

Atopic Dermatitis – An Update

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Abstract

The aetiology of atopic dermatitis is multi-faceted and affects our first line host defence, the skin. Atopic dermatitis has a significant influence on a patients' social and occupational functioning and can have long-lasting effects. The signs and symptoms of AD includes pruritus, erythema, fissuring, and lichenification, which can be reduced by the use of moisturizing agents. Guidelines on how to manage atopic dermatitis aims to improve symptoms and achieve long-term disease control. Patient education remains as important as other treatment strategies and the pharmacist plays an integral role in educating patients on the management of their condition and adherence to therapy.

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Introduction

The skin is our largest organ and acts as a protective barrier between the host organism and its external environment. Except for preventing entry of pathogens and allergens, water loss from the body is also minimized.¹

Atopic dermatitis, also referred to as eczema, is a chronic inflammatory skin disease that commonly affects children younger than five years, but onset can be at any age.² It is characterized by pruritic, erythematous and scaly skin lesions that are in most cases localized to the flexural surfaces of the body. The areas mainly affected include the face, scalp and extensor surfaces, especially in infants and its onset is usually from 3 months of age.^{2,3}

Atopic dermatitis (AD) is the first manifestation of allergy to present in "the atopic march" and precedes food allergy, asthma, and allergic rhinitis.⁶ A family history of AD, asthma or allergic rhinitis often prevails.² The disease is debilitating and impairs a patient's quality of life.⁵ Not only does AD impact on health-related quality



Figure 1. Atopic dermatitis - flexural⁴

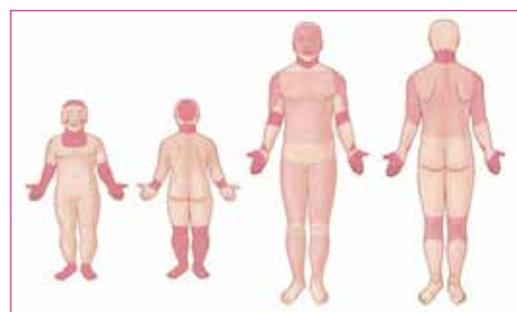


Figure 2. Common sites of AD outbreaks⁵

of life, but also on patients' mental health, and on their social and emotional functioning.⁷ The condition is recognized as a lifelong disposition with variable clinical manifestation and expressivity, in which defects of the epidermal barrier play a pivotal role.⁸

Types of atopic dermatitis

The clinical manifestation of AD is distinct, but due to numerous differences in other aspects, AD can be categorized in two forms: intrinsic (non-allergic) and extrinsic (allergic).^{9,10} An intrinsic form of AD not associated with IgE mediated sensitization contradicts the classic definition of an atopic disease and should be better referred to as non-atopic AD¹¹

Epidemiology

Atopic dermatitis is the most common chronic inflammatory skin disease. The prevalence of AD has plateaued at 10-20% in developed countries but continues to increase in low income countries.^{8,12,13} Although the disease can become apparent at any age, it manifests at an early age in approximately 60% of cases⁸

Table 1. Categories of atopic dermatitis^{9,10}

Types	Non-atopic	Atopic
Onset	Later onset	Early childhood
Frequency	15% – 30%	70% - 85%
IgE serum levels	Normal	High
Specific IgE	Absent	Present for aeroallergens and foods
Skin prick reactions	Negative	Positive
Cytokines: IL-4, IL-13	Low levels	High levels
Skin barrier	Normal	Defect
Filaggrin gene mutations	No	Yes
Other atopic diseases	Absent	Present

with 10-20% lifetime prevalence in children.¹⁴ According to a 2013 report, the worldwide incidence of AD averaged at 7.9% in the 6 to 7 year age group but varied a lot between regions; from 3% in the Indian subcontinent and 4.8% in the Eastern Mediterranean to 10.2% in Asia-Pacific and 10.3% in North America.¹⁵ In South Africa the prevalence of AD in children was found to be around 17%.¹⁶

While the majority of patients usually develop the disease during early infancy, it sometimes persists into or starts in adulthood.¹⁵ Adult AD has been recognized with a prevalence of between 2-10%.¹⁷ The prevalence of AD among different races is not known, but due to AD being a heterogeneous disorder with its different genetic mechanisms, some races may be more prone to develop the disease. Asians have increased T_H17 and T_H22 responses when compared to Caucasians, while the immune response in the African population still needs to be determined.¹⁸

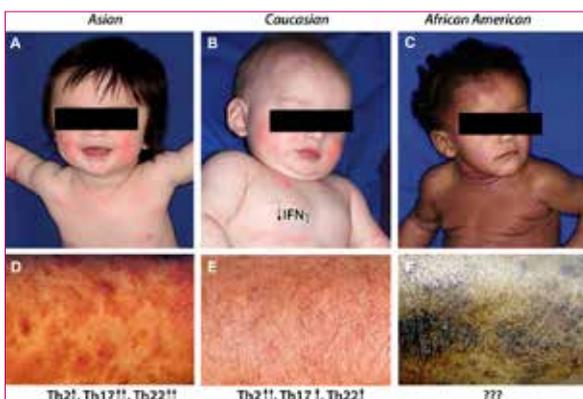


Figure 3. Different races and AD¹⁸

With regards to gender, various studies show the difference to be either insignificant or male preponderant in preschool children, while more females suffer from AD in adulthood.^{19,20}

Pathogenesis of AD

Although the clinical picture of AD is homogenous, presenting with acute flare-ups of eczematous, pruritic lesions on dry skin at distinct areas of the body, the pathophysiological network is

complex and the factors triggering the disease are diverse.²¹ An interaction between genetics, immunologic and environmental factors contribute to the pathogenesis of AD.¹⁵ Genetic studies have mainly focussed on immunological mechanisms, but a defect in the primary epithelial barrier has been anticipated.¹⁴ It is important to have a good understanding of the interaction between the various factors to enable effective management of the condition.

Genetics

Genetic factors play an important role: monozygotic twins showed a consistent higher concordance rate (0.77) compared to dizygotic twins (0.15). A positive parental history is furthermore the strongest risk factor for AD; if the disease is present in one parent, the incidence rate is doubled or tripled should both parents suffer from AD.²²

Filaggrin, a key protein in terminal differentiation of the epidermis and development of the skin barrier, protects the body from the entry of foreign environmental substances that can otherwise trigger immune responses. It is synthesised as a giant precursor protein, profilaggrin. The latter is found within the granular layer of the epidermis and is encoded by the *FLG* gene. This gene is located within the epidermal differentiation complex on chromosome 1q21.¹ It has been shown that two independent loss-of-function genetic variants (R510X and 2282de14) in the *FLG* gene are important pre-disposing factors for atopic dermatitis.²²

Based on a patients' ethnic background, several differences have been noted in AD phenotypes. Lower rates of *FLG* mutations, higher prevalence, and more severe, treatment-resistant AD appears in African Americans compared to Caucasians. A lower ceramide-to-cholesterol ratio is characteristic in normal skin of African Americans and with greater trans-epidermal water loss.¹⁷

Several other candidate genes have been suggested to play a role in AD e.g. chromosome 5q31-33, the locus containing genes for

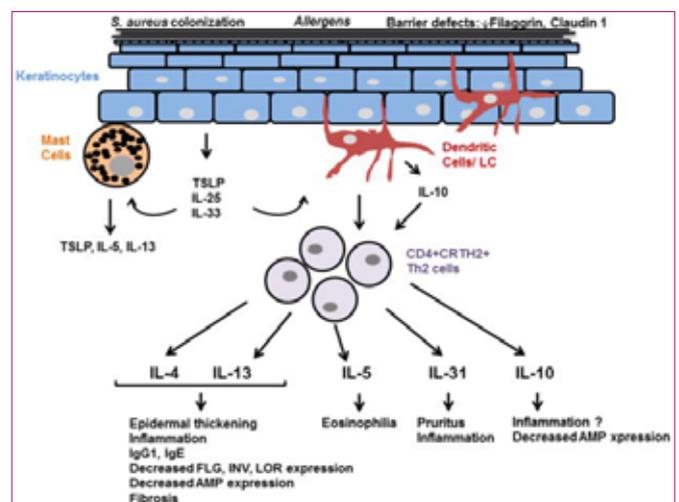


Figure 4. Th2 cytokines and AD: a schematic representation¹¹

TSLP, thymic stromal lymphopoietin; LC, Langerhans cells;

FLG, filaggrin; INV, involucrin; LOR, loricrin

the Th2 cytokines interleukin (IL)-3, IL-4, IL-5, IL-13, and granulocyte macrophage colony stimulating factor.¹⁴ Variants of an encoding region or functional mutations of promoter regions could be linked to the incidence of non-atopic dermatitis. Furthermore, polymorphisms of the IL-18 gene may be the cause of the dysbalance between Th1 and Th2-immune responses, resulting in Th2 predominance.²³ The functions of Th2 cytokines include increased epidermal thickening, sensitization, inflammation, pruritus, decreased expression of antimicrobial peptides and the barrier proteins filaggrin, loricrin and involucrin.¹¹

Figure 4 represents a schematic illustration pertaining to Th2 cytokines and AD: allergens, microbes and mechanical injury (e.g. scratching) activate keratinocytes. A defective skin barrier, due to decreased filaggrin, is an important contributing factor. Thymic stromal lymphopoiectin (TSLP), IL-25 and IL-33 act on mast cells and antigen presenting cells e.g. dendritic or Langerhans cells with a subsequent secretion of several Th2 cytokines.¹¹

Another possible contributing factor to the genetic susceptibility for AD is a genetic variant of mast cell chymase, a serine protease secreted by skin mast cells, which may have organ specific effects.¹⁴

Environmental factors

The incidence of AD worldwide and the variations thereof suggest that environmental factors play a pivotal role in the expression of AD. Some of the environmental factors implicated include climate, diet, obesity, smoking rate, and microbial exposure.¹⁵

Skin microbiota is involved in the homeostasis as well as pathogenic conditions of the skin. Both *Staphylococcus aureus* and *Streptococcus epidermidis* significantly increases during exacerbation of AD.¹⁵ These bacteria release allergenic compounds and superantigens (toxins)²⁴ and can act as effective immunological adjuvants for increased IgE response to aeroallergens. Intense pruritus is a hallmark of AD, and skin damage due to scratching enhances the progress and continuance of the disease.²⁵

Gut microbiota might also be involved in the pathogenesis of AD as it has been shown that children who present with AD later on in life have different early gut microbiota compared to children who do not develop AD, referring both to composition and diversity. Furthermore, systemic antibiotic treatment was reported to

increase the risk of AD.¹⁵ No evidence has however been reported in favour of AD management with regards to probiotics, dietary supplements, botanical extracts and homoeopathy.⁸

Figure 5 depicts factors such as temperature, indoor heating, humidity, and UV-light exposure influencing the prevalence of AD. A combination of high humidity and precipitation are associated with an increase in the disease, while high temperatures and exposure to UV-light has shown to have protective effects specific to AD.¹⁹

The acidic environment of the skin contributes to its barrier function as it has a strong antibacterial effect and controls the desquamation of corneocytes. Soaps and other detergents are common environmental agents that increase the skin pH. In addition, these agents emulsify skin surface lipids, change skin proteases, and consequently thin the stratum corneum.¹⁵

Immunology

Both the adaptive and innate immune systems are implicated in the development of AD. A complex interaction of immune cells mediates AD skin lesions. T cells play a major role in adaptive immunity and pathogenesis of AD. A relative imbalance of different types of T helper cells e.g. Th1, Th2, Th17 cells, is considered in the pathomechanism of many immune-mediated diseases. AD lesions contain an increased amount of Th2 cytokines during both acute and chronic phases of the disease compared to normal skin. Chronic lesions are however associated with a reduced production of IL-4 and IL-13 and an increased production of IL-5 and IL-12.¹⁵

Langerhans cells (LC) and inflammatory dendritic epidermal cells (IDEC) are two types of epidermal dendritic cell populations that are crucial elements of the immune system, bridging innate and adaptive immunity. These cells express increased levels of IgE high affinity receptor, FcεRI, on their surface and have the potential to respond to numerous antigens in an antigen-specific manner. It was shown that Langerhans cells, activated by FcεRI, drive naïve T cells into Th2 cells. They further highly express the receptor for thymic stromal lymphopoiectin. The latter plays a critical role in Th2 skewing and mediation of AD development.¹⁵ Refer back to Figure 5.

Inflammatory AD skin furthermore contains, except for LC, IDEC and various T cell subsets, vast numbers of neutrophils, basophils, eosinophils, innate lymphoid cells, natural killer cells and fibroblasts.²¹

Skin barrier

Skin barrier dysfunction is a major pathogenic factor for AD.²¹

Causes of skin barrier dysfunction include a defect in expression of the filaggrin gene, decrease in skin ceramides, and overactivation of epidermal proteases. Several genetic risk loci relating to epidermal barrier function have been identified in genome-wide association studies.¹⁵ Filaggrin plays a pivotal role in skin barrier integrity.^{15,21}

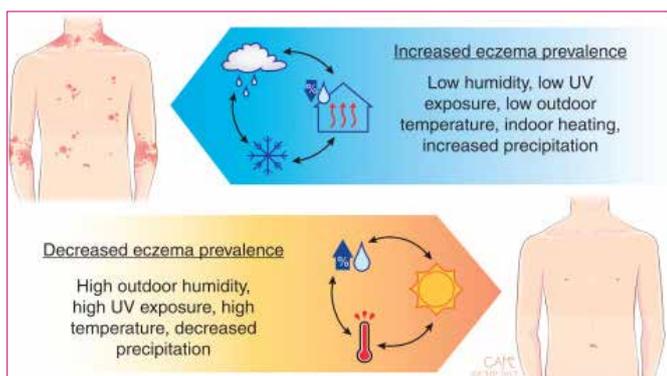


Figure 5. Impact of climate on AD prevalence during childhood¹⁹

- it aggregates keratin filaments into tight bundles
- modifies the composition of keratinocytes and the granular cell layer
- moisturizes the stratum corneum

Reduced availability of filaggrin metabolites alters hydration and pH of the skin.²¹ Patients diagnosed with non-atopic AD, lack barrier dysfunction and/or *FLG* gene mutation and it is therefore a feature of atopic AD.

Although not an inherent factor in patients suffering from AD, ceramide is a lipid that is important for water retention in the stratum corneum. The significance of ceramide is evident as an inversed correlation between transepidermal water loss and the level of ceramides in the stratum corneum of AD patients exists. A decreased level of ceramide in patients with AD is thought to be a post-inflammatory effect.¹⁵

Human kallikrein-related peptidases are key proteases for desquamation of corneocytes. The activity of these proteases is pH dependent with enhanced activity when the pH in the stratum corneum is elevated. Activation of epidermal proteases and subsequent increased corneocytes desquamation can induce AD-like dermatitis.¹⁵

Figure 6 depicts the interplay among contributing factors in the pathogenesis of AD and pruritus as a characteristic feature of the disease. It is important to remember that histamine has little relevance in the pruritic pathway of AD and is therefore poorly effective in the management of the disease. First generation antihistamines are indicated for their sedative effect in order to facilitate sleep which might be impaired due to itching.²⁶ Second generation antihistamines seem to have little or no value in the treatment of AD, as concluded by most studies.²³

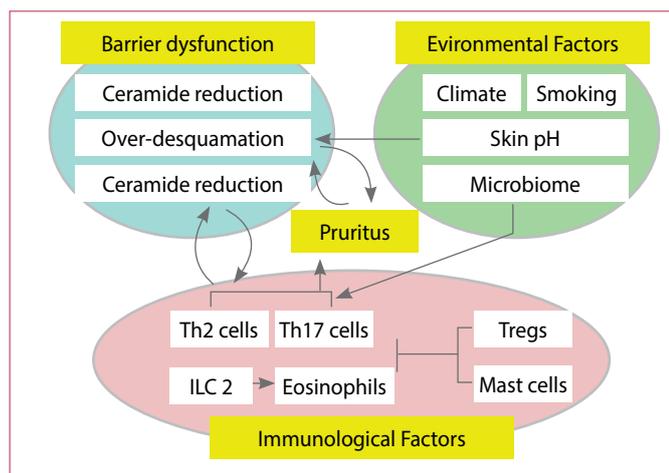


Figure 6. Interplay among contributing factors and pruritus in pathogenesis of AD¹⁵

AD and its management

Atopic dermatitis is a skin condition, considered by experts to be incurable.²⁷ Contrary to this, some experts conclude that

approximately half of children affected by AD reach disease resolution into their adult phase.²⁸ Guidelines on how to manage AD aims to improve symptoms and achieve long-term disease control. Prior to development of novel treatments, a multistep approach has included avoidance of trigger factors, continuous epidermal barrier repair with emollients, and anti-inflammatory therapy with topical corticosteroids or calcineurin inhibitors. The use of phototherapy or systemic immunosuppressant therapy is indicated in severe and refractory cases.⁸ Other options to consider in the management of AD include novel treatments, e.g. dupilumab.²⁹ The management of AD should however always be adapted according to disease severity. Patient education should not be neglected by health care providers and remains as important as other treatment strategies.²³

Non-Pharmacological management

Avoidance of trigger factors

Several factors, usually individualized and based on a previous reaction to an identified provoking agent, can trigger or worsen the symptoms of AD.³⁰ These factors should be avoided in order to reduce disease exacerbations and flare-ups. Based on clinical experience, the following factors are widely assumed to worsen this disease: food, inhalant, or contact allergens, detergents, wool fabrics, climate, infections and stress. Based on evidence, aeroallergens (e.g. dust mites) and food allergens (e.g. cow's milk) worsens the symptoms of AD in both children and adults. Avoiding these trigger factors should be individualized and based on a definite history of worsening of disease symptoms after exposure.⁸

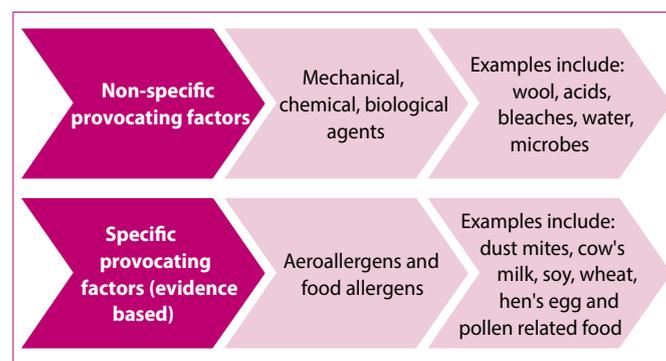


Figure 7: Different factors causing AD flare-ups³⁰

Patients should avoid ingesting food that contains potential allergens, ensure optimum skin care, and most importantly attain educational information on the disease itself. Avoiding provocation factors has shown to contribute to the long-term and effective management of AD.³⁰

Moisturizing

The main aim of using moisturizing agents is to combat xerosis (the cardinal clinical feature of AD that results from a dysfunctional barrier layer). Moisturizing agents predominantly reduce transepidermal water loss and have shown to lessen symptoms and signs of AD, including pruritus, erythema, fissuring, and lichenification.³⁰

The various available products include emollients, humectants and other miscellaneous agents. Frequent use of emollients is of key importance in maintaining homeostasis of the epidermal barrier. Emollients supply exogenous lipids and thereby soften the skin and reduce water loss by forming an occlusive layer. Emollients are mostly composed of different ingredients such as glycerol, petrolatum, mineral oil, purified water (e.g. Dexeryl[®]). These products ensure that the skin is softened and lubricated.³¹ Humectants such as urea (avoid in infants; ≤ 4% in children; up to 10% in adults), glycerine, and lactic acid added to the emollient, further increase water binding in the stratum corneum.^{8,23}

Products containing perfumes, colourants etc. could induce an allergic reaction or act as an irritant and best avoided. Non-soap fragrance free cleaners with a neutral to low pH are highly recommended for patients suffering from AD. The use of wet-wrap therapy, with or without a topical corticosteroid, has also been seen as a favourable alternative in the management of AD. The latter is recommended for patients with moderate to severe AD in an attempt to decrease disease severity and water loss during flares.⁸

It is imperative to remember that Aqueous Cream BP, commonly prescribed to relieve skin dryness, contains the surfactant sodium lauryl sulphate (SLS). Sodium lauryl sulphate affects the effectiveness of the skin barrier. Studies have shown that SLS significantly reduces the thickness of the stratum corneum with an overall increase in baseline transepidermal water loss (TEWL).³²

Phototherapy

In cases where AD cannot be controlled with topical treatment, short-term phototherapy should be considered. It has been shown that narrow-band ultraviolet B radiation and medium-dose ultraviolet A1 radiation are the most effective. This therapy should not be combined with topical calcineurin inhibitors and systemic cyclosporin treatment due to a potentially increased cumulative risk of skin cancer.⁸

Pharmacological management

Anti-inflammatory therapy

Topical corticosteroids are the mainstay anti-inflammatory treatment to control acute outbreaks of AD and has a low risk profile when used appropriately and intermittently.⁸ The mechanism of action of this class of medicine is linked to their potential to affect various immune cells. The latter include T lymphocytes, macrophages, monocytes and dendritic cells interfering with antigen processing and the suppression of pro-inflammatory cytokines release.³⁰ Low-potency corticosteroids are preferred to use on the face, on areas with thinner skin, and in children. Short-term treatment of severe exacerbations is an exception.⁸ Thicker skinned areas should initially be treated with moderate to high potent steroids followed by a dose reduction or an exchange to a lower potency preparation.²³ Refer to Table 2.

Calcineurin inhibitors for topical application include tacrolimus and pimecrolimus and are regarded as a second-line option for

short term and intermittent treatment.⁸ These agents selectively inhibit the production and release of pro-inflammatory cytokines and mediators by T cells and mast cells.³³ The advantage of calcineurin inhibitors is that they do not cause skin atrophy and is therefore of particular value in areas with delicate skin e.g. the face and groin. Topical corticosteroids and calcineurin inhibitors should be applied proactively for two consecutive days per week to help reduce exacerbations of the disease.⁸

Table 2. Different topical corticosteroids used in AD, including their potency and trade names²⁸

POTENCY	EXAMPLES
Weak	
Hydrocortisone 0.5%	Dilucort [®] , Skincalm [®]
Hydrocortisone 1%	Procutan [®] , Mylocort [®] , Biocort [®]
Moderately potent	
Betamethasone Half-Strength 0.05% (as valerate)	Sekpharma [®]
Potent	
Beclomethasone dipropionate 0.025%	Beclate [®]
Betamethasone 0.1% (as valerate)	Sekpharma [®] , Lenovate [®] , Persivate [®]
Betamethasone 0.05% (as dipropionate)	Diprosone [®]
Diflucortolone 0.1% (as valerate)	Nerisone [®]
Fluocinolone acetonide 0.025%	Synalar [®] , Cortoderm [®]
Fluticasone propionate 0.05%	Cutivate [®]
Hydrocortisone butyrate	Locoid [®]
Methylprednisolone aceponate 0.1%	Advantan [®]
Mometasone	Elocon [®]
Very potent	
Clobetasol propionate 0.05%	Dermovate [®] , Dovate [®] , Xenovate [®]

Systemic immunosuppressive therapy

Several immunomodulatory agents that have been investigated for its use in AD including cyclosporine, azathioprine, methotrexate, oral corticosteroids and mycophenolate mofetil. The immunosuppressive agents are usually used in refractory conditions where treatment failure with topical and phototherapy options have been observed. Most of these agents are used off-label with the exception of cyclosporine and oral corticosteroids.

Novel therapy

Dupilumab is a novel therapeutic option that has been approved for use in AD. It is a fully human monoclonal antibody that exerts its action through binding to interleukin 4Ra which is a component of the IL-4 and IL-13 receptors. Binding to these receptors inhibits their signaling and results in the downregulation of type-2 immunity.²⁹ The breakthrough of dupilumab was achieved in 2012 when results from a phase 2 trial showed safety and efficacy as monotherapy for use in moderate-to-severe AD.³⁴ The US Food and Drug Administration (FDA) approved dupilumab, the first biological therapy for use in AD, in March 2017.²⁹ The use of dupilumab has enhanced confidence in the long-term control of AD, especially in patients with resistant, extensive disease.²⁹

Conclusion

Atopic dermatitis affects people of all ages but children are sometimes able to outgrow the condition. The physical effects of AD are unpleasant, but even more worrisome is the link to psychological and emotional distress. Treatment focuses on the use of topical therapies such as corticosteroids and/or calcineurin inhibitors to reduce the immunological response. The use of systemic therapies is usually reserved for AD resistant to conventional therapy. Exciting new treatment options for the long-term control of AD, especially in patients with resistant, extensive disease has recently become available and needs to be considered.

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