Visual Analysis of Water Dispersion Patterns During Hand Drying: A Qualitative Comparison of High-Speed Air Dryers and Paper Towels

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Abstract

This study presents a unique qualitative visual analysis comparing water dispersion patterns between high-speed air dryers and paper towels during hand drying. The videos are the data. As of the date of publication of this study, Dyson LTD and Excel Dryer, manufacturers of the two most common brands of hand dryers, do not address where the water removed from hands after being struck by the forced air stream goes in their literature, promotional materials, and cited science, a remarkable absence for such a foundational element of the complete operational cycle of the devices. Further, Dyson makes the claim their dyers aerosolize water at a rate no greater than paper towels central to their defense of the hygienic properties of their product. Using high-speed videography in controlled lighting conditions, we documented the visible water droplet dispersion patterns from freshly washed hands during the drying process with both hand dryers and paper towels. The visual evidence demonstrates that forced air dryers disperse substantial large and small droplets of water from wet hands into the surrounding environment in all directions via high-shear forces that maximize droplet fragmentation and aerosolization. Paper towels use low shear, gentle pressure to absorb and contain water, minimizing water droplet formation both large and small and binding water into an easily disposable package. This study does not directly measure microscopic true aerosols (≤5 μm) but the difference in visible droplet dispersion between paper towels and hand dryer air is reflective of well-established principles in aerosol science. High-shear conditions generate more true aerosols than visible droplets. Low-shear conditions create fewer true aerosols than visible droplets. The visual evidence of extensive water redistribution by hand dryers onto users and surrounding surfaces demonstrates those dispersion and aerosolization dynamics at play. These findings expose a critical omission in the engineering and use principles of operation for hand dryers and directly challenge Dyson's claims regarding paper towel and hand dryer aerosol formation equivalence.

This paper is part of a four-study series examining hand hygiene practices in retail environments:

1. "Transmission of Bacteria and Fungus via Dyson and Xlerator Hand Dryers in Starbucks, Home Depot and Whole Foods Restrooms: A Comparative Analysis." Blouch, R. A. Jr. 2025 (Main study) DOI: 10.5281/zenodo.15504115 [5]
2. "Testing the Validity of Hand Dryer Drying Time Specifications: A Quantitative Study of Dyson and Xlerator Dryers in Retail Store Environments." Blouch, R. A. Jr. 2025 DOI: 10.5281/zenodo.15503698
3. "Bacterial and Fungal Contamination Assessment of Paper Towel Types: A Quantitative Analysis of White versus Brown Varieties in Retail Restrooms." Blouch, R. A. Jr. 2025 DOI: 10.5281/zenodo.15504144 [7]
4. "Visual Analysis of Water Dispersion Patterns During Hand Drying: A Qualitative Comparison of High-Speed Air Dryers and Paper Towels" Blouch, R. A. Jr. 2025 DOI: 10.5281/zenodo.15503304

All studies are available at www.handdryerstudy.com

1. Introduction

Hand drying is a critical component of hand hygiene, with substantial implications for public health. Previous research has established that wet hands transfer significantly more bacteria than dry hands. Patrick et al. [1] demonstrated that residual moisture determines the level of bacterial transfer following hand washing, making the efficacy of hand drying methods an important consideration. Comprehensive government, professional association, and manufacturers guidelines on hand hygiene practices emphasize the importance of thorough hand drying to reduce microbial transmission risk. Boyce and Pittet [2] provided extensive recommendations for hand hygiene practices in healthcare settings. The Centers for Disease Control and Prevention [31] further emphasizes environmental infection control measures that include consideration of hand drying method impacts on facility contamination. However, significant controversy exists regarding the relative hygiene of different hand drying methods, particularly concerning the potential for these methods to disperse water droplets and microbial aerosols into the surrounding environment. A systematic review of the evidence by Huang et al. [3] noted inconsistent findings across studies and highlighted the need for more research on the comparative hygiene of different drying methods.

Manufacturers of high-speed air dryers have made specific claims regarding the hygienic performance of their products. Dyson LTD [10] states that their Airblade hand dryers have been "proven to aerosolize no more than paper towels" and that they are "as hygienic in drying hands as paper towels". In their marketing materials focusing specifically on hygiene, Dyson further claims their HEPA filters "capture 99.97% of particles". Similarly, Excel Dryer, Inc. [11] makes claims about the hygienic benefits of their dryers, stating they "offer a 99.99% reduction in bacteria and viruses". These claims directly contradict several independent studies that have found substantially higher levels of microbial dispersion associated with high-speed air dryers compared to paper towels, particularly those made in our companion study (Blouch [6]) .

Additionally, manufacturers make specific claims about drying efficiency that warrant scrutiny. Dyson [10] advertises complete hand drying in 10-12 seconds, while Excel Dryer, Inc. [11] claims just 8 seconds. However, our companion study by Blouch [5] has demonstrated these claims to be significantly misleading, with hands retaining approximately 39.04% of initial moisture after the manufacturer-specified drying time. This discrepancy is critical to understanding aerosol generation and water dispersion, as users typically continue drying for 45-90 seconds to achieve satisfactory dryness - dramatically increasing the duration of aerosol exposure beyond what would be expected based on manufacturer specifications.

A study by Kimmitt and Redway [8] found that viruses applied to rubber gloves were aerosolized by jet air dryers and spread further than would occur with conventional hand dryers or paper towels. Similarly, Best et al. [8] found that air bacterial counts in close proximity to a jet air dryer were 27 times higher compared to when paper towels were used. Best et al. [7] also documented significant contamination of surrounding surfaces, finding bacterial transfer to areas up to 2 meters from the drying location, suggesting extensive dispersal of water and microbes beyond the immediate drying area. Manufacturers [10][11] have contested those findings, arguing that the studies "were not conducted under conditions or scenarios that simulate real life" and that researchers contaminated gloved hands without washing them first, creating unrealistic test conditions.

The contradictory nature of these claims highlights the need for additional evidence that bridges the gap between technical microbial studies and observable real-world outcomes.

As of the date of publication of this study Neither Dyson nor Excel Dryer specify or even mention what occurs to the water from wet hands after it is struck by the forced air jet from their wall mounted dryers anywhere on their websites or in their promotional materials. There are no manufacturer documentation or marketing materials containing any discussion of where the water removed from users' hands actually goes. Excel Dryer [11] makes a single comment on its website that water from certain models "drips onto the floor, where it evaporates naturally.”

Our observations reveal a more complex and concerning pattern of dispersion.

Recent work by Hervé et al. [27] documented contamination on surfaces up to 3 meters from hand dryers, indicating significant water dispersal throughout the environment, matching the evidence of the videos in this document.

This study aims to provide that bridge through a unique qualitative visual presentation of water dispersion patterns during hand drying with paper towels and forced air hand dryers, using high-speed videography under controlled lighting conditions to make visible what is typically invisible to the naked eye. Our approach addresses two key questions: (1) the aerosolization potential of different drying methods and (2) the destination of water removed from hands during the drying process.

In the context of aerosol science, it is important to distinguish between true aerosols and visible droplets. True aerosols are typically defined as particles ≤5 μm in diameter, which remain suspended in air for extended periods and are invisible to the human eye. Visible droplets, generally ≥40 μm in diameter, can be observed under proper lighting conditions and settle more quickly due to gravitational forces. Baron and Willeke [12] provided comprehensive explanations of these distinctions in their work on aerosol measurement. This distinction is crucial when evaluating hand drying methods, as true aerosols pose greater risks for pathogen transmission due to their longer suspension times and ability to reach the deep lung when inhaled.

A fundamental principle in aerosol science is that the mechanical processes generating droplets significantly influence their size distribution. High-shear processes, such as those created by high-speed air dryers operating at 400-640 km/h (192 m/s), produce dramatically different outcomes compared to gentle, low-shear processes like absorption with paper towels. Lefebvre [20] and Villermaux [16] described these differences in their respective works on atomization and fragmentation. This difference represents two extremes on the aerosol generation spectrum.

High-shear processes fragment water into polydisperse sprays where tiny aerosols (≤5 μm) typically outnumber visible droplets (≥40 μm) by factors of 100-10,000:1. Morawska et al. [16] and Johnson et al. [17] documented this phenomenon in their studies of respiratory aerosols. Conversely, gentle mechanical processes like those involved in paper towel drying predominantly produce large droplets with minimal fragmentation, resulting in proportionally fewer microscopic aerosols. Villermaux [16] and Lefebvre [20] established these principles in their respective works. This fundamental contrast in aerosol production mechanisms---not just the quantity of visible droplets---underlies the hygiene differences between these drying methods.

While our approach does not directly measure microscopic aerosols, it provides valuable insights into the dynamics of droplet dispersion during different hand drying methods and aerosol production by proxy. Principles of fluid dynamics establish that the mechanical forces visible in our study directly correlate with aerosol generation patterns. Xie et al. [14], Bourouiba [15], and Morawska et al. [15] have all demonstrated these correlations in their research. Therefore, visible dispersion serves as a reasonable baseline for evaluating relative potential for aerosol generation between these fundamentally different drying methods.

The primary research questions of this study are: (1) Does the observable pattern of water dispersion during hand drying differ substantially between high-speed air dryers and paper towels in a way that would challenge manufacturer claims of equivalent aerosolization? (2) Where does the water removed from hands during air drying actually go, and how does this compare with manufacturer documentation? (3) Do these observable patterns align with the theoretical expectations for high-shear versus low-shear processes according to established principles in aerosol science?

2. Methods

2.1 Study Design

This study employed a comparative observational design to document water dispersion patterns during hand drying using two methods: high-speed air dryers and paper towels. For each method, 10 complete drying trials were conducted and recorded. The study was designed to observe both the aerosolization characteristics and the destination of water removed from hands during the drying process.

2.2 Test Environment

2.2.1 Commercial Restroom Setting (Air Dryer Tests)

Testing of air dryers was conducted in public restrooms equipped with high-speed hand dryers in retail establishments including Starbucks, Whole Foods, and Home Depot locations. Lighting was enhanced using portable LED light panels positioned to optimize visibility of water droplets in the air. Background surfaces were selected to maximize contrast with water droplets. Camera angles were varied to capture both the general dispersion pattern and specific areas of water accumulation, including the user's clothing, surrounding walls, floors, and adjacent fixtures.

2.2.2 Controlled Studio Setting (Paper Towel Tests)

Paper towel drying tests were conducted in a photography studio with controlled lighting optimized for droplet visibility. The lighting setup was designed to match or exceed the droplet visualization capabilities of the commercial restroom setting, ensuring a fair comparison that would not disadvantage the air dryer tests. The same camera angles and positions used in the commercial setting were replicated to maintain consistency in observing both aerosol generation and water destination patterns.

2.3 Equipment

- High-speed camera in slow motion capture mode (1000 frames per second)
- LED lighting panels (4800 lumens)
- Tripod and camera mounting system
- Paper towels (standard commercial C-fold)
- Moisture measurement scale (accurate to 0.01g)
- Black backdrop where possible for contrast

2.4 Standardized Hand Washing and Drying Protocol

To ensure consistency across all trials:

1. Hands were washed using standard handwashing technique but without soap.
2. Hands were shaken twice over the sink to remove excess water
3. For air dryer trials, hands were inserted into the dryer and moved according to manufacturer recommendations until visibly dry (approximately 45-60 seconds)
4. For paper towel trials, hands were dried using two folded paper towels until visibly dry (approximately 15-20 seconds)
5. The user maintained a consistent standing position and posture across all trials to standardize the potential for water accumulation on clothing

2.5 Video Recording Protocol

All trials were recorded using the same high-speed camera settings:

- Slow motion, 1000 frames per second
- 1/250 second shutter speed

- f/5.6 aperture
- ISO 1600
- Fixed focal length of 50mm

Camera positioning was standardized to capture:

1. The hands during the drying process
2. The surrounding air space
3. The user's clothing, particularly the torso, arms, and legs
4. Adjacent wall surfaces and fixtures

2.8 Manufacturer Documentation Analysis

In addition to physical testing, we conducted a comprehensive review of manufacturer documentation, marketing materials, and technical specifications to identify any references to water destination or management during the drying process. This analysis included:

1. Product webpages for high-speed hand dryers
2. Technical specification documents
3. Installation guides
4. Marketing brochures and promotional materials
5. Statements regarding hygiene and performance claims

This documentation review provided context for comparing observed water dispersion patterns with manufacturer descriptions and claims about their products' performance and effects.

3. Results

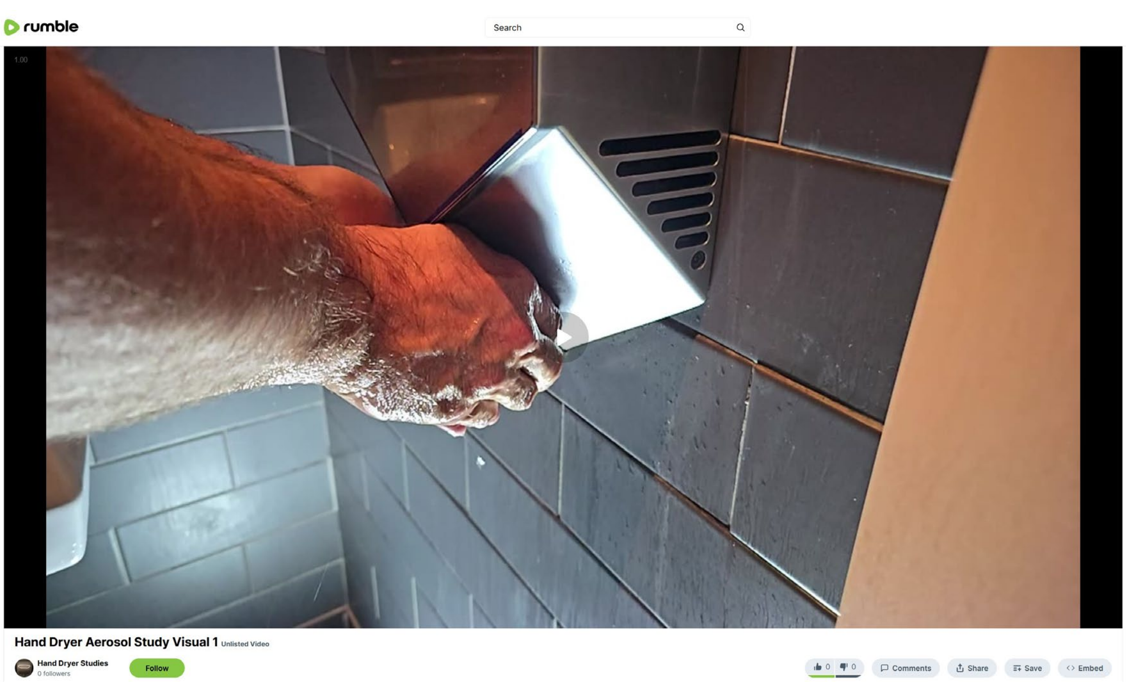
3.1 Visual Droplet Dispersion: High-Speed Air Dryers

Across all 10 trials with high-speed air dryers, substantial visible water dispersion was observed. The following patterns were consistently documented:

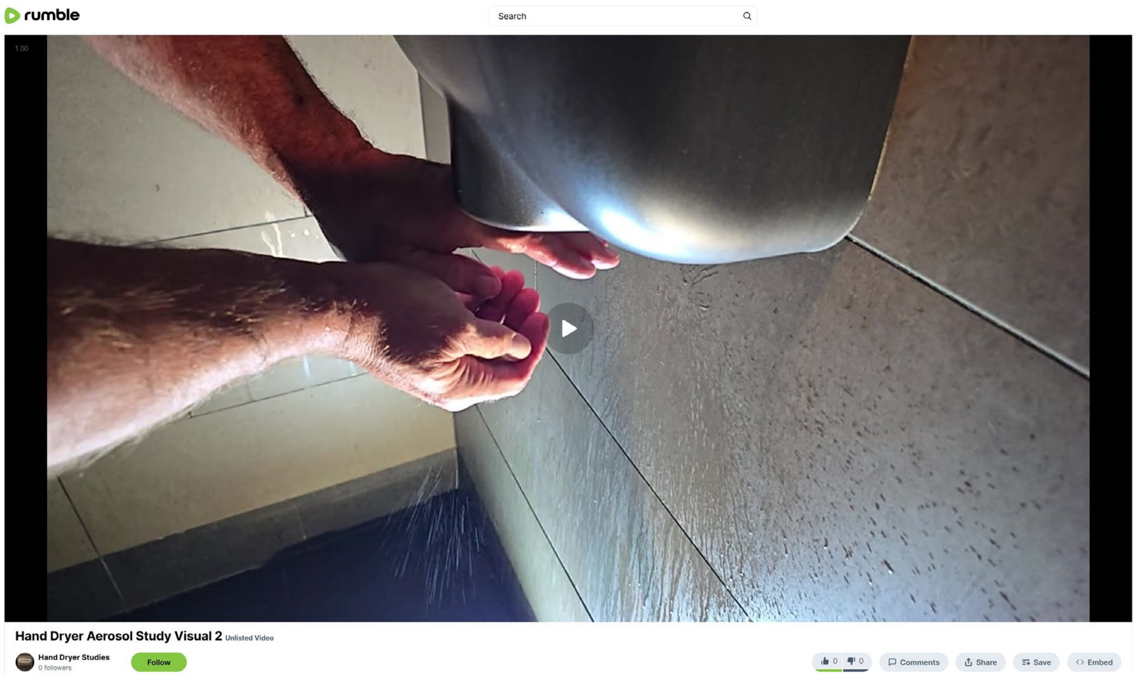
3.1.1 Air Dryer Dispersion Patterns

- Dense cloud of visible water droplets surrounding the hands during operation
- Significant lateral dispersion of droplets
- Visible droplets remaining airborne for 3 or more seconds
- Consistent pattern of droplets settling on surrounding walls and floor
- Multiple streams of water droplets visibly ejected from the hands toward the sides and fronts of units
- Concentrated mist formation
- Substantial backspray of water onto the user's clothing, particularly the forearms, torso, and thighs/legs
- Intense downward and outward spray patterns
- Significant accumulation of visible droplets on user's clothing and surrounding floor area

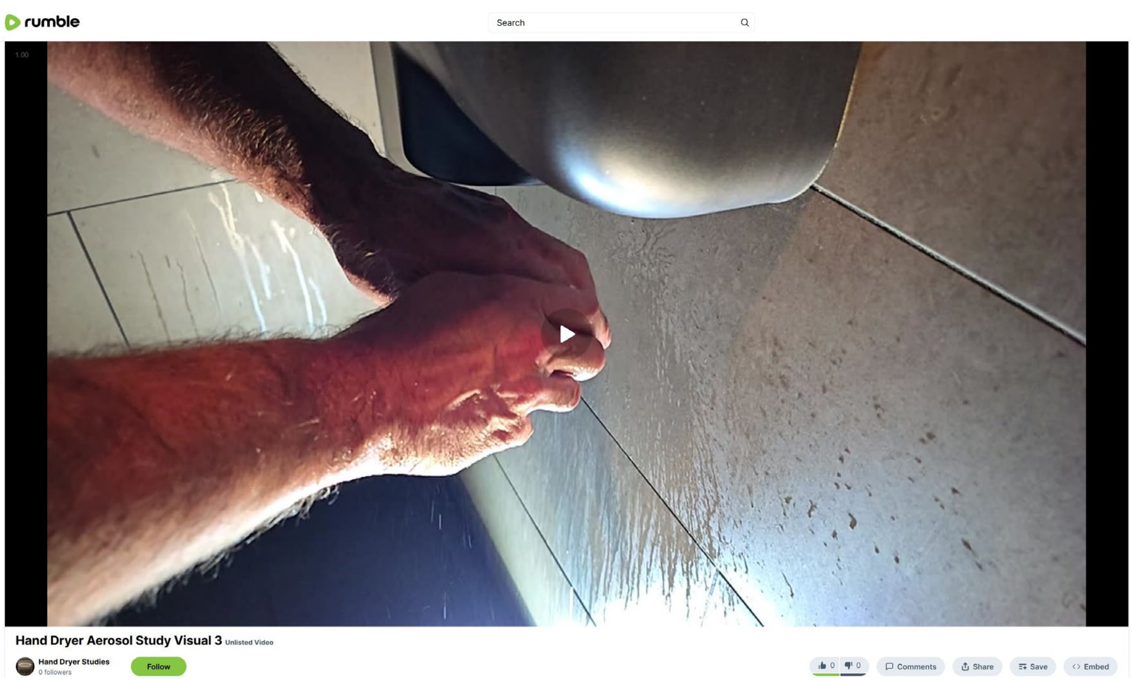
3.2 Hand Dryer Trials



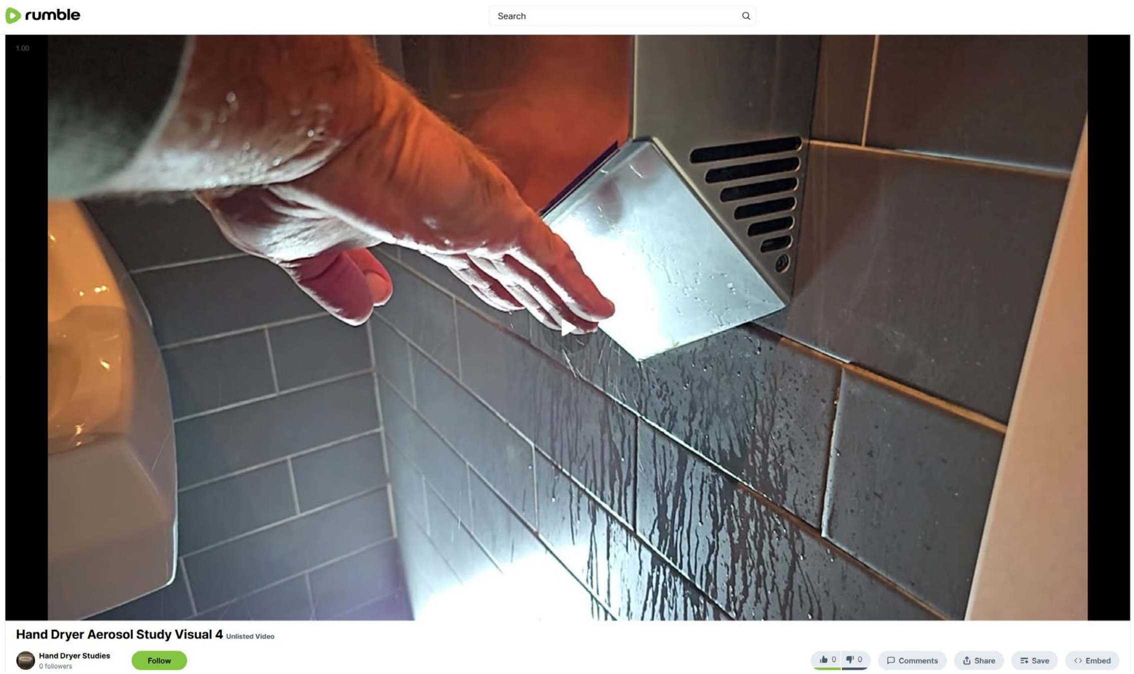
VIDEO 1: Hand Dryer Trial 1 on Rumble



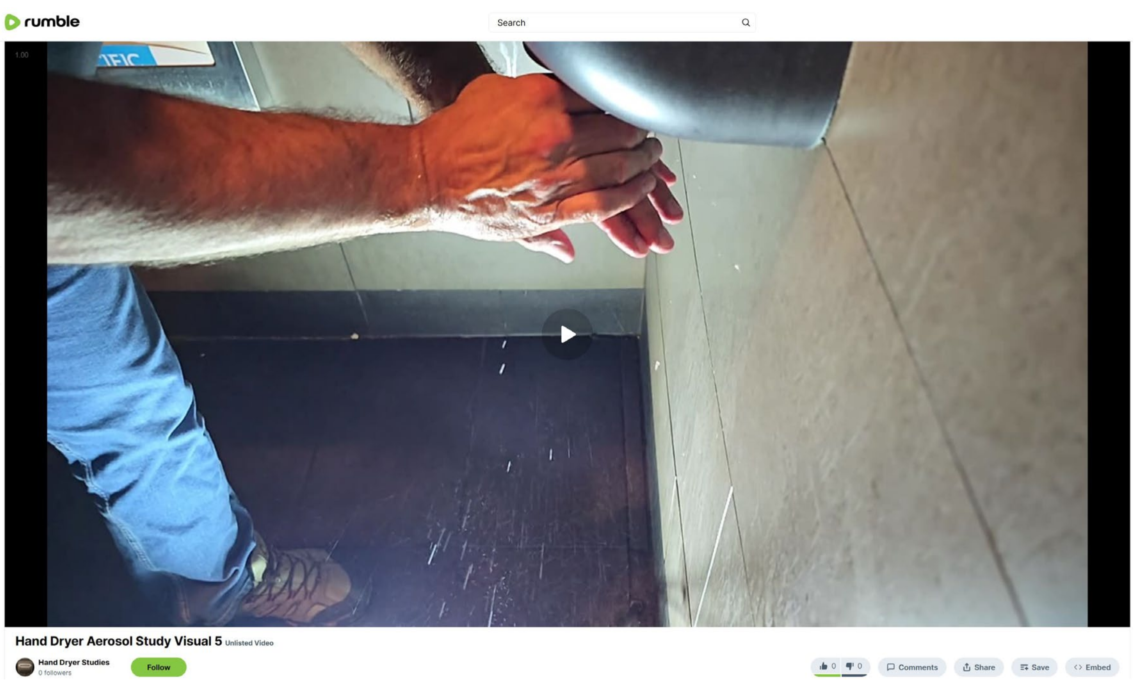
VIDEO 2: Hand Dryer Trial 2 on Rumble



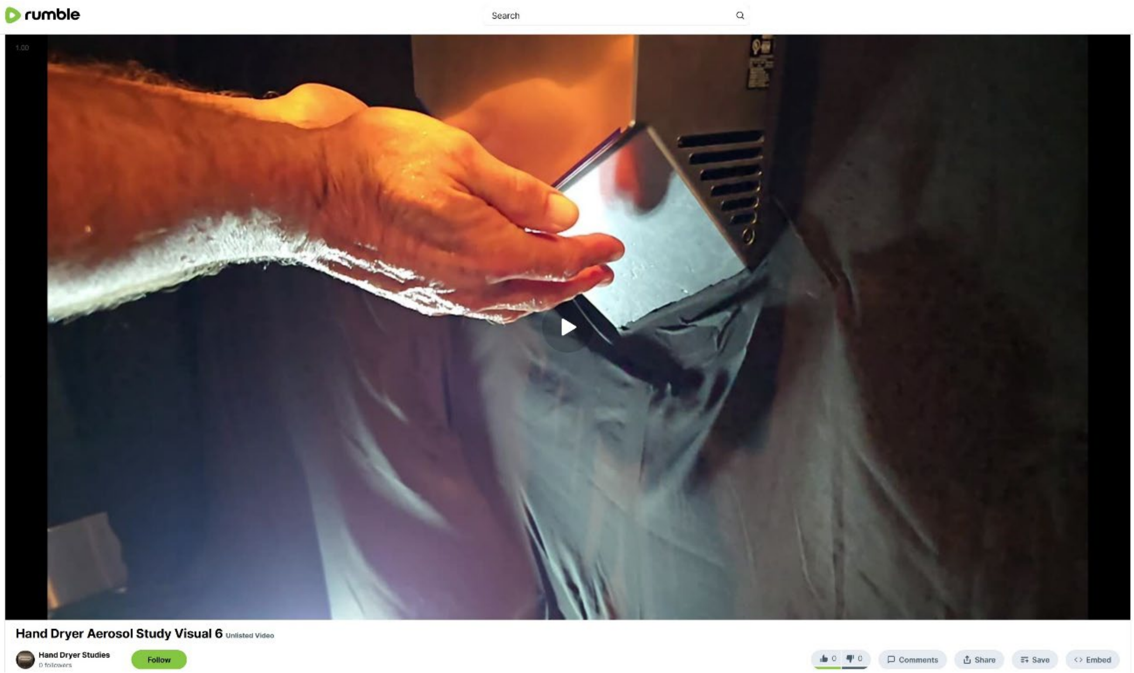
VIDEO 3: Hand Dryer Trial 3 on Rumble



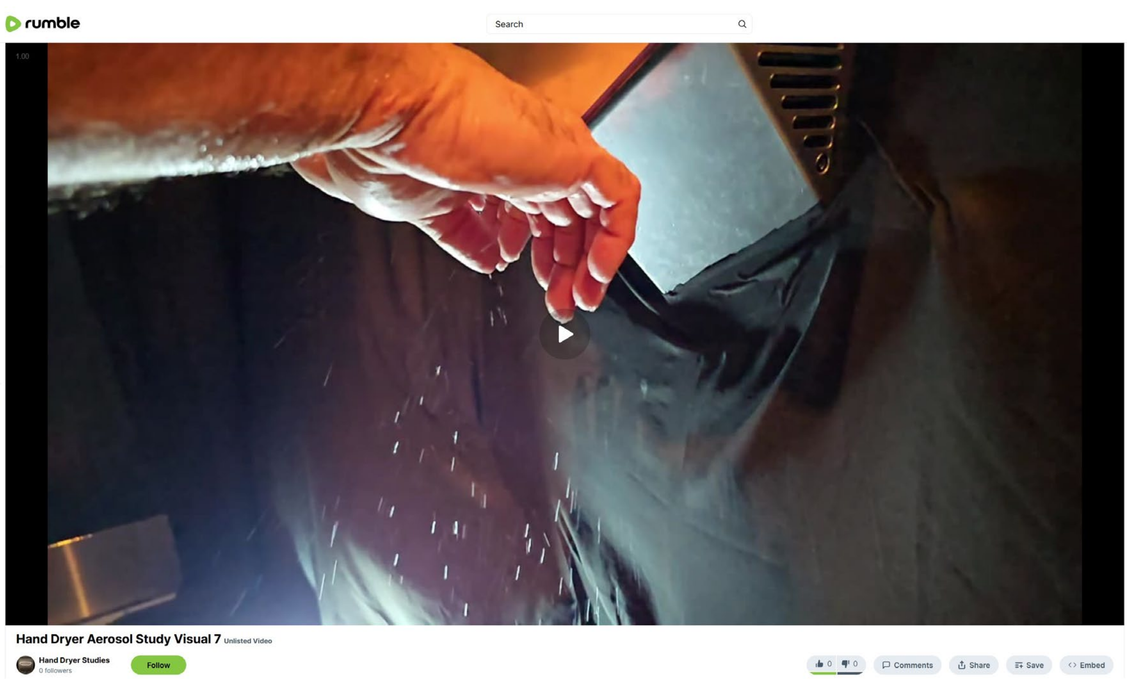
VIDEO 4: Hand Dryer Trial 4 on Rumble



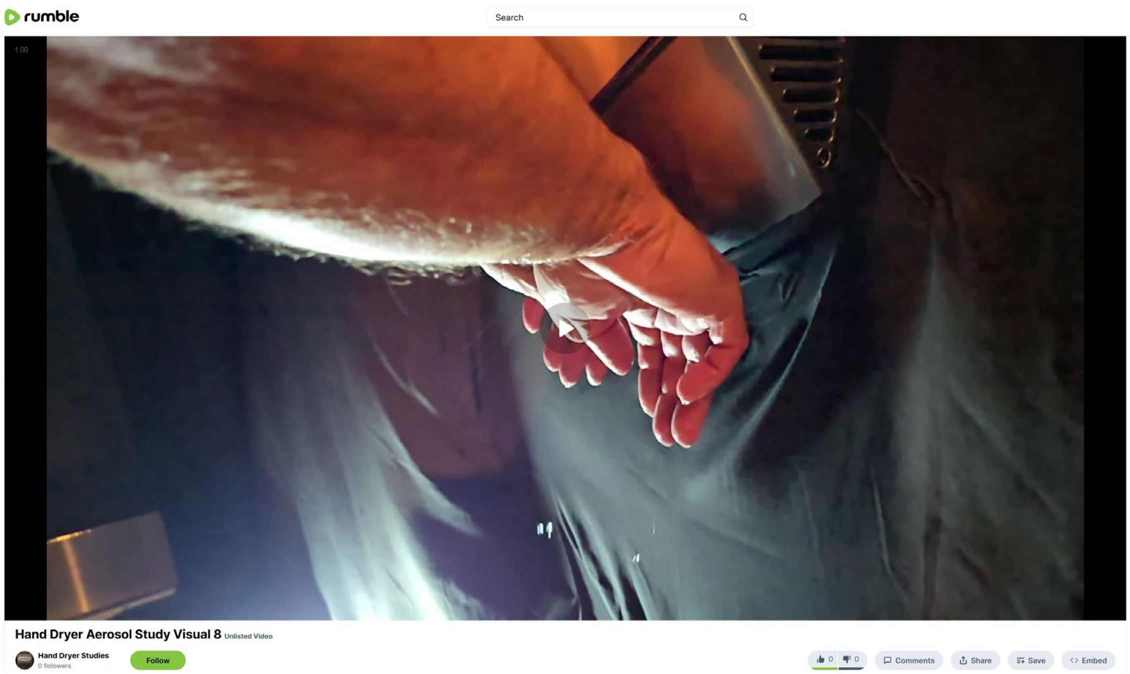
VIDEO 5: Hand Dryer Trial 5 on Rumble



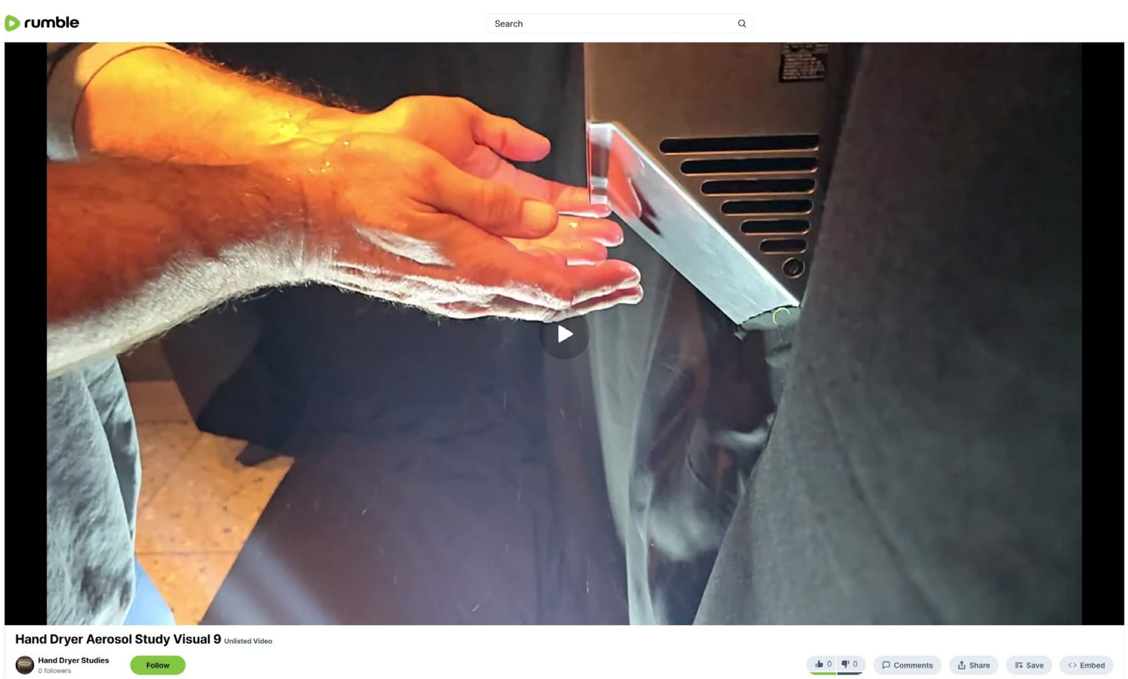
VIDEO 6: Hand Dryer Trial 6 on Rumble



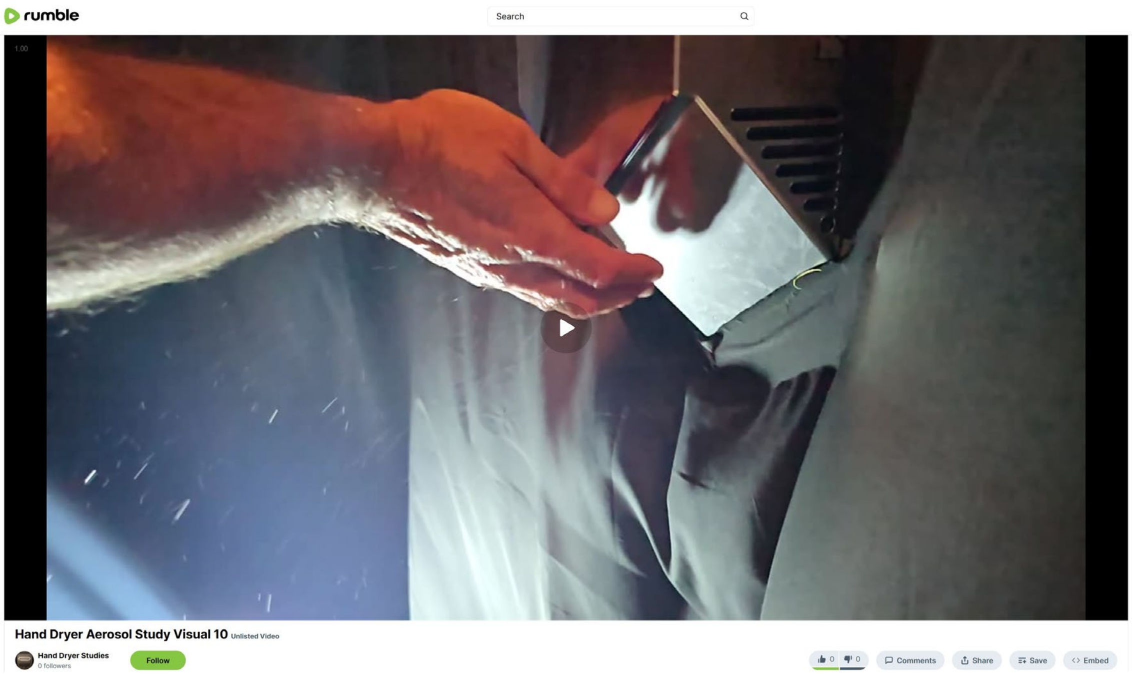
VIDEO 7: Hand Dryer Trial 7 on Rumble



VIDEO 8: Hand Dryer Trial 8 on Rumble



VIDEO 9: Hand Dryer Trial 9 on Rumble



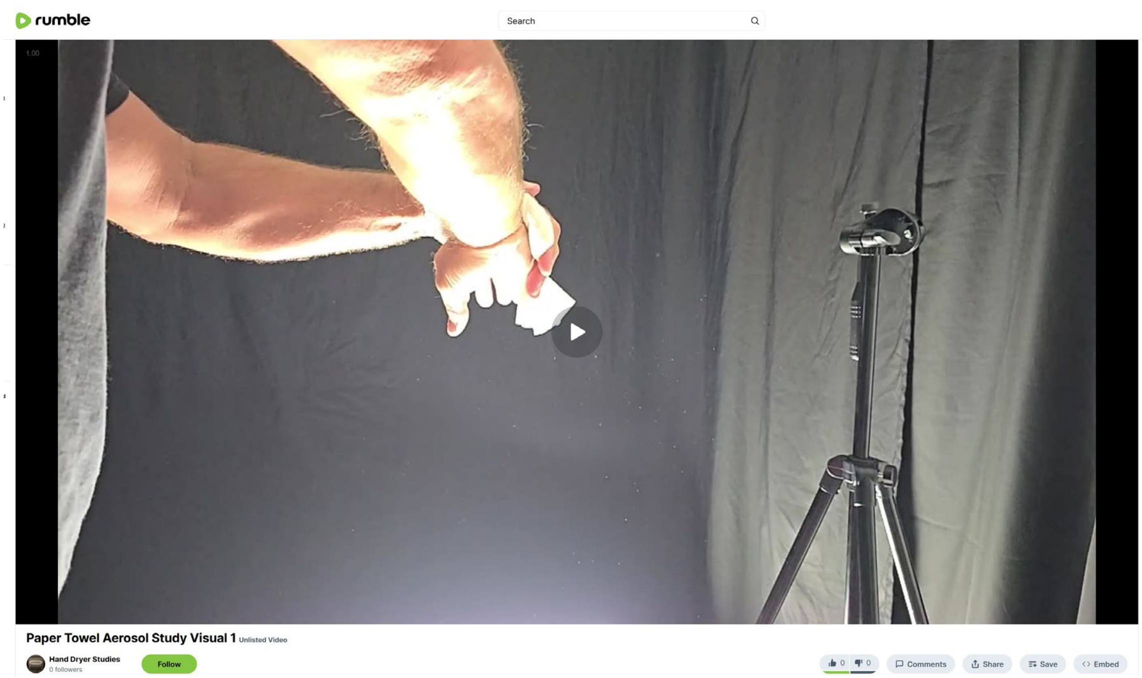
VIDEO 10: Hand Dryer Trial 10 on Rumble

3.3 Visual Droplet Dispersion: Paper Towels

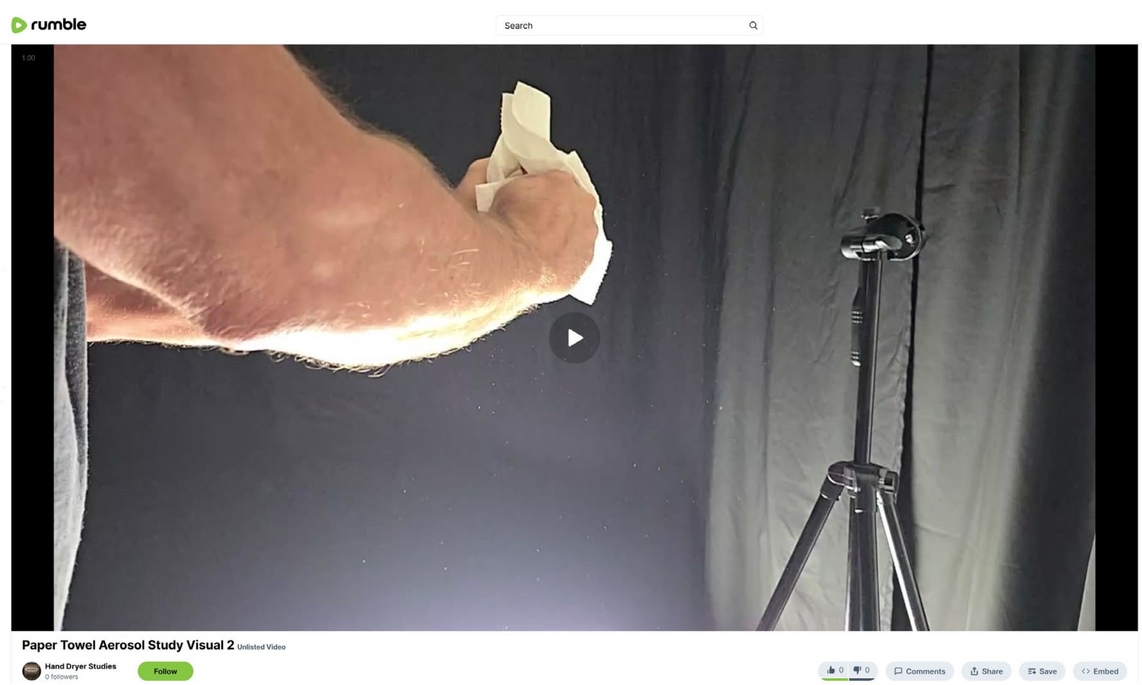
In contrast to the air dryer trials, the paper towel drying method demonstrated minimal visible droplet dispersion across all 10 trials. The following patterns were consistently observed:

- Few to no visible droplets in the air surrounding the hands
- Occasional large droplets falling directly downward
- No lateral dispersion of droplets beyond the immediate hand area
- No visible droplets remaining airborne after completion of drying
- Contained moisture absorption within the paper towel material
- No observable water accumulation on the user's clothing
- Little water dispersion to surrounding surfaces

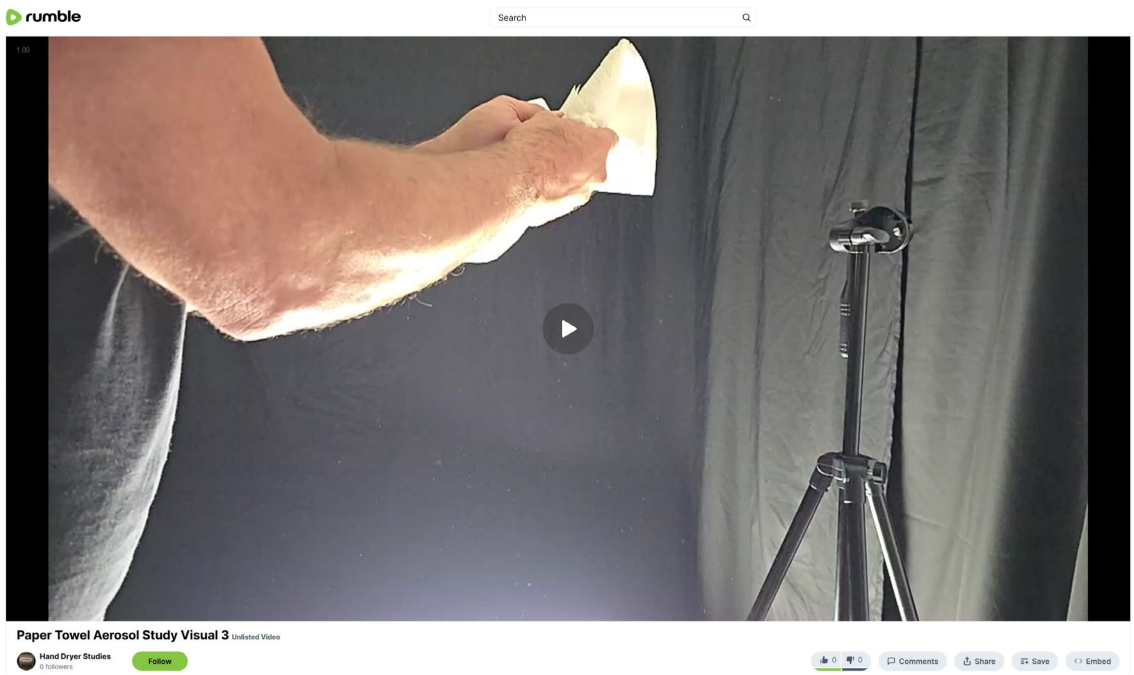
3.4 Paper Towel Trials



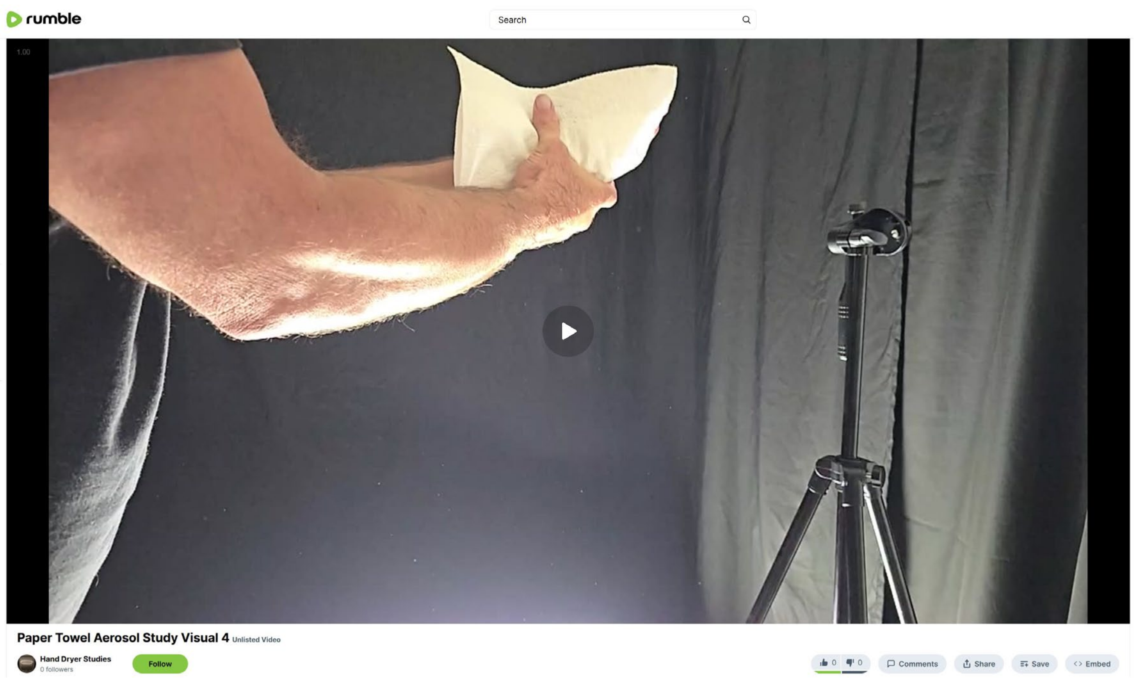
VIDEO 11: Paper Towel Trial 1 on Rumble



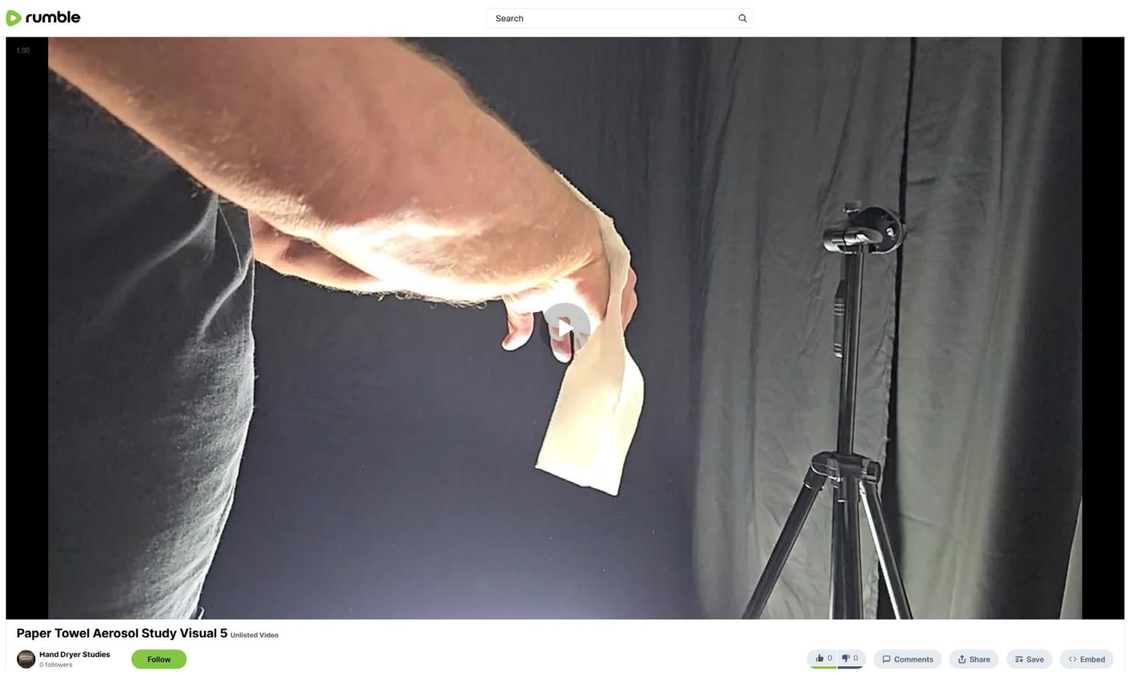
VIDEO 12: Paper Towel Trial 2 on Rumble



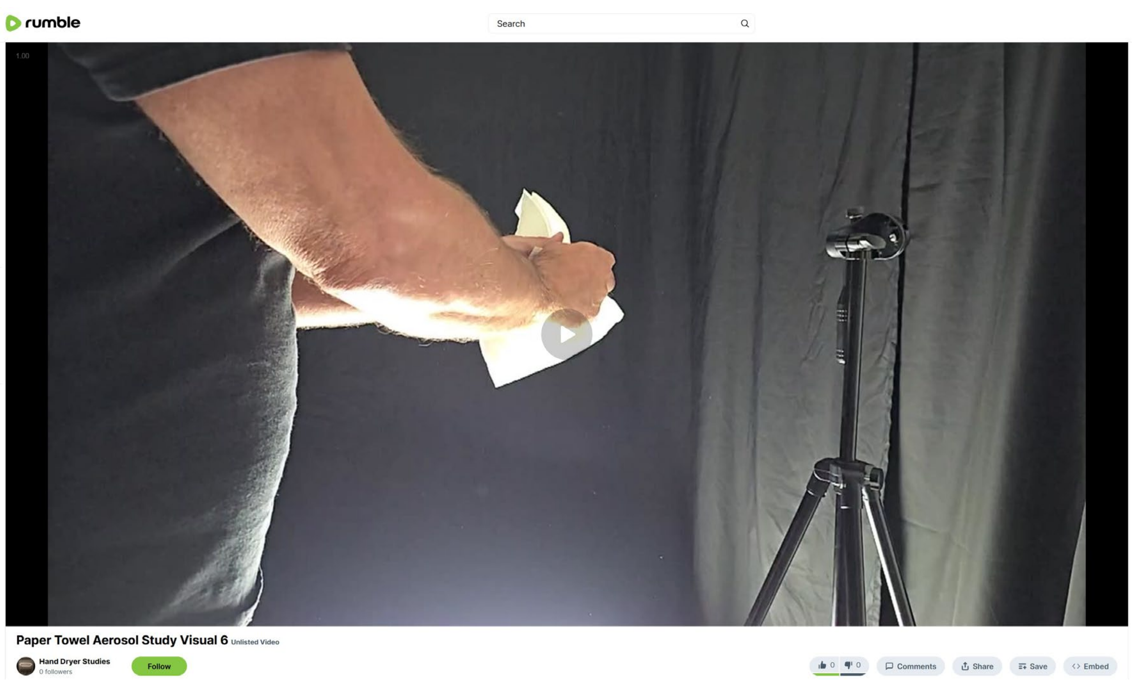
VIDEO 13: Paper Towel Trial 3 on Rumble



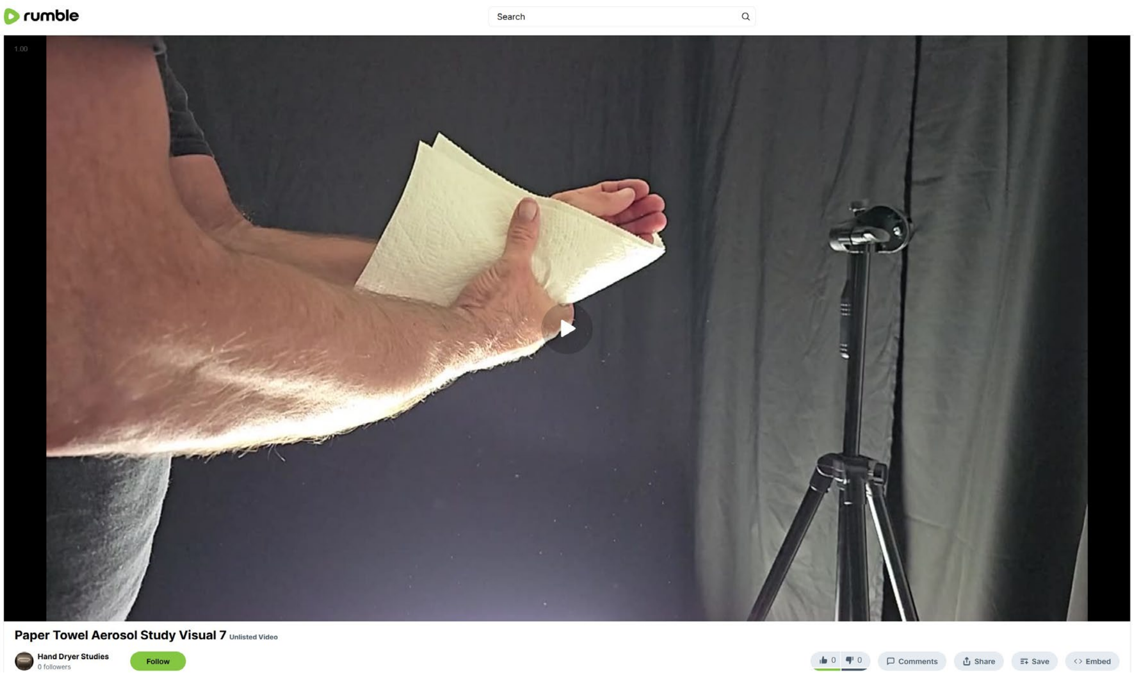
VIDEO 14: Paper Towel Trial 4 on Rumble



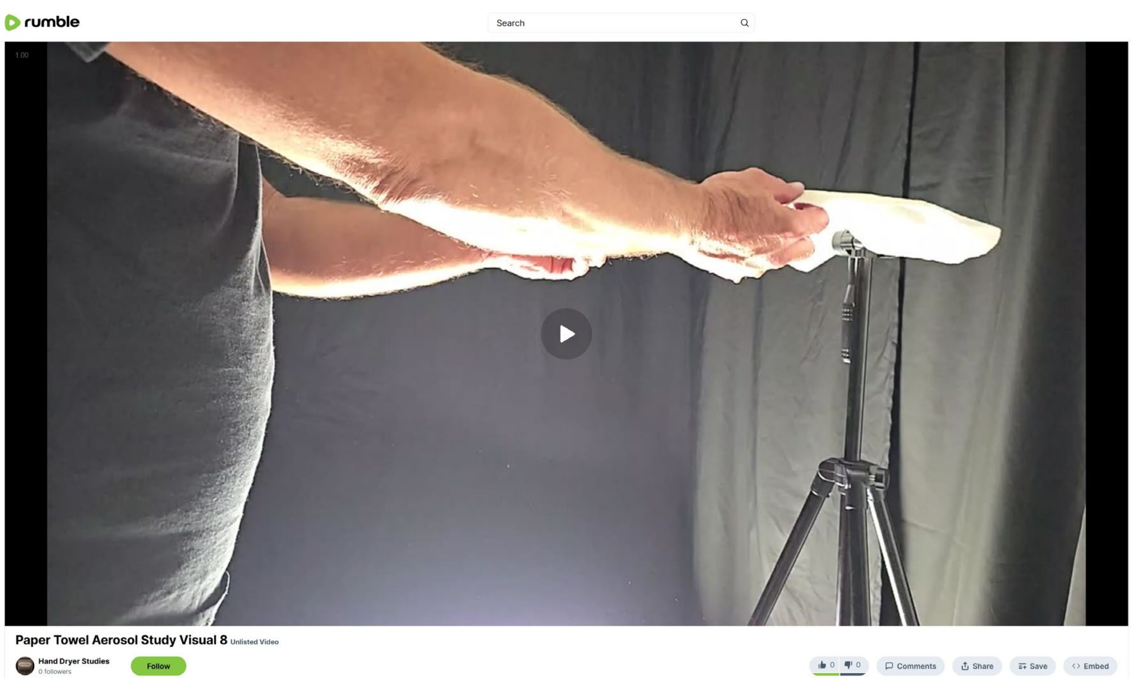
VIDEO 15: Paper Towel Trial 5 on Rumble



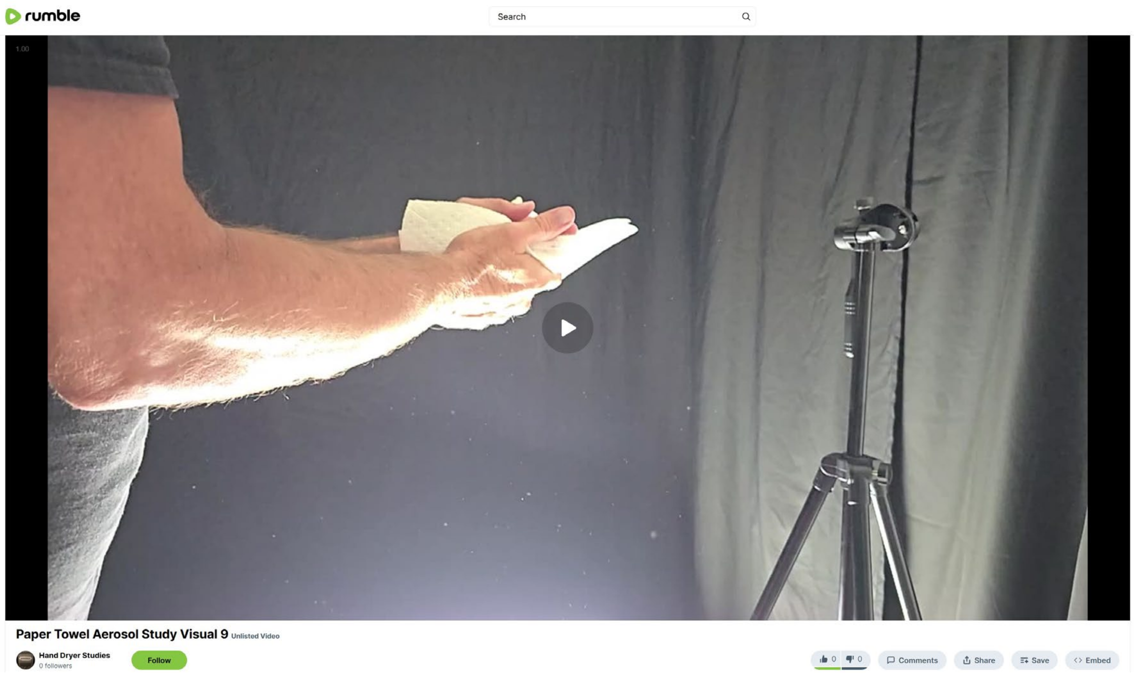
VIDEO 16: Paper Towel Trial 6 on Rumble



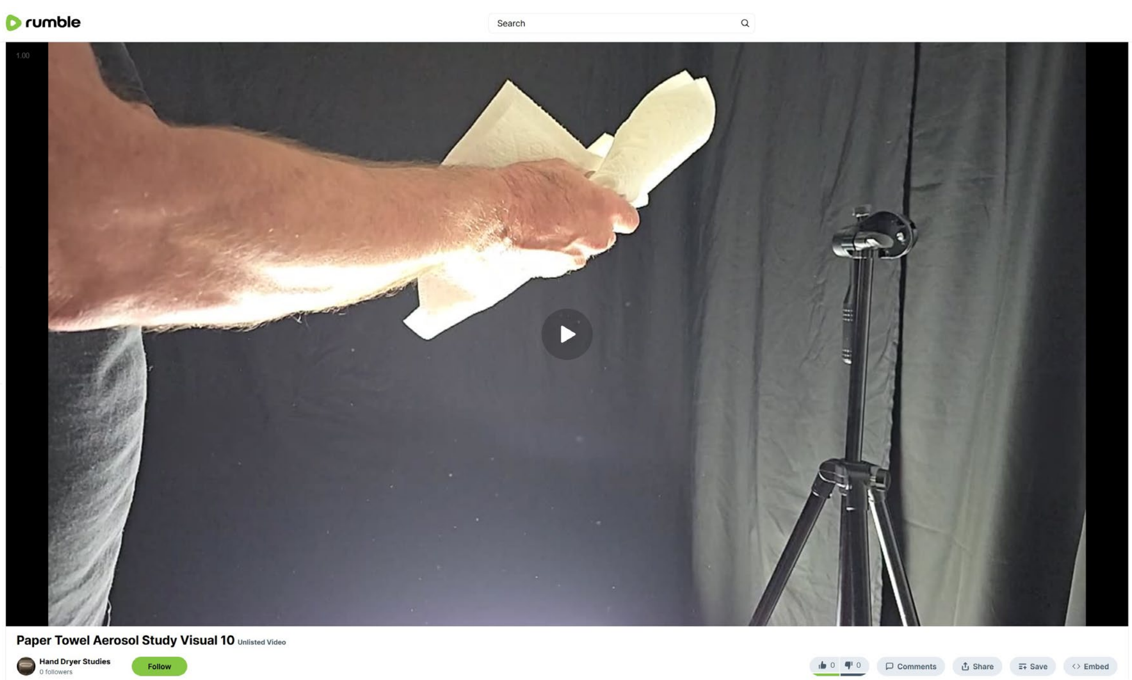
VIDEO 17: Paper Towel Trial 7 on Rumble



VIDEO 18: Paper Towel Trial 8 on Rumble



VIDEO 19: Paper Towel Trial 9 on Rumble



VIDEO 20: Paper Towel Trial 10 on Rumble

The consistent absence of water dispersion across all paper towel trials is notable, as it represents a fundamental qualitative difference in water management between the two drying methods. This observation is consistent with findings from Best et al. [7], who noted significantly lower environmental contamination with paper towel use compared to air dryers.

3.4 Water Destination Analysis

A central finding of this study is the documentation of where water goes during the drying process. Our high-speed video analysis revealed consistent patterns across all air dryer trials:

Air Dryer Water Destination Patterns:

1. **User's clothing:** Substantial visible water accumulation on the user's forearms, torso, and legs, appearing as droplet patterns and damp patches
2. **Surrounding floor:** Visible droplet accumulation in a semi-circular pattern with much of the water headed toward the floor
3. **Adjacent walls:** Water droplet patterns visible on wall surfaces
4. **Airborne suspension:** Visible mist formation that persisted for after drying completion
5. **User's face and hair:** Occasional upward dispersion resulting in visible droplets reaching the user's face area
6. **User's lower body:** Concentrated water accumulation on pants and on shoes

These observations are consistent with findings from In Silico's computational fluid dynamics study [26], which demonstrated that 26.1% of particles disperse beyond the dryer unit. Similarly, Hervé et al. [27] documented contamination on surfaces up to 3 meters from hand dryers, indicating significant water dispersal throughout the environment.

Paper Towel Water Destination Patterns:

In contrast, paper towel drying showed a single, consistent water destination pattern:

1. **Paper towel material:** Almost all visible moisture was absorbed into the paper towel material
2. **Disposal receptacle:** Water remained contained within the paper towel when disposed of

3. **No visible dispersion:** No observable water accumulation on clothing, surrounding surfaces, or in the air

The contrast between these patterns is striking and represents a fundamental difference in how these technologies manage the water removed from users' hands.

4. Discussion

The visual evidence presented in this study directly challenges manufacturer claims that high-speed air dryers "aerosolize no more than paper towels". The dramatic difference in observable water dispersion between the two drying methods strongly suggests corresponding differences in microdroplet aerosols too small to be seen. Additionally, our findings regarding water destination reveal a significant omission in manufacturer documentation, with Dyson and Excel Dryer failing to address where water removed from hands actually goes during the drying process.

Implications for Aerosol Generation

While this study focused on visible droplet dispersion rather than microscopic aerosol measurement, established principles of fluid dynamics support a strong correlation between the two. Mechanical forces that generate visible droplet dispersion also create smaller aerosols below the threshold of visibility as demonstrated by Bourouiba [14] and Morawska et al. [15]. The forceful air streams of high-speed dryers (moving at 400-640 km/h or 192 m/s) create ideal conditions for both droplet and aerosol generation through shear forces applied to water on the hands.

Droplet Size Distribution and Number Dominance

High-shear water aerosolization, such as that produced by high-speed air dryers, creates polydisperse droplet populations that follow log-normal distributions. In such distributions, smaller droplets (<10 μm, particularly ≤5 μm) typically dominate by number (50-90%), while larger droplets (>20-40 μm) contribute most to the visible mass due to the cubic scaling of volume with diameter as described by Baron and Willeke [12], Lefebvre [19], Lefebvre [19], and Hinds [18].

Research across multiple fields consistently demonstrates this pattern:

1. **Respiratory aerosols**: Johnson et al. [17] found that droplets <10 μm comprised 97-99% of the total number during coughing, with ratios of 50-500 ≤5 μm droplets per droplet >20 μm. Asadi et al. [20] reported that 80-90% of speech-generated droplets were <5 μm, outnumbering larger droplets by 100-1,000:1.

2. **Industrial sprays**: Studies of airblast atomizers, analogous to high-speed air dryer mechanisms, show that 50-90% of droplets are <10 μm by number, yielding 10-100 ≤5 μm droplets per ~40 μm droplet, with ratios up to 1,000:1 in high-shear conditions as documented by Lefebvre [20] and Villermaux [16].

3. **Environmental aerosols**: In sea spray, Fuentes et al. [21] found that <5 μm droplets constituted >90% of the number, outnumbering >40 μm droplets by 100-10,000:1. Baylor et al. [22] reported that film droplets (0.1-5 μm) from bursting bubbles outnumbered larger droplets by 100-1,000:1.

Based on this extensive body of research, we can reasonably estimate that for each visible droplet (≥40 μm) observed in our high-speed videos, approximately 100-10,000 true aerosols (≤5 μm) were generated, with 100-1,000:1 being typical for high-shear environments like those created by air dryers.

Water Destination Implications

Our findings regarding water destination raise significant concerns about both hygiene and user experience. The substantial backspray of water onto users' clothing documented in our trials represents a previously unaddressed aspect of air dryer performance. This backspray has several implications:

1. **Self-contamination**: Water removed from hands is partially redistributed onto the user's clothing, potentially transferring any remaining microorganisms from hands to clothing. This self-contamination partially undermines the hygienic benefits of handwashing.

2. **Wet clothing**: Users experience noticeable dampness on clothing after air dryer use, a practical inconvenience not addressed in manufacturer documentation. This dampness can be particularly problematic in professional or formal settings.

3. **Extended microbial viability**: Moisture transferred to clothing can provide conditions for extended microbial viability, as demonstrated by Hervé et al. [27], who found that microorganisms can remain viable on contaminated surfaces for extended periods.

4. **Inconsistency with marketing**: The observed water backspray contradicts the "hygienic" marketing narratives of manufacturers, which emphasize cleanliness without acknowledging this significant water redistribution.

The water accumulation on surrounding surfaces raises additional concerns:

1. **Environmental contamination**: Water dispersed onto floors, walls, and adjacent fixtures creates damp environments that can support microbial growth, as

documented by Best et al. [7] in their study of environmental contamination. The U.S. Environmental Protection Agency [29] provides guidance on environmental sampling and microbiology data interpretation that supports the significance of such contamination patterns in public facilities. Huang et al. [30] established benchmark guidance values for microbiological monitoring on surfaces, providing context for evaluating the contamination potential of the water dispersal patterns we observed.

2. **Slip hazards**: The accumulation of water on floor surfaces creates potential slip hazards, particularly in high-traffic restroom environments.
3. **Maintenance implications**: The dispersal of water throughout the restroom environment increases cleaning and maintenance requirements, a practical consideration not addressed in manufacturer documentation.
4. **Cross-contamination potential**: Water dispersed onto environmental surfaces can facilitate cross-contamination between users, as documented by Kimmitt and Redway [8] in their study of virus dispersal.

The In Silico [24] computational fluid dynamics finding that 26.1% of particles disperse beyond the dryer unit aligns with our visual observations and provides quantitative support for our qualitative findings. This dispersion pattern represents a significant omission in manufacturer documentation and challenges claims of "hygienic" performance.

Fundamental Contrast in Aerosol Generation Mechanisms

Our visual findings highlight a fundamental contrast in the physical mechanisms of droplet and aerosol generation between high-speed air dryers and paper towels. These two hand drying methods represent opposite extremes on the spectrum of aerosol generation physics, with profound implications for hygiene and pathogen dispersion.

High-Shear vs. Low-Shear Processes, Detail

High-speed air dryers operate through high-shear forces, with air velocities of 400-640 km/h (192 m/s), creating significant disruptive forces at the air-water interface on hands. This high-shear environment resembles industrial airblast atomization, where turbulent forces fragment water into a wide spectrum of droplet sizes as described by Lefebvre [19]. The physics of droplet breakup under these conditions is well-documented across multiple scientific fields, consistently showing that higher shear forces lead to greater fragmentation and a higher proportion of microscopic aerosols as demonstrated by Villermaux [16] and Lefebvre [19].

In stark contrast, paper towel drying operates through gentle absorption and minimal mechanical disturbance of the water-air interface. This low-shear process fundamentally limits droplet fragmentation and aerosolization as explained by Baron and Willeke [12]. The physics of low-shear interactions with liquids has been extensively studied, showing that gentle processes like absorption, dripping, or slow wiping predominantly produce large droplets (when they produce droplets at all) with minimal generation of true aerosols as documented by Lefebvre [19] and Lefebvre [19].

Disproportionate Aerosol Generation

As established in section 4.2, high-shear processes like those in air dryers produce dramatically disproportionate results in terms of aerosol generation. The 100-10,000:1 ratio of microscopic to visible droplets documented across multiple scientific fields means that our observed visible droplet dispersion corresponds to vast numbers of invisible true aerosols.

Conversely, in low-shear processes like paper towel drying, the few visible droplets we observed (primarily large drops falling directly downward) correspond to proportionally fewer true aerosols. This principle is demonstrated across multiple scientific domains, from respiratory aerosols to industrial processes to environmental studies.

In our observations, paper towel drying produced minimal visible droplets, primarily consisting of occasional large drops falling directly downward. Based on established aerosol science principles, this low-shear process produces proportionally fewer true aerosols relative to these few visible droplets. Conversely, the dense clouds of visible droplets observed with air dryers likely correspond to vast numbers of invisible true aerosols, consistent with high-shear fragmentation physics.

Evaporation dynamics of suspended droplets follow established principles of atmospheric physics as described by Pruppacher and Klett [28], with smaller droplets potentially transitioning to the aerosol fraction through evaporation.

Manufacturer Documentation Analysis

Our review of manufacturer documentation revealed striking omissions regarding water destination:

- No explicit references to water management across all materials for wall mounted dryers
- Explicit mention of water management for sink-integrated models
- A single acknowledgment that water from wall-mounted units "drips onto the floor, where it evaporates naturally"

- No mention of water backspray onto users
- No discussion of water dispersal to surrounding surfaces
- Marketing emphasis on "hygienic" performance without addressing water redistribution
- Sale of "antimicrobial wall guards" by some manufacturers implicitly acknowledging water dispersal to walls without stating it directly
- No discussion of floor contamination from falling water

In their hygienic hand dryer marketing materials, Dyson [26] emphasizes HEPA filtration but provides limited discussion of water dispersal patterns. Further, few existing installed dryers have HEPA filtering and non HEPA dryers are not discussed.

This pattern of omission is significant in light of our visual evidence showing substantial water redistribution during air dryer use. The discrepancy between manufacturer documentation and observed performance represents a notable gap in product transparency and raises questions about users' ability to make fully informed decisions about hand drying technologies.

5. Conclusion

This visual analysis provides compelling evidence that challenges manufacturer claims regarding aerosol generation. It clearly displays water distribution patterns, starkly illustrating the absence of manufacturer specifications describing an integral part of the device use cycle during hand drying. It shows water containment in paper towels and a lack of visible aerosols during hand drying with them. Our findings reveal three primary elements of note: (1) high-speed air dryers create substantially more visible aerosol dispersion than paper towels through fundamentally different physical mechanisms, (2) hand dryers redistribute significant amounts of water onto users' clothing and surrounding surfaces as it is removed from hands, and (3) paper towels contain post-washing water from hands, allowing for easy sanitary disposal.

The visual evidence demonstrates extensive visible droplet dispersion during air dryer use compared to minimal to no visible droplet dispersion during paper towel use. This stark contrast correlates tightly with established, ubiquitous aerosol science on the difference between high-shear processes that maximize droplet fragmentation and low-shear processes that minimize it.

Established principles of fluid dynamics and aerosol science indicate that these contrasting mechanisms create disproportionate results in aerosol generation. In high-shear environments like those created by air dryers, true aerosols (≤5 μm) are generated at rates 100-10,000 times greater than visible droplets (≥40 μm), with 100-1,000:1 being typical. Conversely, the gentle, low-shear mechanics of paper towel drying produce proportionally fewer true aerosols relative to the few visible droplets observed. This dual contrast---both in visible droplet quantity and in the proportion of invisible aerosols generated---represents a "double advantage" for paper towels in minimizing potential pathogen dispersion.

Our documentation of water destination patterns reveals a significant omission in manufacturer specifications, claims, and promotional and sales materials. As of the publishing date of this study manufacturers have completely failed to address where water goes during the drying process, with our trials showing substantial backspray onto users' clothing and dispersal to surrounding surfaces. The contrasting pattern of nearly complete water containment by paper towels and explosive water dispersal patterns by the dryers represents a clear advantage for towels in terms of both hygiene and practical user experience.

The absence of discussion regarding what happens to the water after the dryer output air stream hits the wet hands, the physics of high-shear aerosol generation, and the undeniable redistribution of water onto users and surfaces creates a concerning public health situation. The visual evidence presented in this study bridges the gap between technical hygiene research and observable real-world outcomes, providing clear documentation of phenomena that have significant implications for public health, user experience, and informed decision-making about hand drying technologies.

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Appendix A: Visual Summary of Hand Drying Dispersion Mechanisms

This study introduces a novel visual method for evaluating hygiene outcomes of hand drying techniques by replacing traditional qualitative descriptions with direct observation via slow-motion video. The videos are the data. The following summary distills the comparative dynamics observed across all trials into a concise, single-page format.

Comparison of Hand Drying Mechanisms

Feature	High-Speed Air Dryers	Paper Towels
Drying Mechanism	High-velocity air stream (400-640 km/h)	Absorptive mechanical contact
Shear Force Environment	High-shear	Low-shear
Droplet Fragmentation	Extensive fragmentation into fine aerosols	Minimal fragmentation
Visible Droplet Dispersion	Extensive airborne spray, backspray, mist	Occasional downward large droplets
True Aerosol Generation Potential	Very high (100-10,000:1 droplet ratio)	Minimal

Water Destination	Dispersed onto clothing, walls, floors	Contained within towel and disposed
User Self-Contamination	Frequent and substantial	Absent
Environmental Contamination	Extensive	Negligible