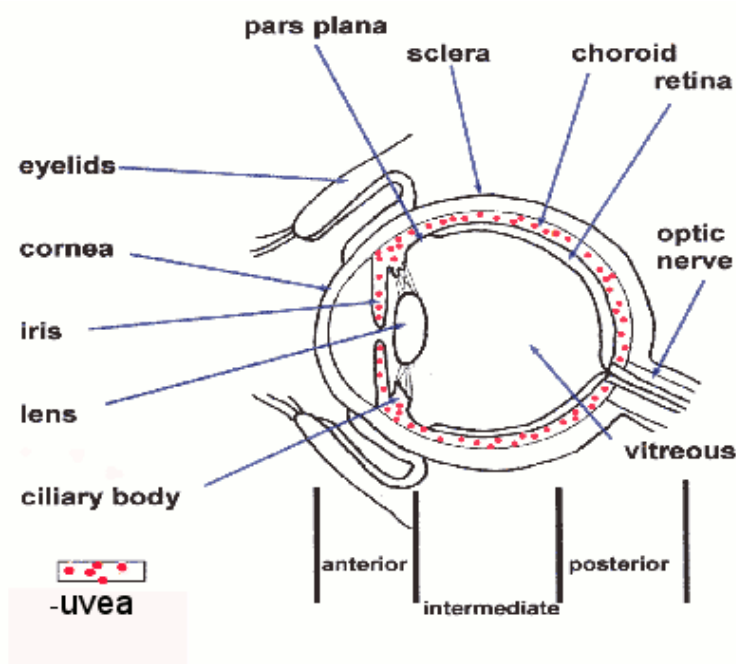


Figure 3. Anatomy of the uvea: 'anterior uveitis' affects the structures towards the front of the eye, such as the iris and the ciliary bodies (structures connecting the iris to the choroid); 'intermediate uveitis' affects the middle of the eye, such as the vitreous humour, the ciliary bodies and the outer portion of the retina; 'posterior uveitis' mostly affects the back of the eye and 'panuveitis' affects the entirety of the uvea¹³.

This is a useful example to explore as there are interesting geographical inequalities in the distribution and effect of uveitis across the globe. Furthermore, as uveitis requires specialists to undertake and interpret investigations, it presents a particularly challenging problem in the application of tele-ophthalmology.

Uveitis is the fourth-most common cause of blindness in MICs yet there is a stark differential in the type of uveitis experienced, with far more cases of posterior uveitis

of infectious causes in LMICs than MICs and far less cases of anterior uveitis in LMICs¹⁴. Uveitis can be acutely sight-threatening, but with urgently delivered treatments, patients may recover fully without permanent sight loss; if treatment is delayed or inaccessible, partial or total sight loss may develop.

Acute uveitis presents a difficulty in being managed through tele-ophthalmology, due to the imaging modalities required to image these structures which require more specialist skills to operate. Diagnosing uveitis requires carefully-operated slit-lamp microscopy to examine the structures of the eye, while treatments for posterior uveitis require specialist input from ophthalmologists, for example to deliver injections into the eye¹⁴. While diagnostic measures such as slit-lamp examination may be enabled by robotic remote-controlled slit lamps, if complex treatments are indicated it may not be possible to provide them remotely, thereby limiting the utility of tele-ophthalmology¹⁵.

Critical Perspectives on Global Health

The dichotomisation of LMICs and HICs is itself constructed by those working in HICs and studying LMICs through 'extractive' observation³. Indeed, the very study of LMICs' health systems and inequalities in HICs is a practice undertaken by primarily white and generally privileged researchers. Critics of 'global health' raise concerns that these researchers' observation of health inequalities without action to change the status quo invokes neo-colonialist attitudes towards those living in LMICs, particularly people of colour living in countries in the global south¹⁶. In doing so, it is suggested that this reinforces racism and perpetuates power asymmetries between LMICs and HICs, in which the narratives of LMICs' health is dictated by researchers in MICs.

At its core, this can be criticised by analysing the concept of discourse and its applications to the question of 'global health'. This is where the philosophy of post-structuralists and critical race theorists becomes useful. 'Discourse' itself is a concept in postmodernist philosophy that describe the process through which

knowledge becomes known by imparting meaning into words¹⁷. This can be an unusually abstract concept in health research but it is an important one. When applied to global health, considering the discourses requires considering who and what is defining the meaning of 'LMIC', the meaning of 'HIC', and the meaning of 'poor health'. Ultimately, this challenges the authority of researchers in HICs to generate knowledge about LMICs and enforce their power through academia and publishing research without the input of citizens or researchers in HICs.

This can be further reinforced by perspectives from Critical Race Theory (CRT). CRT is a controversial and often-misunderstood set of theories that seek to reinterpret commonly-assumed beliefs about race through the experiences and narratives of people of colour¹⁸. CRT's core 'tenets' challenge the notion of race's biological nature, and instead posit that race is a social construct and racism is a normalised part of society. In CRT's other tenets, there is an emphasis on narratives and storytelling, placing an active focus on the lived experiences as acceptable sources of information due to historical ignorance towards lived experiences, in order to challenge eurocentrism and white-centredness in academia. Applying these tenets to 'global health', the saviourist narrative of 'impoverished and disempowered LMICs requiring support from the rich and helpful MICs' is criticised for its MIC-centred creation and foundation¹⁹.

Balancing Critical Theory and Beneficence

It can be difficult to disagree with the arguments set forth by critical theorists whose critiques of identity and discourses undercut the very nature of global health research. Ultimately, the practice of 'global health' must be reflectively analysed as a resurgence in colonialist thinking and a perpetuation of racism. At a time where 'decolonisation' is being rightfully asserted as a key priority for organisations, it can be challenging to defend 'global health'. Yet, it is also important to challenge these theories. CRT does not necessarily have to be accepted, and is indeed challenged on the grounds that it lacks statistical evidence, preferring stories and narratives to provable facts²⁰.

Therefore, CRT should neither be wholly accepted (thus ending the practice of 'global health', nor rejected. Rather, it is best to take CRT and critical theorists' work into account to continually reflect on and consider. In doing so, researchers can analyse their work for risks of perpetuating racism and neo-colonialist attitudes. In doing so, global health researchers (particularly in MICs) can hold themselves to account and encourage themselves and their teams to work effectively with colleagues in LMICs to ensure that LMICs are included in discussions about their health.

In the specific context global eye health and the development of tele-ophthalmology, this requires deliberate collaboration and teamwork with those working and embedded in LMICs. Combatting racist narratives requires reflecting on current work, and asking important questions such as whether ideas about technological barriers and resource disparities are true, or stereotyped. For example, African nations are often racially stereotyped in the West as primitive and lacking modern technologies; this is not necessarily true, and global eye health researchers must be cognisant of racial biases and stereotypes in order to ensure that their work centres LMICs' best interests and avoids 'extractive' practices³.

Conclusion

Fundamentally, 'innovation' and 'necessity' do not form a dichotomy in relation to the development of tele-ophthalmology to promote global eye health. Rather, tele-ophthalmology's development is both an innovation of technological prowess as well as a potential necessity in the years to come. This essay has explored the global need for tele-ophthalmology, its capabilities, and the barriers to its development (such as technological capabilities in the regions where it is most needed and its inability to replace a trained and qualified ophthalmologist local to the region to deliver immediate care). By taking into account interdisciplinary perspectives from critical sociological theories, this essay has found that the progress of tele-ophthalmology in global eye health must be mindful of the biases of its advocates,

while also maintaining not avoiding these important issues, and always maintaining a focus on promoting global eye health.

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