EXPERT OPINION

Topical drug delivery systems in dermatology: a review of patient adherence issues

Xi Tan[†], Steven R Feldman, Jongwha Chang & Rajesh Balkrishnan
[†]*University of Michigan, College of Pharmacy, Department of Clinical, Social and Administrative Sciences, Ann Arbor, MI, USA*

Introduction: Until now, the main focus of medication adherence research has been oral drugs. Fewer studies have examined adherence to topical drugs. The issue of patient adherence to topical drugs is particularly significant in relation to chronic skin diseases, including psoriasis, atopic dermatitis, and acne, which require long-term use of topical medications.
Areas covered: The authors reviewed the current evidence of adherence to topical therapy in dermatological diseases, mainly focusing on psoriasis, atopic dermatitis, and acne. The predictors or factors influencing adherence to topical therapy are then discussed. In general, the prevalence of poor adherence to topical drugs is high in dermatology. However, this research area remains empirically underdeveloped. We are still facing challenges in measuring topical medication adherence.
Expert opinion: The authors recommend some possible ways to improve topical medication adherence and provide some future research directions. Taking patient preference into consideration in selecting the right topical delivery vehicle is particularly important in improving patient adherence. Better drug design, formulation, or technology may be another important direction. Other possible effective ways to improve topical medication adherence include good physician–patient relationship, patient education, individualized treatment plan, psychological intervention, electronic devices, and return visits.

Keywords: compliance, dermatology, medication adherence, patient adherence, topical drug, topical medication, topical vehicle

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1. Introduction

"Adherence to medications" is defined as "the process by which patients take their medications as prescribed" [1]. It is involved with three components: "initiation, implementation, and discontinuation" [1]. "Non-adherence to medications" is thus defined as "late or non-initiation of the prescribed treatment, sub-optimal implementation of the dosing regimen or early discontinuation of the treatment" [1]. The World Health Organization (WHO) states that non-adherence to medications is a "worldwide problem of striking magnitude" [2]. Poor medication adherence can result in negative health outcomes including a worsening of the condition or even death, and evidence shows that there is an association between poor adherence to medications indicated for chronic diseases and health resources utilization [3]. Poor medication adherence may also result in increased health care costs. Thirty-three to Sixty-nine percent of drug-related hospital admissions in the United States are a result of poor medication adherence, which adds up to a cost of about $US100 billion a year [4].

Until now, the main focus of medication adherence research has been oral drugs. Fewer studies have examined adherence to topical drugs. The issue of patient

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Article highlights.

- The prevalence of poor adherence to topical drugs is high in dermatology.
- A variety of factors may make adherence to topical treatment of skin disease different from other medication adherence issues.
- A limitation in our understanding of adherence to topical treatment is the difficulty of measuring adherence. So far electronic monitoring is still considered the most accurate available method in assessing topical medication adherence.
- The recommendations to improve topical medication adherence include selecting patient preferred topical vehicle, better drug design and formulation, good physician–patient relationship, patient education, individualized treatment plan, psychological intervention, applying electronic systems and scheduling return visits.
- Although some causes of non-adherence to topical medications have been identified, we still lack evidence-based recommendations and interventions to improve topical medication adherence. Future large robust studies regarding the interventions to improve adherence to topical drugs are warranted.

This box summarizes key points contained in the article.

adherence to topical drugs is particularly significant in relation to chronic skin diseases, including psoriasis, atopic dermatitis, and acne, which require long-term use of topical medications. This review will mainly discuss the issue of patient adherence to topical drug delivery systems in dermatological diseases. It will explore the current evidence of adherence to topical therapy in dermatological diseases, predictors or factors influencing adherence to topical therapy, and recommendations for improving adherence to topical therapy.

2. Methods

Studies considered for inclusion in our review were identified using PubMed/MEDLINE, Embase, Cochrane database of systematic review, Cochrane Central Register of Controlled Trials, and International Pharmaceutical Abstracts. We searched the studies published from inception to April 2012 by using the following terms: "topical drug" OR "topical medication", AND "adherence" OR "compliance". Search limitations were English language and human subjects. We identified 60 dermatological studies and reviews that met our inclusion criteria. Among the 60 dermatological studies, 15 studies were related to psoriasis, 7 to atopic dermatitis, and 17 to acne.

3. Patient adherence to topical medications in dermatology

There are a variety of treatment options in dermatology due to the unique characteristics of dermatological diseases: the external distribution of the skin [5]. One of the advantages of applying topical medications is that the disease site can be easily targeted with minimum systemic toxicity [5]. There is a link between poor adherence to topical therapy and poor treatment outcomes in patients with skin disease [6-8]. Treatment adherence, treatment satisfaction, and treatment outcome mutually impact each other and may construct a cyclical linkage pattern [9]. Furthermore, improving adherence to topical treatment is associated with better health outcomes [6]. Therefore, in dermatological disease management, ensuring good adherence to topical therapy is as important as making the correct diagnosis and selecting the appropriate treatment [9].

A variety of factors may make adherence to topical treatment of skin disease different from other medication adherence issues. Patients with skin disease may be more likely to adhere to their treatment regimens because dermatological diseases are more visible and highly symptomatic, and because topical treatments have few systemic side effects. On the other hand, patient adherence may suffer as topical treatments are more time-consuming and complicated to use than oral treatments. The wide range of topical medication adherence rates reported in the literature may reflect differences in the definitions of adherence or non-adherence, study design, adherence measurement, and disease and treatment characteristics, but which nevertheless points increasingly to adherence as a significant issue for both patients and physicians [10-24]. For example, Krejci-Manwaring *et al.* (2006) and van der Kerkhof *et al.* (2000) studies on atopic dermatitis and psoriasis found that patients adhered better to oral therapy than to topical drugs [16,25]. Similarly, one large-scale study from Denmark found that the primary non-adherence rate (the unredeemed percentage of initial prescriptions) of topical treatments compared to oral treatments was 35.3% vs 14.3% [15]. Furthermore, another Danish study on topical medication use showed that only 1 out of 17 patients applied the appropriated dosage of the new topical medication, and only approximately one-third of the expected dosages were used [26]. Very few patients used new topical treatments correctly and adequately the first time. The authors even suggest that topical treatments may be an inferior treatment option in dermatology because of the significantly poor adherence and inappropriate use of topical treatments.

Adherence to topical treatments is a multifaceted, multifactorial, and complicated issue. As is the case with adherence to oral therapy, factors that impact adherence to topical treatments include psychiatric comorbidity, drug affordability, concerns about treatment safety, age (adolescence), side effects, fear of side effects, misbeliefs or misunderstandings about the disease and treatment regimen, distrust of the health care system or health care professionals, frequency of administration, prior experience with similar agents, and dissatisfaction associated with medication efficacy expectation. There are also factors that influence adherence to topical drugs specifically. For example, patients may feel that it is inconvenient or time-consuming to apply topical medications; ambiguous

and subjective usage and dosing instructions (e.g. "apply sparingly") may lead to incorrect use of topical drugs [27]; complicated application instructions may be more difficult to understand or remember, and result in more frequent misuses compared to oral therapy (e.g. 'take one tablet daily'); patients may be put off by topical treatments' non-aesthetic and galenic nature (e.g. messiness, smell, spreadability, and discoloration); or side effects such as irritation, burning, and dryness. Most importantly, each patient is unique and we cannot ignore the individual differences in medication adherence. In the next section, we will review this topic in three common dermatological diseases: psoriasis, acne, and atopic dermatitis.

3.1 Psoriasis

Psoriasis is a chronic inflammatory skin disease which typically requires long-term treatments. The WHO indicates that medication adherence in psoriasis is one of the most important factors that can impact the efficacy of treatments [24]. Most patients with psoriasis start with topical treatments. There are a variety of topical agents available to treat psoriasis, including dithranol, coal tar, topical corticosteroids, Vitamin D3 analogs, calcipotriol, retinoids, and calcineurin inhibitors. Patients often regard topical treatments as one of the negative aspects of psoriasis [28]. The Danish dermatologic study found that medication adherence was worst in psoriasis patients among all patients with dermatoses, with half of the prescriptions not being filled [15]. Adherence to topical medications in psoriasis, as reported by patients, ranged from 39% to 72% [22,29]. Adherence to topical corticosteroids in psoriatic patients was approximately in the range of 30 – 50% [15,30]. Overall, adherence to topical medications is poor in psoriasis, a critical issue in the management of the disease.

There are several main treatment-related factors for non-adherence to topical therapy in psoriasis. The first factor is a lack of efficacy or patient dissatisfaction with the efficacy. The chronicity and incurability of disease, and the high rate of treatment failure of topical agents may make patients feel frustrated or dissatisfied with the treatments, which can further lead to non-adherence [5]. More patient education about the chronicity of the illness and delayed improvement of treatments may help with the enhancement of adherence. A second factor is side effects or fear of side effects. The fear of side effects of topical corticosteroids may have a larger impact on adherence than actual side effects [30]. This indicates the possibility for patient education interventions to improve adherence to topical corticosteroids. A third factor is the complexity or inconvenience of the treatment regimen. Topical treatment regimens for psoriasis are typically complicated and require adequate self-management skills to ensure appropriate dosing [28,31]. A fourth factor is the patient's preference of the drug vehicle, which must be considered when the physician prescribes the treatment. The cosmetic and galenic properties of topical agents or even the smell of the drugs may be very important factors contributing to adherence [32]. Patients with psoriasis usually prefer foam, solution, and spray formulations with less messy vehicles to creams and ointments [27]. With the advent of novel preparations and formulations to treat psoriasis with better efficacy and favorable properties, better and better medication adherence can be expected. In addition, return office visits may improve adherence to topical corticosteroids in psoriatic patients, at least around the time of the visit [30,33].

3.2 Acne

Acne is a very common inflammatory skin condition, which mainly occurs in adolescence and may persist until adulthood. Acne presents diverse clinical courses and severity and typically requires treatment for extended periods of time. There are a variety of drugs on the market for treating acne and preventing outbreaks. Topical medications are the first-line treatment of mild to moderate acne and oral antibiotics or isotretinoin for severe cases [34].

Medication non-adherence is a common cause of acne treatment failure. Adherence to topical treatments for acne measured by subjective methods was approximately 40 – 60% [10,18,19,35]. In a 2010 large-scale worldwide study on adherence with acne therapy, patients reported 60% good adherence to topical therapy [10]. The study also found that, among people who were using a combination of oral and topical drugs, poor adherence rate (the risk of poor adherence measured by a validated adherence questionnaire) to oral therapy was worse than to topical therapy (54 vs 44%, respectively), a result that differed from studies on other dermatological diseases. Two recent small-scale studies used electronic monitoring (MEMS caps) to measure adherence, a method that is currently considered the gold standard method of measuring adherence to topical drugs [11,36]. Adherence to once-daily 5% benzoyl peroxide gel among 11 teenagers decreased from 82% on day 1 to 45% on day 43 [36]. Among 12 participants, the adherence to clindamycin phosphate gel 1% and tretinoin cream 0.025% dropped from 82% at week 1 to 14% at week 12 [11]. In another group of nine participants, the adherence to a once-daily combination therapy of clindamycin phosphate gel 1% and tretinoin cream 0.025% did not change significantly over the 12 weeks (100% at week 1 vs 86% at week 12) [11].

Adolescents consistently demonstrate non-adherent behavior [5,10]. One of the primary reasons for non-adherence to topical medications is the lag time of the effects. Patients may expect drugs to achieve quick resolution or improvement. In particular, adolescents may have difficulty delaying satisfaction [37]. Side effects can be another barrier to adherence to topical medications. Topical retinoids and benzoyl peroxide may cause irritation, burning, or dryness. Some unfavorable effects may also prevent patients, especially females, from using them. For example, topical acne treatments may change the appearance of makeup [5,37]. Studies also find positive relationship between quality of life and medication adherence; better quality of life can be associated with better adherence [22,38]. This may be attributed to the

psychological comorbidity or disease burden—such as the frustration or depression caused by lack of responsiveness from the treatments—resulting in poor use of medication [38,39]. Forgetfulness, busy lifestyle, and the complexity or inconvenience of treatment regimens are common reasons for non-adherence as well. One special factor that affects medication adherence in acne patients is related to the large variety of medications and cosmeceuticals for acne available on the market. Information from non-medical professional commercials, articles, and websites is easy to access and may conflict with professional medical information [5].

3.3 Atopic dermatitis

Atopic dermatitis is a chronic inflammatory cutaneous disease with highly pruritic symptoms and frequent recurrence [40,41]. Symptoms often occur from 3 months old and persist for several months to years, and may still exist in adulthood in some cases [40]. Topical corticosteroids remain the mainstay of treatment regimen in atopic dermatitis. Due to the chronicity and intermittent relapses of the disease, long-term use of topical corticosteroids is usually required to control the disease and prevent recurring flares. During asymptomatic disease periods, topical emollient use is also critical to prevent relapses. However, adherence to topical treatments in atopic dermatitis is ubiquitously poor and deceases over time. A 2010 study on atopic dermatitis found that mean adherence to twice-daily application of desonide hydrogel decreased from 81% on day 1 to 50% on day 27 [42] According to Krejci-Manwaring *et al.* (2007), mean adherence to twice-daily use of 0.1% triamcinolone ointment was 32% among 37 children during an 8-week period [24] Cork *et al.* (2003) also identified poor adherence to topical emollients and suboptimal amount usage [12].

There are several specific factors causing non-adherence in atopic dermatitis. Firstly, the topical corticosteroid regimen can be complex, which is especially burdensome when long-term use is required. Frequent applications, multiple medications, rigid dosing schedules, the burden of preparing or mixing medication: all of these factors may be cumbersome or inconvenient to patients, and may even confuse patients about their treatment plans [40]. The complexity of treatment regimens may make it difficult for patients to follow the instructions and use treatments correctly. Secondly, the vehicle of topical drug is another main predictor of patient adherence. Most patients may not appreciate the galenic properties of certain topical products, such as greasy creams or ointments. Some patients who have dry lesions may prefer greasy topical products, but others may not [40]. The selection of topical vehicle is also a major concern for physicians. The features and locations of the lesions, as well as patient preference, should be taken into consideration. Thirdly, family factors can also play an important role in influencing topical medication adherence in atopic dermatitis. Topical treatments are usually applied to patients by parents, family members, or caregivers. The chronic management of a disease that requires long-lasting efforts from caregivers may build up caregiver burden and result in caregiver fatigue. Last but not least, fear of the side effects of topical corticosteroids, which is also called "topical corticosteroid phobia," is quite common in patients with atopic dermatitis [41]. Aubert-Wastiaux *et al.* (2011) not only reinforced the common prevalence of topical corticosteroid phobia (80.7%), but also confirmed that "the greater the fear, the poorer the compliance." [41]. It also found that topical corticosteroid phobia can impact all patients with atopic dermatitis, regardless of disease type, severity, or patient characteristics. Furthermore, most of the fears were from the side effects, both cutaneous side effects and potential systemic side effects.

4. Adherence measurement method issues

A limitation in our understanding of adherence to topical treatment is the difficulty of measuring adherence. Although there are multiple ways of measuring medication adherence, none of them is considered an ideal method especially in measuring adherence to topical medications. Patient adherence to topical medication is difficult to measure since not only does the frequency of dosing has to be measured but also the quantity applied each time needs to be measured and may vary depending on extent of disease. This results in a more complex measurement problem compared to the assessment of adherence to a fixed pill-taking regimen [43]. The most commonly used methods of measuring adherence to topical medications in outpatient clinical settings are patient self-reports, electronic monitoring, pharmacy fill data, and medication weight measurement. Each method has its pros and cons. The electronic medication monitoring device (MEMS cap) is usually regarded as the reference standard method to assess medication adherence and is commonly used in clinical trials of adherence since this method can provide very detailed and precise information regarding the patterns of medication using behavior. However, it has disadvantages, such as the failure to capture the actual medication consumption and accuracy of applied dosage and the high cost and bother of a process that requires return visits and downloading data from the vials [4]. In spite of these disadvantages, electronic monitoring is still considered the most accurate available method in assessing topical medication adherence, compared with patient self-reports and medication weighing [13,14,38].

Pharmacy refill rates and weighing medications are objective measures and can quantify adherence, yet medication consumption is assumed but not confirmed [44]. The patient self-report method usually cannot provide such detailed, objective, and accurate information as objective methods. Usually adherence is overestimated in patient self-reports. Balkrishnan *et al.* (2003) indicated that patient adherence to topical salicylic acid gel for psoriasis was significantly different when measured by MEMS vs patient diary (67 vs 92%, respectively) [13]. However, the patient self-report method

can provide the reasons or factors associated with non-adherence. In addition, patient self-reporting is less expensive and easier to administer in the clinical setting.

5. Conclusion

The prevalence of poor adherence to topical drugs is high in dermatology. However, this research area remains empirically underdeveloped. We are still facing challenges in measuring topical medication adherence.

6. Expert opinion

We can learn from what we have discussed above that, in general, adherence to topical therapy is no better than adherence to oral therapy. Moreover, poor adherence to topical therapy appears to be prevalent in a variety of dermatological diseases. However, there is much less literature examining the medication adherence specifically related to topical therapy, which makes it difficult for practitioners to develop evidence-based interventions to improve patient adherence to topical therapy. Nevertheless, we recommend some possible ways to improve topical medication adherence and provide some future research directions.

6.1 Recommendations for improving medication adherence

Few clinical trials have been done to assess methods of improving adherence to topical treatment. Factors which significantly impact oral medication adherence are very likely to affect topical medication adherence [27]. Therefore, we may apply some lessons from oral medication adherence research and then further develop recommendations and interventions specifically for topical medication adherence. A meta-analysis study found that almost all current effective interventions for general medication adherence in chronic long-term care were complex [45]. These interventions were mixed interventions of more convenient care, information, reminders, self-monitoring, reinforcement, counseling, family therapy, psychological therapy, crisis intervention, manual telephone follow-ups, and supportive care [45]. However, in those intervention studies, we cannot assess the independent effect of each simple intervention in the long run. The best solution may be that we can design tailored or individualized interventions based on the individual's situation and characteristics. We could use a complex combination of different interventions in challenging and recalcitrant cases in order to achieve long-term effect.

Moreover, the link between theoretical medication adherence research and real world practice needs to be investigated. The translation of certain research into practice is not easy. For example, usually medication adherence studies or interventions mainly focus on one disease state while, in reality, a lot of patients have multiple diseases and take several medications. There are very few interventions designed and tested for complex regimens [45]. Furthermore, many interventions were led by multidisciplinary teams, but in practice the resources of a multidisciplinary team to improve patient medication adherence may not always be available. New health care delivery models that reward better outcomes may encourage greater use of resources to promote better adherence.

According to current literature and the experience of researchers and practitioners, there are several interventions that can potentially improve topical medication adherence. Firstly, build up and bolster good doctor–patient relationships. A good relationship between physician and patient is the foundation of trust and respect, which can significantly impact medical adherence. Effective communication is always the key to maintaining a good doctor–patient relationship. Several key elements of doctor–patient communication that can enhance the relationship and improve topical medication adherence include eye contact, good listening skills, and using both verbal and written communication to educate patients [28].

Secondly, educate patients about the disease, the treatment, and the importance of medication adherence. Clear instructions and hands-on demonstrations of application are especially important in topical medication adherence. Effective educational interventions suggest that educators should not overload patients with information, but should ask for patient feedback on the effectiveness of the education and offer take-home references that patients can go back to check frequently [28,46,47].

Thirdly, offer psychological interventions or apply cognitive behavioral therapy techniques. Chronic disease and long-term treatment can increase patients' psychological stress and burden. These psychological discomforts or comorbidities can in turn lead to medication non-adherence. Strategies such as teaching certain coping skills, providing consultation, encouraging the acceptance of the illness, and enhancing motivations to using medications may help with addressing these problems [5].

Fourthly, schedule return visits and monitoring of medication adherence in order to improve adherence. Adherence is improved around the time of office visits [33,48-50]. An office visit can be used to drive adherence behavior. If this is done early in the course of therapy and induces patients to establish a good pattern of medication use—to make it a habit—the early visit could have long-lasting effects. If on-site return visits are not possible, an electronic "visit" may prove valuable instead.

Fifthly, develop and apply electronic approaches of improving or monitoring medication adherence. In order to overcome the difficulties in implement complex interventions in the busy clinical settings, we could consider apply new techniques into the traditional interventions. Electronic systems have been suggested as innovative and promising methods of delivering adherence interventions [51,52]. For example, mobile phone text messaging and automated phone calls with interactive components can not only remind

Table 1. Advantages and disadvantages of topical drug dosage forms.

Vehicle	Advantage	Disadvantage
Creams	Oil and water base makes it suitable for use on most skin areas Tend to be less irritating Emollient properties Most suitable for patients with dry or sensitive skin	May result in an oily feel due to thicker consistency
Foams	Minimal residue after application Quick drying, ease of application, lack of fragrance No difference in cost compared to cream/solution after controlling for body surface area (BSA) Spreads easily, especially helpful if treating larger BSA	A small number of application site reactions (e.g., burning, stinging, pruritus)
Gels	Contain high water content Cooling effect upon application Significant long-term efficacy compared to conventional treatments Fast onset of action, good safety profile, high patient satisfaction	Burning, itching, dryness, irritation, peeling, or redness of skin
Lotions	Can have either water or alcohol base Are the most versatile Can be used for all skin types Have a lighter feel Preferred for treatment of large or hairy areas, or skin sites subject to chafing (e.g., axilla, foot, groin)	Can cause skin irritation (e.g., burning and dryness)
Ointments	Effective for patients with very dry skin Many are preservative-free Provide higher potency and greater drug penetration Effective on thickened skin lesions	Insoluble in water, so are difficult to wash off Can be perceived by patients as being greasy or messy to apply
Shampoos	Short contact application (about 15 min) Reduced side-effects Can be used for extended periods of time High patient satisfaction, which may increase adherence and treatment efficacy	A small number of cases with burning, skin atrophy, and telangiectasia
Solutions	Easy to spread Leave minimal residue	Usually contain alcohol bases that can cause stinging or exacerbate dryness and irritation
Sprays	Can treat large areas of affected skin (up to 15 – 20% BSA) Improved quality of life scores when compared with other formulations	Few cases of erythema, scaling, dryness, stinging/burning, and lack of smoothness

Adapted from [57] with permission.

patients of taking medications but also facilitate the interaction between health care providers and patients. Electronic devices such as electronic diaries are also good tools of monitoring and measuring medication adherence. With the growing development of new technologies, innovative communication mechanisms combined with complex interventions such as tailored or individualized educational interventions are expected to be important and positive in improving medication adherence.

Sixthly, select the best treatment plan. The selection of the right treatment plan should be based on clinical judgment that is informed by patient preference and lifestyle factors. Always keep in mind that the best treatment is one the patient is willing to use. Encouraging patients to actively participate in the medical decision-making process correlates with improvement of self-management behaviors including medication adherence [53]. Simplifying or individualizing treatment regimens is also a good way of improving adherence in some cases [11]. In selecting topical medications, the drug vehicle is a critical concern that can significantly impact patient adherence [30,42,54]. The US Food and Drug Administration (FDA) defines eight topical dosage forms: "solution, suspension, lotion, paste, gel, ointment, cream or 'other', which includes aerosols, powders, patches, etc." [55,56]. The new formulations in the "other" category such as spray, foam, and gels are becoming increasingly popular. New formulations generally possess the advantages of greater cosmetic and aesthetic acceptability, convenience of use, and fewer unfavorable effects, all without compromising with the efficacy. Thus, it is expected that many patients will be more satisfied with these novel formulations and more adherent to medication [55]. There are advantages and disadvantages of different topical dosage forms (**Table 1**) [57]. Taking patient preference into consideration in selecting the right topical delivery vehicle is particularly important in improving patient adherence and achieving good treatment outcomes in diseases such as psoriasis, atopic dermatitis, and acne. Even though conventional formulations such as cream and ointment are considered more potent and effective in clinical trials, patients may not use them since they are greasier, messier and more

inconvenient to use. If patients do not use the medication, the medication will not work at all. Thus, a topical treatment in the patient's preferred vehicle instead of the theoretically more potent vehicle can be linked to better treatment outcomes as a result of greater adherence [58].

Finally, design and develop better drugs or formulations. Novel drug design and formulations could focus on improving efficacy, tolerability, and drug delivery. We could achieve these goals through simplifying treatment regimen or fixing combinations, delaying release of the active drug, improving epidermal barrier function, and reducing unfavorable effects such as irritation and burning [55,59]. There are several new dermatological formulations that contribute to greater medication adherence and better treatment outcomes. Less messy steroid formulations providing topical steroids in a low-residue vehicle can increase patient adherence in treating steroid-responsive skin diseases such as allergic reactions, atopic dermatitis, and psoriasis [60]. New acne formulations of topical retinoid and benzoyl peroxide microsphere gels can improve drug stability and tolerability, and thus may lead to better adherence and clinical outcomes [61-63]. Clobetasol propionate 0.05% spray for psoriasis was examined in a very large community-based clinical trial with over 2400 patients [64]. At week 4, 66.6% of patients were clear or close to clear of psoriasis and patient satisfaction was reported at 92.4%. Calcipotriene 0.005% foam, another new formulation for psoriasis, was safe and effective [65]; this formulation may improve patient satisfaction and adherence due to the preferred vehicle.

Although some causes of non-adherence to topical medications have been identified, we still lack evidence-based recommendations and interventions to improve topical medication adherence. The evidence of interventions in this area is weak, and recommendations are usually based on oral medication adherence research or practice experience. Therefore, future large robust studies regarding the interventions to improve adherence to topical drugs are warranted.

Declaration of interest

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Affiliation

Xi Tan[†1] PharmD, Steven R Feldman[2] MD PhD, Jongwha Chang[3] PhD & Rajesh Balkrishnan[1] PhD
[†]Author for correspondence
[1]University of Michigan, College of Pharmacy, Department of Clinical, Social and Administrative Sciences, Ann Arbor, MI, USA
Tel: +1 734 936 1505;
Fax: +1 734 615 8171;
E-mail: tanxi@umich.edu
[2]Wake Forest University School of Medicine, Department of Dermatology, Winson-Salem, NC, USA
[3]Pennsylvania State University, College of Medicine, Division of Health Services Research, Department of Public Health Sciences, Hershey, PA, USA