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Article

Modern Disposable Diaper Construction: Innovations in Performance Help Maintain Healthy Diapered Skin

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Jennifer L. Counts, PhD[1], C. Tucker Helmes, PhD[2], Dianna Kenneally, BS, ChE, MBA[1], and David R. Otts, PhD[3]

Abstract

Disposable diapers today employ dramatically better fitting, less bulky, and more environmentally friendly features that deliver better performance and help provide protection for infant skin. Continuous innovations in technology and materials have resulted in new generations of disposable diapers that provide extended dryness and reduced leakage. Driven by studies on the skin's response to inherent influences, such as overhydration and irritation, the qualities of disposable diapers today present significant enhancements for skin health compared with earlier disposable versions and even cloth diapers. Over the years, these enhancements in disposable diapers have helped lead to a reduction in incidence and severity of diaper dermatitis.

Keywords

disposable diapers, diaper construction, advanced diaper design, diaper quality, diaper safety, diaper performance, superabsorbent polymers, diaper rash, diaper dermatitis

Disposable diapers have come a long way in the last half century. Built on continuous research and product innovation, today's diapers barely resemble their predecessors, as they employ dramatically better fitting, less bulky, and more environmentally friendly features that help deliver improved performance and protection for infant skin.

Early mass-produced diapers were largely modest cloth products. In the 1950s, however, researchers began investigating product designs that would improve the effectiveness of disposable diapers in maintaining dryness. Since then, continuous innovations in technology and materials have resulted in new generations of disposable diapers that provide extended dryness and reduced leakage (Figure 1). Furthermore, driven by studies on the skin's response to inherent influences, such as hydration and irritation, the qualities of disposable diapers today present significant enhancements for skin health compared with earlier disposable versions and even cloth diapers. These enhancements in disposable diapers have led to a reduction in both the incidence and severity of diaper dermatitis.[1]

Advanced diaper designs have also produced improvements in environmental impact, with leading manufacturers introducing thinner diapers, less packaging, and greater efficiency during all stages of product development and distribution.[3]

> On average, babies in North America may wear an estimated 4000 diapers before they are toilet trained.[2]

Along with the advances in design and function, the popularity of these diapers has risen dramatically. Today, more than 90% of US parents choose disposable diapers for their babies, and the usage rates are at least as high in many developed countries around the world, such as Germany, the United Kingdom, and Japan.[4]

For families and pediatricians around the world who rely on these diapers every day, the quality, safety, and performance of a diaper are paramount. With this in

[1]Procter & Gamble, Cincinnati, OH, USA
[2]Center for Baby and Adult Hygiene Products, Washington, DC, USA
[3]Kimberly-Clark Corporation, Neenah, WI, USA

Corresponding Author:
Jennifer L. Counts, 6280 Center Hill Ave, Cincinnati, OH 45224, USA.
Email: counts.jl@pg.com

Figure 1. Modern diaper design. Represents size newborn and size one sold in hospital channel.

Figure 2. Detailed view of microporous, breathable covers.

mind, research on design enhancements focuses on several important skin health considerations: reducing overhydration of the skin by urine, protecting against wetness, and reducing the risk of rash.

Design Feature: Enhance Breathability to Reduce Overhydration

Many advanced diapers have integrated microporous materials on the outside of the diaper that are flexible and breathable. Small calcium carbonate inclusions in the polyethylene film on the outside of the diaper create holes that are small enough to allow movement of water vapor and air, while retaining the liquid urine within the diaper. Diapers with these microporous covers have been shown to reduce both relative humidity and skin hydration by facilitating moisture vapor transmission under the occlusive diaper conditions (see Figure 2).[5]

Protect the Skin: Lotions Help Protect Against Wetness and Irritation

A *Pediatric Dermatology* article based on a series of double-blind clinical trials concluded that infants wearing breathable disposable diapers experienced significantly fewer episodes of diaper dermatitis, including infection with *Candida albicans*, compared with infants wearing standard nonbreathable disposable diapers.[6]

In recent years, some diaper designs have incorporated the application of small amounts of lotion or ointment to help maintain skin health in the diapered area. In these diapers, a thin layer of mild lotion transfers from the topsheet to the baby's skin to help avoid overhydration, without compromising the absorbency of the diaper.

The lotions contain ingredients that have been extensively evaluated for their safety on even the most sensitive skin. These lotion ingredients, including petrolatum, are commonly recommended by dermatologists to condition and help protect skin.

A series of clinical studies have evaluated the outcomes associated with use of lotion-treated diapers

Figure 3. Skin erythema reduced among infants using petrolatum-treated diapers.
Each data point represents the mean ± SEM of 30 to 32 infants. Statistical comparisons were done by repeated-measures ANOVA.

versus conventional diapers (see Figure 3). Data indicate the application of lotion:

- Facilitates restoration of skin barrier function as compared to an untreated control, and reduces the severity of irritation;
- Improves the transepidermal water loss rate, demonstrating reduced skin hydration; and
- Reduces the severity of diaper rash, even among participants considered to be "rash prone" (based on parental assessment).[7,8]

Maintain Dryness: Absorbent Layers Help Maintain Skin pH, Reduce Severity of Rash

Maintaining optimal skin pH is particularly important to protect diapered skin from the irritating effects of fecal enzymes. Clinical study results have indicated that the use of disposable diapers containing super absorbent polymers (SAP) is associated with reduced skin hydration and improved maintenance of pH compared with conventional or cloth diapers (see Table 1). Helping maintain pH in the diaper area helps reduce skin irritation, which in turn contributes to a reduced risk of diaper rash.[9]

Research has shown a correlation between use of super absorbent polymers (SAP) in disposable diapers and reduction of the frequency and severity of rash.[1] A retrospective analysis was conducted, evaluating the results of numerous clinical studies and comparing outcomes prior to and after the introduction of SAP in diapers.

In that comparison, the frequency of moderate to severe diaper dermatitis declined by 50% after the introduction of SAP into disposable diapers, while the number of normal diaper skin exams nearly doubled in the same time period (see Figure 4).[1,9]

Table 1. Disposable Diapers With Super Absorbers Provide Better Diapered Skin pH Control.

	n	Skin pH (Diapered − Undiapered Skin)[a]
Superabsorbent disposable diaper	93	0.59*
Conventional disposable diaper	94	0.9
Home laundered cloth diaper	106	1.16

[a]Skin pH was measured on both the diapered and undiapered skin (representing normal skin pH) after 4 weeks of using the test products. The difference in pH measurements shows that using disposable diapers with super absorbers results in a skin pH closer to normal skin than using conventional disposable diapers or home laundered cloth diapers.
*$P < .05$ versus conventional disposable and cloth diapers.
Source. Adopted from Campbell et al.[9]

Figure 4. Diaper rash grading.
Patterns in severity of diaper dermatitis before and after the introduction of superabsorbent disposable diapers. The data were compiled from: (A) Gray bars: 6 clinical studies conducted between 1984 and 1988, involving 1850 children of various ages (pre-SAP period); (B) Black bars: 6 clinical studies conducted between 1988 and 1995, involving 1975 children (post-SAP period).

Lorraine Stern, MD, clinical professor of pediatrics, UCLA.

Since I started seeing pediatric patients more than 45 years ago, I've noticed a significant improvement in the quality and performance of disposable diapers, and my real-world experience with these diapers clearly validates the evidence from clinical data. The improved features on today's diapers have solved the issues that are most pressing for parents and physicians. The body of evidence in advanced designs and performance should help reassure pediatricians and parents about the safe and effective use of disposable diapers.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Jennifer L. Counts and Dianna Kenneally are employees of Procter & Gamble. David Otts is an employee of Kimberly-Clark Corporation.

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