



RESEARCH WHITE PAPER

Closing the Action Gap in Sun Protection

A deeper evidence review of sunscreen behavior, women's skin concerns, reapplication, contextual prompting, wearable awareness, and the opportunity for actionable personal care.

57%

regretted not protecting themselves better
from the sun

20% to 60%

of regular SPF users did not reapply,
depending on category

52.1%

reported forgetting to bring or apply
sunscreen

THE CENTRAL QUESTION

If people already understand that sun protection matters, what prevents consistent action at the moment protection is needed? WearSpray explores whether contextual intelligence combined with immediate wrist based access can reduce that final layer of friction.

Prepared for research, innovation, skincare, beauty technology, wearable technology, and strategic partnership discussions.
August 2026



SECTION 01

Executive Summary

The evidence points to a behavior and access problem, not simply a formulation problem.

Modern sunscreen science has made major advances in broad spectrum protection, sensory properties, pigmentation control, and daily skincare integration. Yet real world effectiveness depends on human behavior. Consumers must choose the product, carry it, apply enough, remember when another application may be needed, and have the product available at that moment.

Across the evidence reviewed in this paper, five themes recur:

- Knowledge does not reliably translate into consistent protection. A 17 country study found high awareness of sun related skin risks, yet only a minority systematically used multiple protective behaviors.
- Reapplication is inconsistent even among people who identify themselves as regular SPF users. A United States industry affiliated study found that roughly 20% to 60% did not reapply, depending on product category.
- Practical friction is measurable. Forgetfulness, sensory dislike, cost, inconvenience, and difficulty selecting the right product appear as reported barriers.
- Women are highly engaged with skincare and sunscreen, but engagement does not eliminate friction. Women report substantial regret about past sun protection, skin concerns related to pigmentation and hormonal change, and practical challenges where sunscreen must coexist with daily beauty routines.
- Prompts and wearable awareness can influence behavior in some studies, but the overall intervention literature remains mixed. This argues for better context, better personalization, and rigorous validation rather than claims that reminders alone solve adherence.

WEARSPRAY RESEARCH HYPOTHESIS

WearSpray does not claim that the existing literature proves its system will improve sunscreen adherence. The literature establishes the problem. WearSpray proposes a testable intervention: connect relevant context and prompting with immediate physical access to the personal care product, reducing the distance between awareness and action.

The proposed architecture is simple:

SENSE → UNDERSTAND → PROMPT → ACT



SECTION 02

Why Sun Protection Behavior Matters

Effective photoprotection depends on use, dose, coverage, and repetition.

The National Academies reviewed sunscreen use as a preventive health behavior in 2022. The report emphasized that sunscreen is one element of a broader photoprotection strategy that includes shade, protective clothing, hats, sunglasses, and reducing exposure during peak ultraviolet conditions. It also summarized a persistent real world issue: consumers rarely use sunscreen at the thickness or frequency recommended for tested protection levels.

**0.39 to 1.0
mg/cm²**

estimated real world application range
summarized by the National Academies

2 mg/cm²

standard application density used to
establish labeled SPF

33.7%

routine sunscreen use reported in cited
United States population data

SOURCE National Academies of Sciences, Engineering, and Medicine. Review of Fate, Exposure, and Effects of Sunscreens in Aquatic Environments and Implications for Sunscreen Usage and Human Health. National Academies Press, 2022. Chapter 7.

The same National Academies review highlighted a large prospective cohort of 143,844 women ages 40 to 75 in Norway. In that cohort, use of sunscreen above SPF 15 was associated with an approximately 30% reduction in melanoma risk. The review appropriately notes limitations in comparing observational use patterns with randomized evidence, but the cohort is important because it demonstrates that sunscreen behavior in women is not merely a cosmetic issue. It is connected to long term health outcomes.

WHY THIS MATTERS TO WEARSPRAY

A delivery innovation cannot replace correct sunscreen formulation or medical guidance. Its role would be behavioral: making an appropriate product easier to keep present and easier to access when the user has already chosen to use it.



SECTION 03

The Reapplication Gap

A major industry affiliated study documents inconsistent reapplication among regular SPF users.

In 2023, Food and Chemical Toxicology published a nationwide online survey of 2,283 self identified regular SPF consumers in the United States. This paper is particularly relevant because its authors represented the Personal Care Products Council, Beiersdorf, Revlon, L'Oréal USA, Procter & Gamble, and an independent scientific consultancy.

2,283

regular SPF consumers in the United States

20% to 60%

did not reapply, depending on SPF product category

<33%

reapplication on cloudy and partly cloudy days

The study found that sunscreen use was highly contextual. Usage changed according to product category, season, weather, gender, age, and geography. Reapplication was commonly triggered by water exposure, hours spent in the sun, and being active or sweating. Those triggers are important because they are events that can potentially be represented by time, location, weather information, user input, or wearable sensing.

The paper also revealed a troubling decision rule among parents: 45% reported redness as a signal for reapplying sunscreen to children. Redness is a late signal because skin exposure has already occurred. This finding reinforces the value of earlier contextual cues rather than waiting for visible consequences.

SOURCE Norman KG, Loretz L, Kowcz A, Kaufman LE, Ruvolo E, Traudt M, Santos I, RoseMansfield R, Nash JF. Application habits and practices of regular sunscreen users in the United States: Results of an online survey. Food and Chemical Toxicology. 2023;181:114093. DOI 10.1016/j.fct.2023.114093.

WHAT THIS PUBLICATION DOES NOT PROVE

The survey records claimed behavior. It does not demonstrate that a wearable dispenser improves reapplication. Its value is different: it shows that inconsistent reapplication is present even inside a population that already considers itself a regular SPF using population.



SECTION 04

The Knowledge to Action Gap

People can understand the risk and still behave inconsistently.

A 2023 paper in the Journal of the European Academy of Dermatology and Venereology analyzed an Ipsos panel of 17,001 adults across 17 countries. Researchers included leading dermatologists and investigators affiliated with La Roche Posay International. The study was designed to assess awareness, attitudes, and behavior across different geographies and skin phototypes.

88%

knew sunlight can cause skin health problems

83%

reported having experienced sunburn

57%

regretted not having protected themselves better in the past

The contradiction is central. Awareness was high, but consistent behavior was much weaker. Only 12% reported systematically or often using all types of sun protection during exposure. Only 23% said they protected themselves all year round regardless of season. The study described this tension as a compromise between competing beliefs, habits, pleasures, and risk perceptions.

The paper also found that people perceived risks extending beyond cancer. Across the surveyed population, respondents identified photoaging, hyperpigmentation, new moles, and skin cancer as potential future consequences. This expands the relevance of photoprotection from disease prevention into daily skin health and appearance concerns.

SOURCE Passeron T, Lim HW, Goh CL, Kang HY, Ly F, Morita A, Ocampo Candiani J, Puig S, Schalka S, Liu W, Demessant Flavigny AL, Le Floc'h C, Kerob D, Dreno B, Krutmann J. Sun exposure behaviours as a compromise to paradoxical injunctions: Insight from a worldwide survey. Journal of the European Academy of Dermatology and Venereology. 2023;37:2481 to 2489. DOI 10.1111/jdv.19421.

THE REGRET SIGNAL

Regret is strategically important because it appears after the missed behavior. The innovation opportunity exists earlier, while the user can still take protective action.



SECTION 05

Women, Regret, Pigmentation, and Changing Skin Needs

Women's skincare needs are dynamic, visible, emotional, and often context dependent.

The same worldwide sun behavior research shows an important gender pattern: subsequent reporting from the study found women expressed regret about inadequate past sun protection more frequently than men. This matters because women may be highly aware of skincare and still experience a gap between intention and consistent protection.

65%

women reported regret in published reporting of the 17 country study

50%

reported pigmentary disorders in a separate La Roche Posay global study

3 in 4

women in a Vichy survey said skin problems appear or worsen around menstrual periods

L'Oréal presented two additional global datasets at the World Congress of Dermatology in 2023. La Roche Posay surveyed 48,000 people across 34 countries and reported that 50% self identified as having pigmentary disorders such as melasma, post inflammatory hyperpigmentation, or vitiligo. Among those reporting a pigmentary disorder, 28% described a strong impact on quality of life and 44% reported hiding visible affected skin.

Vichy separately surveyed 20,000 women across 20 countries. Seventy two percent said hormonal variations negatively affected their wellbeing, while roughly three out of four said skin problems were present or worsened during menstrual periods. These findings are not sunscreen adherence studies, but they demonstrate a broader truth relevant to intelligent personal care: skin needs and concerns are not static.

SOURCE L'Oréal Groupe research presented at the World Congress of Dermatology, 2023. La Roche Posay pigmentation survey: 48,000 people, 34 countries. Vichy hormonal variation survey: 20,000 women, 20 countries.

IMPLICATION FOR PERSONAL CARE INTELLIGENCE

A future intelligence layer should not assume that every user has one fixed need. Product preference, skin concern, environment, activity, life stage, and daily routine can all affect what intervention is appropriate.



SECTION 06

Friction Is Measurable

Forgetting, inconvenience, sensory dislike, and selection difficulty all interfere with use.

In 2026, AJPM Focus published a United States online panel study of 739 White adults examining barriers to sunscreen use by gender, generation, and skin phototype. The authors were affiliated with Brigham Young University and Utah Valley University. The paper provides a contemporary behavioral view of why sunscreen use breaks down.

52.1%

forgot to bring or apply sunscreen

24.2%

disliked the feel or smell

20.3%

cited inconvenience

Other barriers included cost at 21.7%, preference for tanning at 14.1%, and difficulty selecting an appropriate sunscreen at 12.6%. Younger cohorts had greater odds of reporting at least one barrier than baby boomers, and patterns differed across gender and skin phototype.

The authors explicitly recommended strategies that integrate sunscreen into daily routines and use cues to action to support bringing, applying, and reapplying sunscreen. That phrase, cues to action, is especially relevant to an intelligent wearable concept because it connects behavioral science to timely prompting.

SOURCE Hall SM, Steadman M, Major S, Oldham MF, Mitchell H. Sunscreen Use Barriers in White U.S. Adults: Gender, Generation, and Skin Phototype Differences. AJPM Focus. 2026;5(4):100495. DOI 10.1016/j.focus.2026.100495.

LIMITATION

This study intentionally focused on White United States adults. Its percentages should not be generalized to all populations. Its strongest contribution is identifying categories of friction and demonstrating that barriers differ across demographic groups.



SECTION 07

Application Quality Is Another Behavioral Problem

Having sunscreen is not the same as applying enough or covering skin evenly.

A 2018 PLOS One study used black light photography and weighed sunscreen containers to examine coverage and quantity after one application and after two consecutive applications. The results demonstrate how far real world self application can fall below the conditions under which SPF is tested.

0.60 mg/cm²

median amount after one application
across accessible skin

1.10 mg/cm²

median amount after two applications

2 mg/cm²

amount associated with labeled SPF
testing

After a single application, none of the participants reached 2 mg/cm². Even after a second application, only 19% did so. Double application reduced missed areas and increased quantity, but difficult anatomical areas remained poorly covered. The study therefore distinguishes two behavioral failures: insufficient quantity and incomplete coverage.

Women in the study protected their ears less than men, which the authors suggested could relate to hair covering the ears. This is a useful reminder that personal habits and physical context can influence coverage in ways that a simple instruction may not anticipate.

SOURCE Heerfordt IM, Philipsen PA, Larsen B, Wulf HC. Sunscreen use optimized by two consecutive applications. PLOS One. 2018;13(3):e0193916. DOI 10.1371/journal.pone.0193916.

WEARSPRAY RELEVANCE

WearSpray cannot by itself guarantee adequate dose or complete coverage. Those outcomes would require product specific instructions, reservoir metering studies, usability testing, and potentially app guidance. This is an important boundary for responsible claims.



SECTION 08

Prompting Can Help, but the Evidence Is Mixed

One randomized trial showed a large adherence effect. A later systematic review cautioned against overgeneralizing.

In a randomized controlled trial published in Archives of Dermatology, 70 adults were assigned either to receive daily text reminders for six weeks or to receive no reminders. The message combined daily local weather information with a prompt to apply sunscreen. Adherence was measured with an electronic monitoring device.

56.1%

mean daily adherence with reminders

30.0%

mean daily adherence without reminders

89%

of reminder recipients would recommend the system

SOURCE Armstrong AW, Watson AJ, Makredes M, Frangos JE, Kimball AB, Kvedar JC. Text message reminders to improve sunscreen use: a randomized, controlled trial using electronic monitoring. Archives of Dermatology. 2009;145(11):1230 to 1236. DOI 10.1001/archdermatol.2009.269.

The result is encouraging, but it should not be treated as settled science. In 2020, PLOS One published a systematic review of five randomized controlled trials of SMS based sun protection interventions. The studies used different populations, interventions, and outcome measures. Results for sunscreen use and broader sun protection behavior were contradictory, and the authors judged the certainty of evidence to be very low.

SOURCE Chambergo Michilot D, Tellez WA, Becerra Chauca N, Zafra Tanaka JH, Taype Rondan A. Text message reminders for improving sun protection habits: A systematic review. PLOS One. 2020;15(5):e0233220. DOI 10.1371/journal.pone.0233220.

DESIGN LESSON

The evidence argues against simply sending more notifications. The better research question is whether prompts become more useful when they are timely, context aware, personalized, low burden, and connected immediately to the ability to act.



SECTION 09

Wearable UV Awareness Has Already Changed Behavior

L'Oréal demonstrated a direct link between wearable sensing and reported sun safety behavior.

In 2016, La Roche Posay introduced My UV Patch, a stretchable skin sensor for monitoring ultraviolet exposure. In 2018, L'Oréal introduced UV Sense, a battery free wearable electronic ultraviolet sensor designed for longer wear and connection to a mobile application.

1M+

My UV Patches distributed across 37 countries according to L'Oréal

34%

applied sunscreen more often in reported consumer studies

37%

tried to stay in the shade more frequently

The UV Sense app translated sensor data into consumer friendly information about exposure and encouraged sun safety habits such as shade seeking and reapplying sunscreen. L'Oréal described the design goal as combining real time data, human centered design, personalization, and a discreet form that fits daily life.

SOURCE L'Oréal. L'Oréal advances its commitment to promoting sun safety with La Roche Posay UV Sense, the first battery free wearable electronic UV sensor. CES press release, January 2018.

THE STRATEGIC PRECEDENT

This is one of the clearest precedents for WearSpray. The beauty industry has already demonstrated Sense → Understand → Prompt. WearSpray explores whether the architecture can be extended to Act by keeping the chosen topical product physically available on the body.



SECTION 10

Major Beauty Companies Are Already Moving Toward Context and Routine

Industry research increasingly treats skin as dynamic and sun protection as something that must fit everyday life.

L'Oréal and Verily launched the My Skin & Hair Journey registry in 2023, designed to enroll thousands of self-identifying United States women ages 18 to 70. The study is intended to examine biological, clinical, environmental, lifestyle, wellness, and personal beauty routine factors over time. L'Oréal has explicitly framed the work as a foundation for precision beauty at the individual level.

SOURCE L'Oréal and Verily. World's largest and most diverse skin and hair health study launched by L'Oréal and Verily. July 2023.

Beiersdorf's 2025 annual report provides a complementary industry signal. The company described daily sun care innovation as an effort to create ultraviolet protection that consumers can easily integrate into skincare routines while meeting high standards for sensory properties and skin care. Its NIVEA Sun daily ultraviolet serum was positioned around both protection and compatibility with makeup and everyday routine.

SOURCE Beiersdorf Annual Report 2025. Research and Development section, NIVEA SUN innovation and daily routine integration.

In 2026, Beiersdorf also emphasized that consistent photoprotection is foundational in hyperpigmentation management and noted that effective protection depends not only on whether sunscreen is used, but on how much is applied and how consistently it is reapplied. Beiersdorf's photobiology researchers also highlighted visible light as an additional contributor to persistent pigmentation in susceptible skin.

SOURCE Beiersdorf. No Day Without Sun Protection. May 2026, including discussion with Dr. Ludger Kolbe and cited photobiology research.

INDUSTRY SIGNAL

The direction of travel is clear: better formulas, better sensory experience, daily routine integration, precision beauty, environmental context, and personalization. WearSpray is positioned not as an alternative to those advances, but as a delivery and action layer that can connect them to the user in motion.



SECTION 11

The Unresolved Problem for Women Using Daily Beauty Routines

Reapplication must coexist with makeup, skincare layering, work, exercise, and real life.

For many women, sunscreen is one layer inside a larger routine that can include moisturizer, treatment serums, complexion products, makeup, and later touch ups. The scientific literature shows that layering sunscreen and facial makeup can increase total protection, but it also shows that typical application amounts may fall below labeled testing conditions. The practical challenge is therefore not simply whether an SPF product is present in the routine, but whether adequate protection can be maintained as the day changes.

This is particularly relevant for active women. Sweat, water exposure, towel drying, long outdoor periods, and physical activity are common reapplication triggers identified in industry research and clinical guidance. These are also the moments when retrieving a bottle, interrupting an activity, or disturbing makeup can become friction points.

A BETTER QUESTION

Instead of asking why a consumer failed to follow a generic rule, ask what made the desired action difficult at that exact moment. Was the product elsewhere? Was she moving? Was she wearing makeup? Did she lose track of time? Did environmental conditions change? Did the prompt arrive too late or at an irrelevant moment?

That framing shifts innovation from education alone toward behavior centered product design.



SECTION 12

WearSpray: From Awareness to Action

The proposed value is reducing the distance between recognizing a need and being able to respond.

WearSpray combines a refillable wrist worn topical delivery platform with a proposed intelligence layer that can incorporate environmental, activity, routine, and user supplied information. The purpose is not to diagnose skin conditions or replace professional guidance. The purpose is to create a shorter path from relevant context to user action.

SENSE	Capture or receive relevant signals such as ultraviolet conditions, location, time, heat, movement, or user input.
UNDERSTAND	Interpret those signals in the context of the user's routine, chosen product, previous application, preferences, and current activity.
PROMPT	Deliver a relevant cue when action may be useful, while minimizing unnecessary notification burden.
ACT	Make the chosen topical product physically available on the wrist so the user can dispense, apply, and continue the activity.

The key strategic distinction is access. Most behavioral interventions end with a recommendation. WearSpray is designed to put the product at the same place the recommendation is received: on the person.

CLAIM DISCIPLINE

The literature supports the existence of adherence and reapplication problems. It supports the plausibility that context and prompting can influence behavior. It does not yet establish that WearSpray improves adherence, reduces ultraviolet exposure, or improves health outcomes. Those are questions for controlled product research.



SECTION 13

A Research Program That Could Validate the Hypothesis

The next step is not a bigger marketing claim. It is a better experiment.

A partner pilot could compare conventional sunscreen access with WearSpray assisted access in realistic outdoor settings. A staged design could begin with usability and behavioral endpoints before advancing to clinical or photoprotection outcomes.

Primary behavioral endpoints

- Reapplication frequency compared with each participant's baseline behavior.
- Time from contextual prompt to acknowledged application.
- Percentage of prompts that result in application, dismissal, postponement, or no response.
- Frequency of missed applications attributed to product unavailability.
- Carry compliance: how often the participant actually has protection available during relevant outdoor periods.

Human factors endpoints

- Convenience and perceived interruption burden.
- Ease of refill, dispensing, palm delivery, and application during motion.
- Compatibility with exercise, beach activity, makeup, work routines, and travel.
- Notification burden and user tolerance for contextual prompting.

Advanced validation endpoints

- Metered dose consistency for the specific sunscreen formulation used in the study.
- Coverage behavior and whether users apply adequate amounts to intended skin areas.
- Optional objective ultraviolet exposure measures using validated sensors.
- Longitudinal habit formation and whether behavior persists after novelty declines.

PARTNER OPPORTUNITY

A beauty, dermatology, consumer health, or wearable technology partner could help answer the most important question: does combining contextual intelligence with immediate topical access produce a meaningful improvement over awareness or prompting alone?



SECTION 14

Conclusions

The research points toward a new design problem: turning protective knowledge into timely physical action.

The sunscreen category has already solved many difficult scientific problems. It has developed better filters, broader spectral protection, more elegant textures, daily skincare formats, pigmentation focused technologies, and increasingly personalized consumer experiences. The remaining challenge is that these advances still depend on behavior.

The publications reviewed here consistently show friction between knowledge and use. Consumers forget. They underapply. They fail to reapply. Their behavior changes with weather, activity, product format, gender, age, geography, and routine. Women may be highly engaged in skincare while simultaneously reporting regret about past sun protection and managing changing concerns around pigmentation, hormones, appearance, makeup, and daily life.

Digital prompting offers one possible intervention, but the evidence is mixed. Wearable ultraviolet sensing has shown that awareness can influence behavior. Major beauty companies are moving toward precision, context, daily routine integration, and human centered design.

The next evolution may be to connect awareness directly to access.

SENSE → UNDERSTAND → PROMPT → ACT

WearSpray is a testable proposition at that intersection: personal care intelligence that does not stop at telling the user what may be needed, but is designed to make the chosen topical product immediately reachable when action matters.



SECTION 15

References and Source Notes

Each source is identified so readers can distinguish peer reviewed evidence, institutional reviews, and company reported research.

1. Norman KG, Loretz L, Kowcz A, et al. Application habits and practices of regular sunscreen users in the United States: Results of an online survey. *Food and Chemical Toxicology*. 2023;181:114093. DOI 10.1016/j.fct.2023.114093. Author affiliations included Personal Care Products Council, Beiersdorf, Revlon, L'Oréal USA, and Procter & Gamble.
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3. L'Oréal Groupe and La Roche Posay. UVMune 400 consumer education page reporting 77% without year round protection and 57% regret, sourced to the 2021 La Roche Posay epidemiological study of approximately 17,000 people across 17 countries.
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10. L'Oréal and Verily. World's largest and most diverse skin and hair health study launched by L'Oréal and Verily. July 10, 2023. My Skin & Hair Journey longitudinal registry.
11. L'Oréal Groupe. Research presented at the 2023 World Congress of Dermatology. Includes La Roche Posay survey of 48,000 people in 34 countries on pigmentary disorders and Vichy survey of 20,000 women in 20 countries on hormonal variation and skin concerns.
12. Beiersdorf Annual Report 2025. Research and Development. Discussion of NIVEA SUN product innovation, sensory experience, daily skincare integration, and compatibility with makeup routines.
13. Beiersdorf. No Day Without Sun Protection. May 27, 2026. Research discussion on consistent photoprotection, hyperpigmentation, visible light, adequate amount, and reapplication.
14. American Academy of Dermatology. Sunscreen guidance and application recommendations. Broad spectrum SPF 30 or higher is recommended as part of a comprehensive photoprotection strategy.



SECTION 16

Research Integrity Note

This paper intentionally distinguishes evidence from hypothesis.

This white paper is an innovation and research overview. It is not medical advice. WearSpray does not claim that the platform has been clinically proven to improve sunscreen adherence, prevent sunburn, prevent skin cancer, treat pigmentation, diagnose skin conditions, or measure ultraviolet exposure without an appropriate validated sensor or external data source.

Percentages from company reported studies are attributed to the company source when a peer reviewed primary publication was not used. Peer reviewed publications are identified by journal and DOI where available. Survey findings represent the populations and methods studied and should not be generalized beyond their appropriate scope.

Any future WearSpray sunscreen study should specify the exact sunscreen formulation, labeled directions, dosing requirements, sensor inputs, prompt logic, user population, and outcome measures. Claims should be based on the resulting evidence, not inferred from adjacent literature.

THE RESEARCH STANDARD

The strongest WearSpray story is not that the literature proves the product. It is that the literature defines a persistent, well documented problem and gives us a disciplined way to test whether a new delivery architecture can help solve it.