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Review

No stain, no pain – A multidisciplinary review of factors underlying domestic laundering

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ABSTRACT

Today's washing appliances are much more efficient than those of a decade ago, but the environmental benefits of this efficiency are counteracted by shifts in consumer behavior. Initiatives to reverse these shifts have often proven futile, indicating a basic lack of clarity on why we clean our clothes.

This article is an explorative review with the aim of identifying dominant factors that shape how we do our laundry. The results can be used both as an introduction to laundry research in general, as well as a baseline for future interdisciplinary research. Three guiding principles are presented that describe the most influential factors underlying laundering: (1) technology changes conventions, while social context dictates technology acceptance; (2) technological solutions are often suggested to influence consumers, but individual concerns seem to override the effect of such interventions; (3) consumers are guided by social conventions, rooted in underlying psychological dynamics (e.g. moral dimensions of cleanliness).

Looking at these principles it is understandable why interventions for sustainability are failing. Many interventions address only a part of a principle while disregarding other parts. For example, consumers are often informed of the importance of sustainability (e.g. "*washing at lower temperature is good for the environment*"), while questions of social belonging are left out (e.g. "*many of your neighbors and friends wash at lower temperature*"). To increase the possibility of a lasting change, it would be beneficial if instead all of the three principles could be addressed given the specific consumer group of interest.

1. Introduction

Contemporary consumers buy more clothing [1] and wash it more frequently [2] than during any other time in history. This means that even though today's washing appliances are much more efficient those of a decade ago [3,4], the environmental benefits of efficiency are counteracted by consumer behavior [5]. For example, the average energy consumption of washing machines in Europe per wash cycle has fallen by more than 50% since the 1970s [4]. Yet during that same time period, the overall energy consumption associated with household laundry washing has grown. In the U.K. for example, energy consumption for household laundries grew by over 100% between 1970 and 2012 [6]. The increased technical efficiency of washing machines seems also to be underutilized due to consumer decisions in the laundry. For example, many consumers only partially fill the machine when running a cycle, due to the fear of overloading or by using excessively many (and strict) sorting categories [7]. It is also common for consumers to fail to adjust the amount of detergent in relation to water hardness or the amount of laundry, either because we are creatures of habit or because the instructions on the packaging were confusing [8]. Overall, laundry activities represent a significant part of direct household impacts in terms of energy consumption and pollution caused by nutrients and greenhouse gases [9]. The desire to reduce these impacts drives this work.

Looking at this development, some researchers argue that most of the potential impact reduction is limited by the washing habits of the consumers, rather than the design of the machines [10]. As a counter measure, attempts have been made to influence consumers to make more environmentally friendly laundering decisions. Unfortunately, such attempts have often proved futile. As noted by Throne-Holst et al. [11] and Bartiaux [12], simply providing information about emissions and appealing to consumer's (assumed positive) environmental

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attitudes generates little success. In fact, very few consumers express any willingness to change their washing and drying habits [13].

Taking a step back, these failed interventions (i.e. deliberate attempts by an actor such as a company, government, or NGO to change behaviors) indicate a lack of clarity regarding the underlying drivers and barriers for sustainable laundering[1]. Or in more general terms, failures to change practices or behaviors may question our general beliefs regarding why people wash their clothes to begin with. Perhaps factors other than simply removing dirt or odor are shaping laundering decisions.

Addressing these issues, authors from different research fields have suggested interdisciplinary collaborations that better explain the underlying motivations for laundering [6,16]. However, as a subject of study, the act of laundering is often viewed either as consumer behavior (i.e. a number of individual decisions) or as a practice (i.e. a set of interconnected elements such as bodily behavior, routinized ways of understanding, knowing how, and desiring [17]). Because of this, interdisciplinary endeavors face rather large challenges in overcoming divergent theoretical and methodological traditions [18,19]. Regardless, the apparent elusiveness of understanding laundering calls for the research scope to be extended outside traditional research fields, looking beyond immediate consumer decisions (e.g. choice of temperature, detergent dose, etc.) and including more abstract influences such as cultural differences, available technology, and perceptions of cleanliness.

This article should thus be viewed as an explorative first step towards such an extension. The aim of this work is to describe and summarize current research regarding laundering practices and laundering behavior. By collecting, comparing, and organizing findings from divergent fields we hope to illuminate previously overlooked dissimilarities and overlaps. More specifically, this article aims to review research literature from several fields and traditions to answer the question: *What underlying factors shape how we do our laundry?* Our goal is to establish a better basis for interdisciplinary research and future policy, in order to facilitate successful interventions aiming to reduce the environmental impacts of textile consumption.

2. Method

The purpose of this mapping review is not to paint a complete picture of all the available research within the field, nor to be as rigorous and thorough as a systematic review. Instead, the goal is to identify gaps and overlaps in research literature, while categorizing existing literature from which further research can be commissioned [20–22]. Initially, a search string was developed with a focus on laundry and consumer motivations connected to laundering. Using keywords from already known sources within the field, eight blocks of strings were identified as relevant:

1. Laundr* OR Clothes OR Apparel* OR Linen*
2. Wash* OR Clean* OR Laundr* OR "Soil removal"
3. "Washing machine" OR "Tumble dryer" OR "Drying cabinet" OR "Household appliance"
4. "Laundry room" OR Laundromat OR Launderette
5. Psycholo* OR Cleanliness* OR Driver* OR Barrier* OR "Psychological factor*"
6. Habit* OR Behaviour* OR Practice* OR Action* OR Pattern* OR Routine* OR Attitude*
7. Tradition* OR Culture* OR Convention* OR Inconspicious OR Conspicious
8. "Personal hygiene" OR "Shower*"

Combinations of these blocks were then used in Scopus as well as in ProQuest on the 1st of February 2021. Search results were limited to published articles in English up until that day. A complete search string for Scopus and ProQuest, as well as a description of the filtering of the initial search result, can be found in the appendix. The work was carried out using the software EndNote and Rayyan [23].

The search strings generated 1554 articles in Scopus and 1492 articles in ProQuest. After removing the duplicates 2544 articles remained. The titles and abstracts of these articles were then skimmed to eliminate any articles that did not focus on consumers in relationship to domestic laundering practices or behavior, clothes, detergent, or personal hygiene (i.e. excluding articles focusing on mental health patients, product brand marketing, elderly care, purely technical and chemical investigations, laundry solutions for health care, industrial laundering etc.). After this initial screening 323 articles remained.

The second screening involved reading through the abstracts in more detail and excluding articles that failed to focus on one of the following:

- Dirt or cleanliness in relationship to clothes, laundry, or laundering
- Behaviors, emotions, values, or attitude in relationship to dirty clothes, laundry, or laundering
- Personal cleanliness practices that could be attributed to clothes, laundry, or laundering from a social or moral perspective.

After the second screening 68 articles remained, which were then read in full. Out of these, 6 were deemed out of scope (e.g. focusing more on clothing consumption in general). Lastly, additional records were identified using the remaining 62 articles' reference lists, as well as their citation patterns in Scopus and in Web of Science. This method identified an additional 47 potentially relevant although only 18 were included in the final analysis after being read in full. All in all, a total of 109 journal articles were read in full, and 80 of these were included in the final synthesis. See Fig. 1 for an overview of the workflow.

3. Results

To facilitate for the reader, the identified articles have been categorized into three main groups: articles written mainly from a perspective based in sociology, psychology, or technology (i.e. the physical, chemical and electrical engineering systems connected with the laundry process).

3.1. Laundry and laundering from a sociological perspective

19 articles regarding laundry and laundering practices were identified as having a sociological perspective. The findings were based primarily on qualitative case studies and interviews, which were sometimes backed by quantitative measurements. Most of these studies focused on a western context and were published during the last 10 years, see Table 1.

Although many of the findings overlap between studies three general themes, *social conventions, religious and moral concerns,* and *individual relationships* can be noted. Note that for the purposes of this article, "conventions" are seen as patterns of behavior generally accepted in a social context (e.g. within an urban community, amongst peers, or by other groups of people).

3.1.1. Laundry and laundering practices based on social conventions.

The argument for seeing laundering as a result of social convention was initially highlighted by Shove [25]. For her, the patterns of energy

[1] The term "Sustainable laundering" is difficult to define because sustainability is in itself difficult to define. For this article we adopt an environmentally-focussed definition reflecting the pioneering work of Karl-Henrik Robert [14] but also the difficulty of defining sustainability absolutely (e.g. Bjørn et al. [15]). Sustainable laundering should thus be seen as laundering that reduces the amount of material extracted from the lithosphere, or the mass of unnatural substances produced by society, or it preserves natural ecosystems (or preferably all of these three things) compared to current laundry behavior.

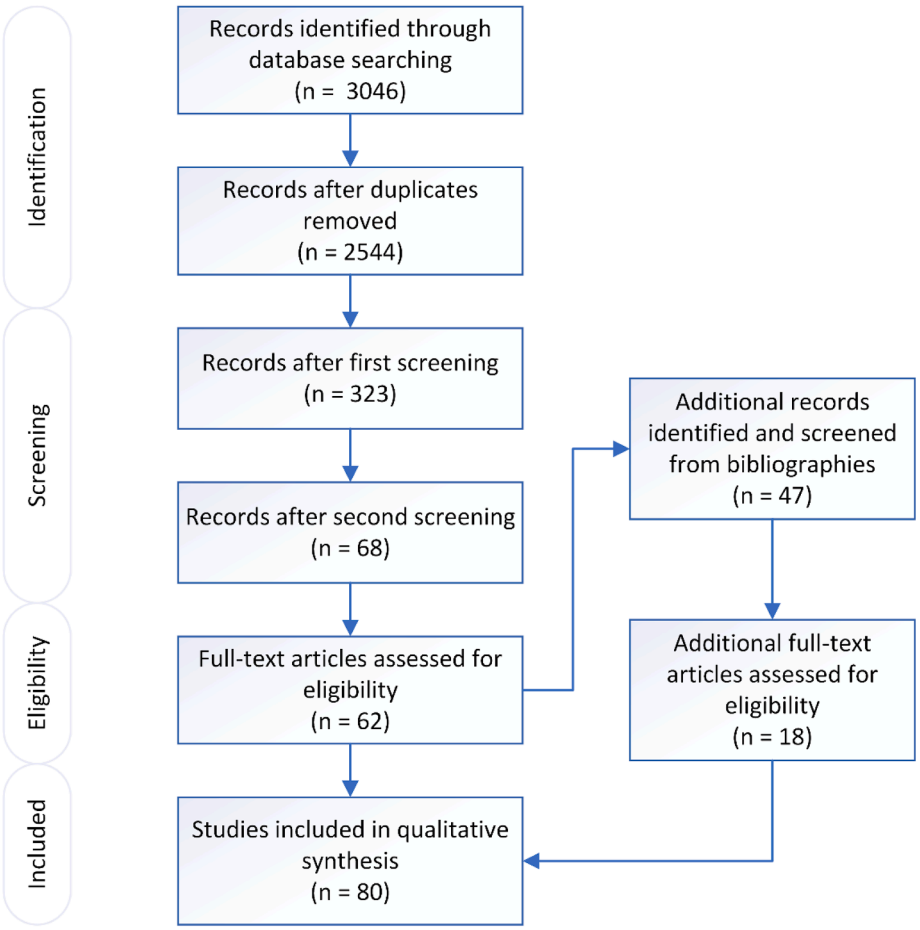

Fig. 1. *Workflow and results for the literature review. Adapted from Moher et al.* [24].

Table 1
Characteristics of articles focusing on sociological aspects of laundering. The term 'Western' means a combination of Europe, North America, Australia, and/or New Zeeland. 'N/A' means theoretical work, or a review without any specific geographical limitations. Number of articles in parenthesis.

Year of publication	Country/ Region	Data type	Top 3 journals
1990–1999 (2)	Europe (7)	Qualitative (13)	Sustainability: Science, Practice and Policy (2)
2000–2009 (4)	Australia (4)	Quantitative (2)	Journal of Consumer Culture (2)
2010–2020 (13)	Africa (2)	Mix (4)	International Journal of Consumer Studies (2)
	Western (2)		
	Brazil (2)		
	Asia (1)		
	N/A (1)		

and water consumption for mundane, inconspicuous everyday activities (such as washing clothes) are not a result of environmental commitments by the consumer. Instead, the patterns should be seen as a result of how the consumer relates to the (culturally dependent) social and temporal priorities and expectations. The article also acknowledges that the final consumer practice is a result of many factors. These include: *the technical solutions available, cultural norms*, and *sensory stimulus*. Trends in cleanliness can thus be explained by a societal normalization of both what it means to be clean and how laundering should be done (e.g. by using a washing machine, tumble dryer etc.).

Similar findings was reported by Retamal and Schandl [26], who examined laundry practices in Manila; both from a quantitative perspective of resource consumption and from a perspective of social practice theory. One interesting result was that a dominant factor determining the choice of washing practice was the income level of the different households, including the level of workforce participation of the woman in the specific household. Low-income families washed their clothes by hand, middle-income families used their own machines or a laundry service, and high-income families employed maids to wash their laundry by hand. However, all participants expressed a belief that hand washing resulted in the cleanest clothes.

Mylan and Southerton [27] also acknowledge that social mechanisms structure laundering activities. Particular mechanisms of interest include *social relationships, cultural conventions, materialities of the home,* and *institutional temporal rhythms*. Adhering to the prevailing UK social norms, the authors found that women in heterosexual couples usually took principal responsibility for laundering activities. In some cases practices were influenced by economic concerns such as not using the tumble drier, but generally, textiles were cleaned when they did not perform their "task" properly, which in turn was dictated by social conventions. Towels should be "fluffy", linen should "feel fresh", and clothes and shirts should look, feel, and smell clean without any creasing. The way the laundering was performed was in turn influenced by the technical and temporal constraints of the family's lifestyle, something also noted by Jack [28] and Southerton [29]. This meant that even though some consumers stated that they were willing to alter habits regarding laundering, the practice itself was interlocked with other domestic activities that collectively proved too much of a challenge to change [30,31].

Few would contest that laundering is tied to gender roles. The *magnum opus* regarding this subject is certainly Cowan [32], who showed

that advances in technology (amongst other things) only reduced the household work load for men and children. This phenomenon seems to still exist today, as a study done by Baxter [33] illustrates that men in dual-earning couples from western industrial countries (US, Sweden, Norway, Canada and Australia) only contribute 7–17% to domestic laundering labor. This skewed balance might also influence attitudes towards the washing machine per se. For example, in an investigation regarding laundering practices in Soweto, Meintjes [34] noted that for both men and women the washing machine emerged as a powerful symbol of laziness. To use it would undermine the women's image as 'good' wives, and by extension the credibility of the household. This clinging to old attitudes and habits also seems, in addition to deficient infrastructure, to be a reason for the exceptionally slow introduction of the modern washing machine in Britain. For example, in 1969 only 5% of all British households had an automatic washing machine, although the technology at the time had been around for more than 30 years [35].

Looking more closely at evaluation criteria of laundry dirtiness, four main drivers have been identified and proposed by Jack [36]:

1. *physical motivators* – such as odor, stains, or that the clothes had lost their shape
2. *habits* – such as wash frequency for specific laundry items
3. *emotional and sensual* – such as getting a fresh start before, or after, a specific occasion
4. *self-auditing* or *community censorship* – i.e. not being a nuisance to others

An extreme version of habitual behavior was also described by Gram-Hanssen [37] who found that for some people, the only way back into the wardrobe for the clothes was through the washing machine. This held true even for clothes that had only been picked out by accident and never used (i.e. not even tried on or left the room).

In addition, three main drivers for *not* washing were identified and presented by Jack [36]: *convenience* (e.g. avoiding a mundane chore, saving time and saving money); *longevity* (e.g. making the clothes last longer) and; to *preserve emotions* (e.g. preserving the current feeling or memories attached to worn clothing such as a sweater worn by a deceased parent).

3.1.2. Laundry and laundering practices based on religious and moral concerns.

How we relate to clean clothes is often tied to social conventions, stemming from for example religious beliefs and moral judgment. From a historical point of view this is not new. In Spain during the 3rd −13th century, not washing or changing clothes was revered as an "intimate Christian practice" and a sign of the True Faith. Muslims, on the other hand, were much cleaner and sometimes bathed several times a week [38]. Comparing these religious practices in more recent settings in Egypt, Boulos [39] found that the conceptions of personal cleanliness had inverted between the two religions at the beginning of 20th century. Reports from Christian missionaries in the area speak of dirty clothes and unhygienic living conditions in Muslim families and the resistance to modern cleanliness practices. Interestingly, the German-speaking missionaries did not consider these dirty houses and clothes to be the failures of the housewives, who were seen as responsible for these types of labor, but rather a consequence of the patriarchal rule of men. Dirty clothes and dirt within the household was a sign of women's oppression [39]. A more recent example of religious influences was provided by the participants interviewed by Neves [40]. For them, having clean clothes while attending church meant to *"love God"*. Additionally, this connotation did not stop at the personal relationship with God but extended to all surrounding people. Thus, being clean was explicitly motivated by a desire to get the attention and admiration of others.

There are also examples of the moral connections to laundering activities when looking at the sorting practices of dirty items. For example, many Brazilians categorize laundry according to a 'polluting principle': textiles associated with pollution from outside the home (i.e. clothes) and textiles associated with pollution from inside the home (i.e. tablecloths, towels etc.). In addition, baby clothes as well as women's underwear have to each be washed separately, usually by hand in the bathroom [41]. A suggested mixing of articles from different categories was repeatedly met by a strong emotional response: *"My goodness, no! That is disgusting!"* [40,41]. These types of unspoken social rules and "logic of polluting" did not stop at the laundry but were extended to other parts of the household. For example, one *must* clean one's home with water or it would be deemed "dirty" and potentially harmful to others within the social circle [42]. However, such sorting rules for laundry might not be a unique Brazilian phenomenon. For example, when Ellmer et al. [43] asked about sorting criteria for laundry, 40% of the German participants acknowledge that that they sometimes use "gut feeling" when sorting. Additionally, 50% also agreed that they sometimes sort according to type of textile, and another 25% agreed to sometimes sort according to the stain/stain intensity. Also, in a Norwegian study, 39% state that underwear is washed separately from kitchen towels [7].

The moral dimensions of laundering also seem to include the changing of clothes as well. For example, teenagers interviewed by Gram-Hanssen [37] explained that all *"normal"* youngsters change clothes often and if you did not, it was often because you were *"mixed up in something"* (e.g. smoking marijuana). Some people in the study seemed to intuitively understand this dynamic and either adapted their behavior to fit the norm or deployed alternative tactics to give the illusion of changed clothing.

3.1.3. Laundry and laundering based on individual relationships.

Further evidence of the connection between having clean clothes and social risk can be noted. For example, one driver of laundering habits seems to be the idea of wanting to be confident in social settings, while at the same time minimizing the risk of standing out or being isolated from the group [28,36,37]. Pink and Postill [44] provide one clear example of this dynamic. When interviewing Indonesian immigrants living in Australia, several of the interviewees stated that they had changed their laundering practices (including choice of clothing) as a direct result of the cultural differences between Australia and Indonesia. For example, in Indonesia clothing were frequently washed due to the hot weather and social pressure of wearing formal clothing at work. However, for many immigrants this changed when they arrived at Melbourne. The more informal attitudes towards clothing in general, and professional attire in particular, prompted them to wear their clothes for longer times, as well as launder less frequently.

In a more general sense, these results indicate that cleanliness is a state of mind rather than a physical fact. This dichotomy was pointed out by Shove [25] and has also been illustrated by Jack [36] and Jack [45]. Here the *thought* of not washing was more repulsive than the *actuality* of not washing. This means that being clean is not solely a positive thing. Depending on the setting, as well as the age of the person, dirty clothes may very well be preferred. For a child, dirty clothes might signal a happy childhood, and for adults the same type of display could be valued as honesty, masculinity, and participation in "proper work" [46].

In relation to these factors influencing the perception of cleanliness, some of the strongest laundry norms consistently found throughout the studies of Mylan and Southerton [27] and Pink [47] were individual concerns regarding sweat and odor. The fear of odor was also stated as the main motivator of regular changes of clothes, in addition to the normative injunctions of not wearing the same clothes on consecutive days [37]. Interestingly, when these fears and unspoken rules were challenged in real life, few of the consumers experienced any negative consequences. This means that the potential repercussions of breaking these social norms might not be as serious we believe, or that deviant behavior is hard to recognize for others – up to a certain point [45,48]. Instead, the major reason people avoid changing laundering practices may be an initial resistance to deviation from the norm. Ways of

laundering are often normatively constituted as coherent and many people seem to need an excuse to try alterative practices, such as "permission" from a research team or through their own engagement [49].

3.2. Laundry and laundering from a psychological perspective

Among the articles with a psychological perspective only three of them, Labrecque et al. [50], Hess et al. [51], and Conrady et al. [16] explicitly mention laundry and laundering activities. However, a number of articles were identified that points towards more abstract psychological concepts that could guide laundry descisions. These were either caught by the initial search string or referenced to by the other articles focusing more clearly on laundry and laundering practices. In order not to limit the analysis these additional 21 articles are included in this subchapter.

The findings presented are primarily based on quantitative measurements, published during the last 10 years. The data is based in a western context, see Table 2.

Three general themes can be noted here: the psychological dimensions of cleanliness (and cleansing practices) with focus on *social interactions, intrapersonal dynamics, and daily activities*. Each of the themes are explained below.

3.2.1. Psychological dimensions of cleanliness and cleansing practices, with focus on social interactions.

The earliest work found in the reviewed literature on psychological dimensions of cleanliness regarding social interactions was Worrall et al. [52]. In their survey, participants evaluated four personal hygiene cues (bad breath, sweat, dirty fingernails, and dandruff) commonly noticed during first impression formation. The cues were evaluated on a five-point scale for same-sex interactions as well as opposite-sex interactions. Olfactory cues (bad breath and sweat) were found to be more unfavorable than visual cues (dirty fingernails and dandruff). However, it is unclear if the participants would exercise the same harsh judgments about their own odors. Especially since it seems that people carry a specific olfactory marker that can be recognized as "their own smell" amongst other (i.e. correctly pick one of their worn t-shirts from a sample of 10). This marker, and the ability to distinguish between markers, could thus facilitate an individual's sense of self or uniqueness within a population [53].

Olfactory cues were also investigated by Kerr et al. [54]. In their study, 478 persons (70% women) smelled a small odor sample of either lemon, onion, pine or smoke. The participants then assessed a fictive person whose clothes were said to smell like the odor sample. Findings included that a fictive person that smelled like pine was assessed more favorably on a number of categories (i.e. more sociable, intelligent, clean, and attractive) than any fictive person smelling like lemon, onion, or smoke. Some gender differences were also found [54].

Odor not only seems to affect judgement of personality traits but can also trigger and prime behaviors such as promoting collaboration. Additionally, clean scents seems to influence feelings of virtue, leading to increased reciprocity and charity [55].

However, there is also a possibility that smells can be used to undermine collaboration. In seven different studies, Lee and Schwarz [56] identified metaphorical effects between olfactory cues and language as well as bidirectionality in the dynamics. Since smell is used as a basis of common spoken metaphors to indicate suspicion in at least 18 countries, they tested the possibility of an embodiment effect (i.e. an overlap and bidirectional influences between conceptual information and bodily sensations) of smell between language and decisions. Since metaphors vary between cultures, they chose to use fish-smell as a point of departure since this smell matches the English metaphors of suspicion (i.e. *"something smells fishy"*). The study concluded not only that olfactory cues can elicit social suspicion, but also that many languages use unpleasant smells to indicate questionable character or dislikable characteristics [56].

Beyond olfactory influences, psychological dimensions of cleanliness in social interactions can also be shaped by feelings of disgust. For example, interpersonal disgust sensitivity (e.g. unwillingness to wear used clothes even when they are clean) has been shown to predict negative attitudes to marginalized groups such as immigrants and foreigners [57]. Interestingly, this held true even after controlling for participants' concerns about contamination and disease, which are traditionally seen as the main sources for feelings of disgust.

Disgust sensitivity may thus be seen as a strong cultural force that protects the self from potentially offensive objects and social groups [57]. This point was also argued by Speltini and Passini [58] who suggest that disgust bias in social relationships functions through a moral exclusion process. Thus, referring to outgroups as dirty and impure (as well as ones in-group being clean and pure) can be used as supporting strategies for moral exclusions of others. Another study with similar focus were performed by Reicher et al. [59]. Here, in two different setups student participants were asked to smell a sweaty t-shirt, which had a logotype that provoked either an in-group, out-group, or interpersonal condition. The results indicate that ingroup relations seems to attenuate core disgust in relation to sweaty clothing. Interestingly, variations of these different dynamics can also be observed throughout history, although what is considered clean and dirty vary between cultures as well as time periods. For example, during the 18th and 19th century sensations of smell seemed to hold a specific value as a marker for social class: the poor would stink while the elites sought out clean and non-smelly places [60].

Lastly, cleanliness might serve a social function much as grooming practices within groups of animals lead to better group cohesion [61]. Although mutual grooming behavior, such as two persons cleaning each other, are rare among humans today, the symbolic meaning of such practices may linger. This would mean that individual cleanliness also serves as a signal for close social relationships. Even though many of these claims are speculative, there is evidence that the need to express cleanliness is connected to our desire for social relationships, not just a desire to avoid health risks associated with sources of contamination [61].

Table 2
Characteristics of articles focusing on psychological aspects connected to laundering. The term 'Western' means a combination of Europe, North America, Australia, and/or New Zeeland. 'N/A.' means theoretical work, or a review without any specific geographical limitations. Number of articles in parenthesis.

Publication year	Country/Region	Data type	Top 3 journals
1970–1980 (1)	North America (12)	Quantitative (19)	Psychological Science (3)
1990–1999 (3)	Europe (6)	Qualitative (3)	Perceptual and Motor Skills (3)
2000–2009 (4)	N/A (6)	Mix (2)	Social Psychology (2)
2010–2020 (16)			

3.2.2. Psychological dimensions of cleanliness and cleansing practices with focus on intrapersonal dynamics.

Looking at psychological dimensions of cleanliness within the individual, one study is especially interesting. In an attempt to integrate aspects from Social Practice Theory (SPT) with social-psychology, Hess et al. [51] tested if washing practices could be linked to latent constructs such as personal norms and hedonic values, as well as perceived meaning, competence, and material elements of the practice. Their result indicate that the variance in practices of laundering could mainly be explained by socio-demographic factors and practice-specific wants and materials. In other words, people wash their laundry because they want to have fresh clothes, regardless of their own stated norms, values and competences [51].

Yet, in general, research on psychological intrapersonal dimensions of cleanliness seems to focus on moral transgressions alleviated by physical cleaning practices. This would suggest that for many people there is be a conflation between bodily and moral contaminations, and that moral purity is enhanced by the pursuit of bodily purity. For a review on this type of *moral cleansing,* see West and Zhong [62].

For example, exposure to behaviors that pose a moral threat may stimulate the need for physical cleansing. In turn, the act of cleaning was found to work as a compensatory behavior as well as influencing an individual's emotional state [63]. This means that the act of cleaning (e.g. washing the hands, taking a shower) could work as a powerful antidote to the emotional effects of unethical actions. A relationship between moral transgressions and cleanliness was also shown by Schnall et al. [64]. Here two different cleanliness manipulations were performed: one cognitive (experiment 1) and one physical (experiment 2). In both manipulations, participants who had their cleanliness concepts activated made less severe moral judgments than the control group. However, these results stand in stark contrast to the opposing findings made by Zhong et al. [65]. Here a clean self was shown to be linked to a virtuous self, resulting in much harsher judgments on 16 different moral dilemmas. Zhong et al. [65] suggest that these contradictory findings stem from a distinction between abstractly primed feelings of cleanliness (i.e. performing a scrambled-sentences task containing cleanliness words such as pure, washed, pristine etc.) and primed self-cleanliness (i.e. reading and visualizing sentences like *"My hair feels clean and light. My clothes are pristine and like new"* etc.). Since abstractly primed feelings of cleanliness do not have a clearly identifiable source, it makes participants prone to misattribution and consequently varying scientific results. Another type of explanation is provided by a replication study of Schnall et al. [64]. Here, the findings suggest that the frequency of the effect within a population is substantially smaller than the original estimates. This means that researchers investigating this connection (between cleanliness and morality) should use large sample sizes to have the necessary statistical power to detect these subtle effects [66]. Another suggestion is that the findings in such studies might only be applicable under certain conditions. For example, the work of Zhong and Liljenquist [63] has recently been the focus of numerous replication attempts. A recent *meta*-analysis compared the results from 15 of these replication studies and noted that the resulting weighted mean effect size was small across all the studies, and nonsignificant for the subset of studies conducted in independent laboratories [67]. Regardless, it is not unreasonable to believe that psychological responses to moral transgressions could influence laundering decisions, and that there is more to doing the laundry than just cleaning clothes.

Looking at a broader picture, self-cleaning not only seems to remove any past *moral* concerns but also remove past concerns in general (i.e. *"wiping the slate clean"*). For example, athletes on a winning streak avoided washing their "lucky socks" while those on a losing streak changed their outfit and took a shower [68]. In other words, physical cleansing not only removes physical contaminants but also moral taints and mental residues [69].

Closely linked to these concepts are associations between religious purity rituals and concepts of cleanliness. Preston and Ritter [70] found that religious priming made concepts of cleanliness more available and increased the subjective value of cleaning products. In turn, Chan [71] found that religious people expressed stronger desire for showering and using soap when reminded of immoral acts such as casual sex. The same type of dynamic for personal hygiene products and cleaning behaviors were also found for participants that held more conservative political views, as well as for participants who expressed more negative attitudes towards casual sex.

Religiousness, or specifically God-beliefs, also seem to moderate daily experiences of cleanliness. In a two week study with 135 participants, Fetterman [72] collected daily measurements of feelings of cleanliness together with daily measurements on neuroticism, behavioral impulsivity, and levels of prosocial actions during the day. The results showed that daily impulsive behaviors predicted lower feelings of cleanliness, and daily prosocial behaviors predicted higher feelings of cleanliness. Additionally, daily feelings of cleanliness predicted lower levels of neuroticism for people with strong God-beliefs. All of the effects were amplified by strong feelings of God-belief [72].

3.2.3. *Psychological dimensions of cleanliness and cleansing practices with focus on daily activities.*

One psychological article that explicitly included laundering in the study of habits was Labrecque et al. [50]. Here, the occurrences of 'habit slips' as resistance to new products (in this case a fabric refresher) were investigated through a survey and later through a four-week experiment. The study demonstrated that high product usage was achieved by two specific groups: participants who chronically thought a lot about their laundry (regardless of the experimental condition) and participants who integrated the fabric refresher into their laundering routine through a habit-cued strategy, especially if they normally thought little about their laundry. The authors also noted that many participants slipped back into their old habits regardless of favorable intentions to use the product. Thus, behavioral change and adaptation of new products must consider pre-existing habits for successful implementation. This final conclusion fits well with the findings from Gärling [73] who noted that previous frequencies of performance, regarding cleaning and taking showers, better predicted future frequencies of performance rather than reported intentions.

Another initiative with an psychological focus for behavioral change was recently tested by Conrady et al. [16]. In the study, participants' laundering behavior were observed at the beginning and end of a three-year period. During the period, each of the households were subjected to motivational interviewing (a method traditionally used in therapy for behaviors constituting health risks). The results indicate that methods that go beyond traditional consumer information are needed to increase the sustainability of laundering habits. Some barriers to change were identified:

- Anxiety about damaging the washing machine by a higher laundry load
- Anxiety about having a poor wash results by using less detergent
- Resistance to changing laundering habits (e.g. a fixed wash day)
- Resistance to accumulating too much dirty laundry before washing

3.3. *Laundry and laundering from a technical perspective*

The largest category of research publications on laundry and laundering was the technical category. Here, 37 articles were identified. Most findings in this literature stem from statistical values collected and analyzed through large surveys, although quantitative data collection or

Table 3
Characteristics of articles focusing on technological aspects of laundering. The term 'Western' means a combination of Europe, North America, Australia, and/or New Zeeland. 'N/A.' means theoretical work, or a review without a specific geographical limitation. Number of articles in parenthesis.

Publication year	Country/ Region	Data type	Top 3 journals
1990–1999 (1)	Global (6)	Quantitative (20)	International Journal of Consumer Studies (10)
2000–2009 (1)	Europe (17)	Mix (9)	Sustainability (6)
2010–2020 (35)	Asia (6)	Qualitative (8)	Journal of Cleaner Production (4)Energy Efficiency (4)
	Western (2)		
	North America (2)		
	Australia (1)		
	Mexico (1)		
	N/A (2)		

mixed methods is not uncommon. The geographical spread is quite large although studies focusing on e.g. African consumers are missing, see Table 3.

Four general themes can be noted. These themes are the technological dimensions of laundering with focus on *national context, international comparisons, textile and fashion consumption,* and *specifics of the laundering practice.* Each theme is explained below.

3.3.1. Technical dimensions of laundry and laundering based in national context.

Looking at laundering from a national perspective, one interesting observation is how culture and availability of technology interact. In Sweden for example, shared laundries were introduced during the 1920 s and have been the norm throughout the nation since the 1950 s [74]. However, a major shift began in the early 1990 s and since then most new multi-family buildings are equipped with private, in-unit washing machines, replacing the shared laundry rooms. This has implications both for the behaviors when washing laundry, as well as the associated material aspects and resource consumption [75].

Another ongoing change seems to be happening in China where consumer preferences have been shifting from the presently common impeller washer, towards the drum washers [76]. This change also seems to be coupled with a change in consumer perceptions of how clothes should be cleaned. Lin and Iyer [76] argue that the main reason for this change is recent marketing campaigns from European manufacturers advertising the drum washers' "superior quality" in cleaning performance, in addition to longer lifetimes and water saving features. Drum washers are also marketed as much more fashionable, compared to impeller washers [77]. Unfortunately, the data also show that the adoption of the drum washer in China will lead to increased cost for consumers and higher national greenhouse gas (GHG) emissions on account of their use of warm water.

Changing laundering behaviors has also been noted in Japan. New family structures and life styles, as well as the introduction of automatic washer-dryers, are currently altering environmental impacts of laundering chores [78]. One initiative strives to use design approaches to steer consumers toward product sharing alternatives (i.e. use of laundromats). Amasawa et al. [79] identified several drivers for making communal laundry rooms attractive (such as availability and concerns with security/privacy) as well as countervailing reasons for not being able to forgo a private washing machine (such as unwillingness to share machines or laundering space with others, or the perceived lack of freedom to launder anytime). Crosstabulation of the results also showed that consumers feel the need for laundromats the most during lifestyle changes, or when new laundromats open in the neighborhood. Similar dynamics were observed in Thailand although the acceptance of laundromats and variability in their users' behavior was greater [80]. For example, whereas different types of laundromats were used in order to save time, handwashing was still thought to offer the highest quality of cleanliness. This perception leads many consumers to pre-wash their clothes by hand before using a washer. The study also revealed that the majority of respondents (87.8%) wear their clothes only once before washing them, and that sweaty clothes have to be changed in less than a day.

The same authors also provided a more detailed comparative study regarding consumer motivations in Tokyo and Bangkok [81]. Notably three main findings could be identified:

- Residents in Tokyo seems to use coin-operated machines out of convenience whereas inhabitants in Bangkok use them for more basic laundering needs.
- Having access to both private and coin-operated washing machines lead to inefficient utilization and higher emissions of GHG.
- Changing (i.e. reducing) consumer requirements for laundering show high potential to reduce emissions of GHG.

In this context it should be noted that there are no, or very few, options for using heated water in the washers sold in Thailand, much like other Asian countries such as China, South Korea and Japan [80]. This might explain the difference in perception between Asian and Western consumers where the latter have much stronger belief that clothes must be washed in heated water to become clean. An exception to this seems to be consumers living in India who generally associate heat with hygiene and thus typically wash clothes in hot water when someone is ill [82,83].

The laundering behaviors of German [43,84], Norwegian [7], and Finnish [85] consumers were recently investigated. Kruschwitz et al. [84] identified reasons for laundering decisions as well as reasons for dissatisfaction with washing performance. Participants in their study who washed when they thought they could fill a machine had a higher load factor than people that washed as soon as they felt that they needed one or a few specific items. Additionally, the more exactly the laundry was sorted, the higher the wash frequencies [43]. That being said, neither of the stated reasons for washing resulted in a full machine in terms of its technical definition. Instead the filling rate varied between 58% and 78% [84]. This is consistent with previous findings that household factors (such as age and household size) hardly relate to load size and choice in temperature. Instead, load size seems to positively correlate with wash frequency apart from small households (one – two persons). In these smaller households the correlation is instead negative, perhaps because the consumers need laundry articles within a specific time and have fewer articles [86]. The top three reasons for dissatisfaction with washing performance in the German study by Kruschwitz et al. [84] included: (1) no/bad stain removal, (2) bad smell, and (3) crumpled textiles.

On a sidenote, other socio-demographic and physical factors than just household size might also influence decisions. For example, unemployed consumers or consumers with a lower level of education seems to use fabric enhancer more, and iron their clothes less often, than those with a university degree. Lower levels of education also seem to correlate with a smaller number of weekly laundry loads, fewer cases of pre-wash, higher average wash temperature, and more frequent use of the tumble dryer [87].

The German reasons for dissatisfaction with washing results [84] differed from Norwegian consumers investigated by Laitala et al. [7]. For them the top three reasons for dissatisfaction with washing performance were instead: loss of color or shape, or poor stain removal. Notably an overwhelming majority of the Norwegian participants agreed that it was embarrassing to wear clothes smelling of body odor. This fear of having body odor may inhibit the change to lower washing temperatures.

For Finnish consumers some of the main reasons for putting clothes in the laundry basket were the loss of fit and firmness, the "odor of wear", or obvious discoloration [85]. Changes in laundering were mostly connected to changed family size (i.e. having children) and the introductions of new technology (i.e. buying a new tumble drier). The study also concluded that a majority of the respondents felt that their behavior could have an effect on the environment.

Lastly, consumer laundering behavior has also been investigated in Mexico. One interesting finding was that most Mexican participants looked to their elderly for washing advice but not for advice when purchasing of new machines [88]. Another finding was that hand washing was common (dominant for around 20% of Mexicans). However, this statistic is falling as Mexicans try to minimize time and effort connected to laundering work.

3.3.2. Technical dimensions of laundry and laundering based in international comparisons.

Globally speaking, the demand for sustainable laundry products is growing rapidly [83]. However, how laundering is performed vary considerably between countries and reliable data about actual consumer behavior is missing. Even so, some cultural differences can be noted.

According to Pakula and Stamminger [89], it is common to reuse bath water in Japan for laundry washing. Japanese consumers also tend to be the most frequent washers with about 10 loads per week per household, which probably is a result of the widespread use of short and cold wash programs. In Europe the average wash frequency is instead around 3.2 loads per week per household, although it should be recognized that consumer behavior is distributed around this mean. Similar wash frequencies can be found in Turkey, North America, Australia, and South Korea. The lowest wash frequency is identified in China.

Another finding in the multinational study by Pakula and Stamminger [89] was that consumers in some countries (e.g. South Korea and Japan) had high levels of pre- and post-treatments for laundry. This might indicate that the performance of the washing machine does not match consumer demands, or that consumers lack knowledge on how to effectively use the machine. For example, consumers who wash in areas with hard water are much more frequently disappointed with the wash result, compared to consumers living in areas with soft water [90]. One reason for this might be that many consumers are unaware that higher detergent doses or water softeners are needed when washing with harder waters.

It is also evident that the drying patterns vary between countries and consumers [91]. Around 50% of Danes, Britons and Swedes have access to a tumble dryer within the household unlike Italians (8%), Hungarians (8%), and Czechs (3%). The use of a tumble dryer varies with yearly seasons but a correlation between ownership and usage has been found. This means that, on average, more energy is used for drying laundry in Sweden compared to the Czech Republic. Schmitz and Stamminger [91] also note that line drying outside is preferable, but line drying clothes inside might cause serious problems for the residents due to the fostering of mold. However, the problem might be avoided by increasing the ventilation in the room while drying (i.e. opening a window), although this will lead to additional energy loss from the room itself.

When comparing consumer behavior in India, UK, and Brazil, both similarities and differences can be noted. For example, according to Spencer et al. [82] people in India, UK, and Brazil all seem to evaluate their dirty clothes in the same way. This was either done by a sensory perception of dirtiness (e.g. appearance or smell) or a time related variable (e.g. worn for two days).

Drawing on the same dataset, some different elements of behavior could however be identified between the countries, which in turn were classified as cultural significant or independent. One example of a cultural significant variable was the external environment (e.g. climate or built environment) that shaped how and when the laundering was done. The cultural independent elements were instead categorized as more tied to the perceptions, aspirations, senses etc. of the person doing the laundering [92].

3.3.3. Technical dimensions of laundry and laundering based in textile and fashion consumption.

Laundering has also been analyzed using the clothing itself as a reference point. A literature review by Laitala et al. [93] showed that woolen garments are treated differently compared to garments made out of cotton. This was true even after controlling the data for garment type. For example, clothes made from wool were used twice as many days before washing as the same clothes made from cotton. Similar conclusions were found in a broader investigation into the relationship between fiber content and environmental impacts from clothing [10]. Here, the authors found that the type of garment were a dominant factor for influencing washing frequency. Clothes worn closer to the skin were changed and washed more often. Interestingly, Laitala et al. [10] also noted that odor intensity alone cannot explain the difference in wash frequency. This might have to do that some clothes differ in terms of usage pattern (i.e. only worn at special occasions) but might also be a result of different design or structures of the fabric. McQueen et al. [94] also focused on the fabric itself and provided a striking report on how the loss of mass and color differed for denim jeans for different user profiles (washed every second day or washed every 20th day) during a 60-day trial period. The indicators of garment damage and wear caused by doing the laundry in these different ways differed by 50 – 100% between the two groups.

However, even though textile type and wash frequency affect the clothing lifespan (as well as the associated environmental impact of garments) these findings are seldom incorporated into life cycle assessments for clothes or for laundering [93]. Additionally, since arguments of a more altruistic nature (e.g. *"it's good for the environment"*) seems to fail to change behavior, another possible avenue to explore according to McQueen et al. [94], would be to focus on benefits to the consumer (e.g. *"by washing more frequently you damage your clothes"*).

Harris et al. [95] also endorsed this change in perspective, noting that social norms relating to consumption and affluence (as well as to cleanliness and freshness) pose a specific challenge for consumption of sustainable clothing. They suggest communicating money and labor savings from reduced frequency and temperature when washing our clothes. Such information might be especially important since only a few participants in their study reported awareness of the environmental and social impacts of fast fashion, while those that did still was attracted by trendy styles and low prices [96]. Contrary to common belief, garment use periods seem to be fairly consistent regardless of the consumer segment. This means that the common argument used by wealthier consumers that they are *"buying less but better"* and using their clothes for a longer time is generally false [97]. On the other hand, openness to alternative business models for sustainable fashion (e.g. sharing) varied between consumer segments with higher or lower income. Similar arguments and underlying values for sustainable fashion consumption have been captured by Lundblad and Davies [98]. Here, consumers expressed motivations to engage in eco-clothing consumption in terms of six different types of personal values linked to perception of:

1. economic value from buying less but better
2. better self-expression and self-esteem
3. less health problems from natural materials
4. environmental responsibility
5. accomplishment (i.e. guiltlessness and good feelings)
6. social justice

Unfortunately, it is unclear whether these values continue to guide consumer decisions during the use-phase of the clothes (i.e. when they wash their laundry). Additionally, since the study built on *post hoc* reflections, the respondents might over-rationalize their purchase decisions [98]. This is especially important for questions regarding garment consumption since clothing is closely linked to individual identity, which might subconsciously influence the participants answers [99].

3.3.4. Technical dimensions based in specifics of laundering behavior.

Laundering can also be defined and investigated based on the decisions and preconceptions of different consumer segments. Stamminger [100] constructed six different consumer segments and calculated energy consumption for each group. The result shows a variation between the most careless and the most sustainable groups by a factor five regarding energy and water usage. Interestingly, line-drying in a heated room inside the home appears to be the most energy-consuming process when doing the laundering. This means that the total energy needed by the heating system in a ventilated house outweighs the energy needed for a traditional tumble dryer. In another technical evaluation of emissions from laundering, long wash cycles as a possibility for saving energy were investigated. One specifically interesting detail that was revealed from the data collection of Alborzi et al. [101] was that 40% of the participants in the study stated that they used the short cycle program to "save energy and water". At the same time, 38% of the participants did not believe that a washing program with a long wash cycle could be energy-saving. These types of reasoning and preconceptions have also

been acknowledged by recent sociological research such as Sahakian [49] and Pink and Postill [44].

However, it is not all studies that engage with consumers that find an interest in reducing environmental emissions. For Conrady et al. [16], 70% of their participants did not take sustainability into account in the laundering process. Half of these participants said that a low-cost or a good washing result was instead more important than minimizing environmental impact when washing the laundry [16]. Interestingly, this focus on lowering costs might be utilized to facilitate changed behavior, at least for consumers open to alternative business models such as pay-per-use laundering. In a small test group with consumers from the start-up HOMIE (a private pay-per-use laundry service), participants exhibited a reduction both in the number of washes and the average wash temperature as soon as they started to pay for each wash compared to the initial first free month [102].

Other more detailed analysis of environmental impacts from laundering decisions include an experimental study performed by Laitala et al. [5]. Here five variables (washing temperature, machine filling, detergent dosage, spin speed, and drying method) were connected to the behavioral aspects of the consumer. The study included suggestions for guiding consumers towards lower wash temperatures and detergent dosage, as well as technological improvements like automatic dosage and higher spin speeds. However, the authors conclude that the largest positive effect could be obtained by changing consumer habits to a greater degree, rather than new technical solutions.

A much bigger campaign for behavioral change regarding laundering habits is instead Procter & Gamble's "low-temperature laundry initiative" that recently has developed into the ongoing international campaign "*I prefer 30*". According to Mylan [103] this campaign has led consumers to wash at lower temperatures and the success can be attributed in part to a change of focus: instead of categorizing consumer segments from shared demographics or attitudes, Procter & Gamble developed understandings of how consumer behavior varied as a function of different types of laundry (e.g. soiling, materials, colors, and use of clothing). In addition to developing physical and chemical properties for detergents suited for low-temperature washes, Procter & Gamble also trained specific "sniffers". These personnel compared aromas of the laundry at different phases during the wash in order to optimize the design of the fragrances emitted from wet and dry laundry. Unfortunately, as impressive as this is, some authors argue that the considerable effort and resources put in to the "*I prefer 30*" campaign will not suffice to meet the European aspirations of reducing emissions from laundering. Instead, policy must be developed that recognize system-level interactions between industries, consumers, and regulatory bodies [104].

With that said, the interest in the smell of laundry and how odor might influence behavior, has also been investigated by McQueen et al. [105]. Here, stated behaviors about laundry care was linked to whether the imagined dirty clothes smelled or not. Cross tabulating survey answers from a number of western countries/regions (Australia, Canada, Europe, New Zeeland, UK and USA) showed a change in behaviors; respondents were more prone to wash odorous clothing in hotter water, as well as air dry the washed clothing rather than using a tumble dryer.

4. Analysis: Towards interdisciplinarity

The aim of this study to illuminate previously overlooked dissimilarities and commonalities of studies investigating factors that may underlie domestic laundering. The goal is to establish a basis for interdisciplinary research and future policy, in order to enable effective interventions aiming to reduce the environmental impacts of textile consumption.

Looking at the results, it is evident that trying to understand and explain domestic laundering is not a new endeavor. However, only a few of the studies listed in this review attempt to find common ground between different fields of expertise. This chapter should be viewed as a first step to account for this missing perspective. Based on the different general subjects of study presented in the listed articles we have constructed a simple framework void of any boundaries of scientific traditions. In this regard, a first category that needs to be included would be the individual herself and how he or she personally consciously and subconsciously relates to laundering. For example, Jack [36] identifies individual drivers and barriers for laundering and Gram-Hanssen [37] illustrate personal rules for handling clean and dirty clothes amongst her participants. At the same time, Hess et al. [51] investigate subconscious dynamics tied to laundering decisions, while Alborzi et al. [87] try to find correlations between laundering behaviors and socioeconomical indicators (e.g. level of education).

With that said, no individual exists in a vacuum. A second category reflects how individuals simultaneously create, shape and form the outside world and are being shaped and formed by the outside world. This means that aspects such as cultural heritage and social conventions will indirectly affect laundering and influence consumer decisions. This point has for example been highlighted by Shove [25] and Mylan and Southerton [27]. Further, more explicit, examples of how such "unwritten rules" can influence decisions can for instance be found in the Brazilian studies by Neves [40] and Neves [41]. In a more general sense, examples of cultural and geographical differences of how people launder can also be seen in the numerous national and international investigations listed under chapter 3.3.1 and chapter 3.3.2.

Looking at the huge amount of technological research it is obvious that the known and available methods, tools, and chemicals (i.e. technology) heavily influence the ways we clean our clothes. This third and final category thus complements the first two by focusing more on the materialistic aspects of laundering.

It should be noted that each of these categories are interesting in and of themselves. However, if the quest is to understand what *shapes* laundering it might be more interesting to look at how each of these categories interact. Going through the listed articles once more, looking more closely at potential interactions between these new categories, three general principles can be identified regarding domestic laundering:

1. Technology changes conventions, while social context dictates market acceptance of new cleaning technology.
2. Technological solutions are often suggested to influence consumers, but individual concerns seem to override the effect of the interventions.
3. Consumers are guided by social conventions, rooted in underlying psychological dynamics (e.g. moral dimensions of cleanliness).

This overarching structure is illustrated by Fig. 2 and described in more detail under chapter 4.1 – 4.3.

4.1. Interactions between technology and social conventions

4.1.1. Technology changes conventions.

As noted by Shove [25], the introduction of new technology tends to alter established conventions in regard to cleanliness practices. For example, the introduction of automatic washing machines both in China [77] and in Brazil [82] has been associated with a higher consumer class. As a consequence, the introduction of these machines has reduced the need for hired household-helpers. The available and accepted technological system also defines which social conventions flourish. In many western cities, laundering has traditionally been a labor-intensive work confined to the private sphere of the home. This changed with the social spaces of wash houses and public laundries. As washing machines became more affordable, laundering practices once again departed the public sphere, re-privatized in the home [106]. Another example is Sweden where most newly built multi-family buildings are equipped with private, in-unit washing machines, forgoing the traditional shared laundries [74]. As one can expect, these technical changes have ramifications both for the social convention of what it means to launder, as

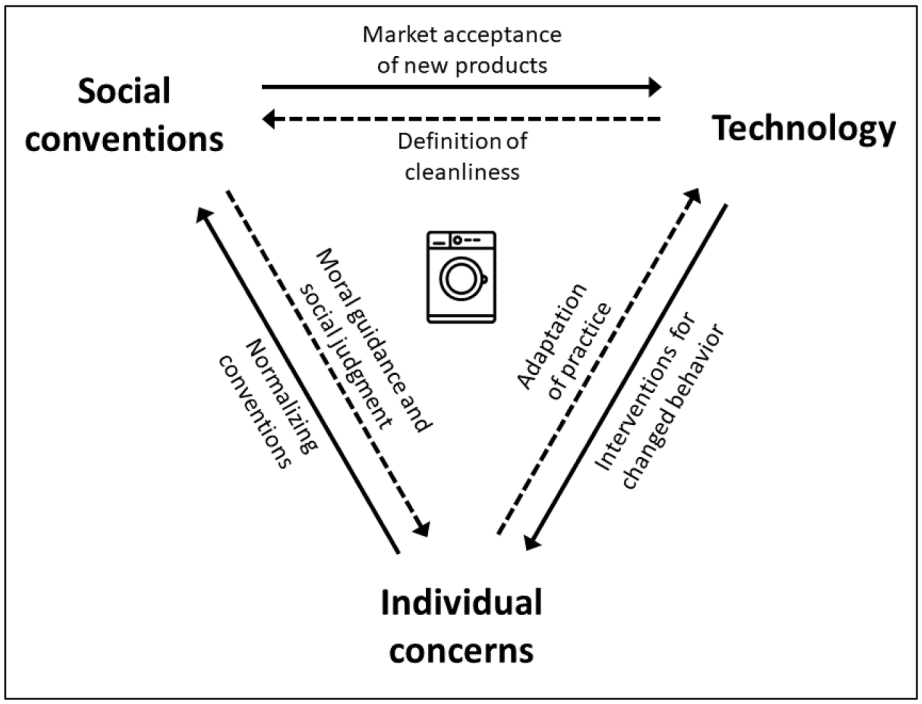

Fig. 2. Suggested interactions between social conventions, individual concerns, and technology that shape how we wash our clothes. Arrows indicate the direction of the influence.

well as the emissions associated with the practice or behavior. This notion has also been acknowledged by the work of Retamal and Schandl [26].

Technological advances also change how consumers define "cleanliness". For example, while this once meant sanitized (i.e. without bacteria) the concept of laundry cleanliness has been shifting towards a broader meaning of "whiteness" [25]. This becomes especially evident when looking at the use of optical brightener technologies (chemicals which convert UV to visible light) in washing powders, additives which reached widespread adoption during the second half of the 20th century [107]. Changes in the definition of cleanliness for laundry are important to acknowledge since they have implications for resource consumption, and by extension environmental emissions. Such changes in definition not only relate to the composition of detergents (i.e. different formulas focusing on dirt removal rather than bacteria killing properties) but could also influence the use period for the clothes themselves (e.g. consumers discard clothes due to stains that are not removed by the washing machine). For example, many consumers avoid buying white clothing since these inevitably end up with unremovable stains (i.e. yellow armpits and collars) that are considered especially disgusting [48].

4.1.2. Social context dictates technology acceptance.

Presently many Asian consumers wash their laundry in cold water, and the most common type of washing machine in the continent is the impeller washer. One reason for the low market penetration of the drum washer could be its European origin compared to its competitor the Japanese (i.e. Asian) impeller washer but might also be the societal perceptions regarding heat and cleanliness. In contrast to many western countries and cultures, washing temperature has traditionally not been a criterion for cleanliness evaluation [80,82]. This has in turn undermined the attractiveness of drum washers since the machine then provides a purposeless service (i.e. washing in hot water), at a higher cost compared to the impeller washer [76]. However, as noted by Wang et al. [77] and Lin and Iyer [76], this seems to be changing. Marketing campaigns in China are currently focusing on changing housewives' perceptions towards it being fashionable to have a drum washing machine at home (compared to the impeller washer), resulting in a steady growth of sales for drum washers since the 1990s [76]. In the long run such a change could mean a much higher resource consumption and emissions for laundering practices in Asia.

Social contexts could also work as a barrier toward the general *usage* of washing machines, rather than a specific brand or technology. This was obvious the case in Soweto, where washing machines had become a symbol of laziness, leading consumers away from using them [34]. Contrary, in Brazil, ownership of a private washing machine has traditionally been quite low (35.6% in 2006). However, marketing efforts have connected the ownership of washing machines to consumer class and status. These initiatives are thus moving consumer preferences away from alternative cleaning practices such as airing, brushing, and handwashing and are currently driving market penetration at a rate of 5.3% per three years [82].

4.2. Interactions between technology and individual concerns

4.2.1. Technological solutions are suggested to influence consumers.

A common trait in the reviewed literature was that technological solutions often are proposed to steer consumer behavior towards more sustainable laundering decisions. These types of approaches often assume that consumers lack adequate knowledge, or that they act in irrational ways when interacting with technology [108].

For example, Harris et al. [95] suggest that consumers need more information, as well as education, about the technical and chemical aspects for clothes care (e.g. to communicate time, money and labor savings from changed behavior). These conclusions are also echoed by several other authors within the field, e.g. McQueen et al. [94], Alborzi et al. [87] and Stamminger [100]. Another example is design interventions to steer interactions with the machines, such as automatic dosing as a way to avoid over/under-dosing of detergent [5], or integration of cultural aspects when designing the machine [82]. Intelligent machines that adjust resource consumption to the level of the machine's loading are common in new equipment. However, due to the long lifecycle of the machines much of the current global infrastructure is old and regulatory measures on this front are warranted.

The reviewed literature also suggests that decisions are highly influenced by personal preconceptions about laundering as well as fear of a poor washing result. Thus, contrary to previous studies, it might be more useful to look at behavior not as misinformed (e.g. by consumers not *knowing* the appropriate detergent dose) but as risk management (e.g. consumer using the amount of detergent that has previous resulted in a good wash result). With that in mind, there are some technological interventions that are worth pursuing because they are so far upstream in the garment life cycle that they are disengaged from the individual concerns. For example, greenhouse gas emissions from laundering in Europe vary by a factor of 6.5 between countries depending on the energy source [109]. A rapid transition to clean energy production globally would thus lead to a major reduction in greenhouse gas emissions from household laundering, without changing consumer practices or behavior.

4.2.2. Individual concerns seem to override the effect of interventions.

Unfortunately, design interventions and information campaigns seem to have little success in changing behavior [11,12]. Regardless of available technology, habits rather than intentions seem to guide behavior [50,73]. None of the identified articles addressed this type of individual adaptation with the exception being Conrady et al. [16]. Thus, any successful policy targeting laundering must consider already existing habits. Habits are "a form of automaticity in responding that develops as people repeat actions in stable circumstances" [110]. Strong habits are difficult to change without a major external destabilization of a person's circumstances, something like a divorce, change of career, emigration, or the loss of a family member. Weak habits on the other hand may be influenced by information alone, but successful habit change strategies focus on the contextual cues of habitual behavior. In the absence of such strategies, individual intentions to change seem trumped by expressed individual concerns such as anxiety about damage, poor wash results, or self-identification with ownership of private washing machine. One such example is that many consumers mistakenly believe that the eco-programs installed in modern washing machines have lower cleaning capabilities. However, the underlying reasons for these beliefs are unclear and need to be further investigated.

Since habits and individual concerns seems to be a barrier for sustainable laundering. Some general strategies to overcome these include (a) environmental reengineering [111] (b) stimulus control and (c) vigilant monitoring of the unwanted response to heighten inhibitory, cognitive control processes [112]. Monitoring with normative feedback that is descriptive (comparing with others) and injunctive (denoting social approval) may be more effective than other kinds of feedback [113]. Studies examining these psychological processes may lead to a better understanding of when and how normative information affects behavioral antecedents. One approach that combines the first two of these could be to use engineering and stimuli that relate laundering decisions to other important goals for the individual (e.g. immediate feedback regarding cost). For example, alternative business models (e.g. private pay-per-use services) seem to push consumers towards fewer washes at lower temperature. The potential environmental benefits of these services should be further investigated.

4.3. Interactions between social conventions and individual concerns

4.3.1. Consumers are guided by social conventions.

Neves [40] concluded that in Brazil, washing machines are generally looked upon with skepticism and only hand washing is seen as the proper way to clean clothing [40]. Similar attitudes seems to be held by consumers in Japan and South Korea [89], Thailand [80], and Mexico [88] judging by the extensive practice of manual prewash and/or post wash when using a washing machine. Especially interesting in this context is how laundering practices are taught over generations, while at the same time adapting to change.

From the literature, it is apparent that the social conventions for sorting laundry steer practices and influence judgment. In addition, social conventions were evoked as the reason for specific decisions by the majority of the participants interviewed by Mylan and Southerton [27], as well as the underlying reason for historical changes in laundering practice investigated by Klepp [2]. That social conventions dictate garment use periods, as well as laundering frequency, also became quite evident when challenged by Jack [36] in regards to jeans usage.

Since social norms are part of the problem, it might be effective to address these concerns directly. Although on a small scale, two such examples have already been tried by Jack [45] and Sahakian [49] with promising results. Another example could be social campaigns that tries to establish shabby clothes as a signal of environmental righteousness, or "challenging" consumers to try alternative cleaning practices (i.e. providing an "excuse" to try new ways of relating to laundering).

4.3.2. Social conventions might be rooted in psychological dynamics.

Shove [25] concludes that *"Freshness is in essence a state of mind: Knowing things are clean, people feel good about wearing them"*. Jack [36] made similar findings. This resonates well with the psychological dimensions of cleanliness in which cleaning tend to remove past concerns in general, as described by Bleak and Frederick [68].

The importance of psychological dynamics is also evident when comparing the explicit reasons for laundering behavior described in the Brazilian study by Neves [40]. Not only were moral concerns relating to the sorting decisions explicit, but there were also emotions and values connected godliness and the workload needed for hand wash. For example, one of the participants explained that *"[…] When I go out, I want to smell good, fresh and clean. When I go to church, I go this way, it means love to God"*. This might be a practical example of the role that God-beliefs plays in relationship to psychological dimensions of cleanliness shown by Fetterman [72]. Many participants in the Brazilian study also expressed the desire to attain the attention and admiration of others as a main motivator to cleanliness. This type of desire can be described by costly-signal theory [114,115] in that the clean clothes function as a way to signal virtue (i.e. availability to time and effort) to other consumers. It is also possible that clean clothes can function as a moral signal, as expressed by the popular Brazilian saying *"I am poor, but clean"* [40].

Another factor to keep in mind is that what constitutes a moral transgression in relation to cleanliness (and in this case dirty laundry) is culturally and historically dependent [38,116]. This means that in today's society, mixing pants and underwear with a table cloth when washing would activate feelings of disgust in Brazil but not in Sweden.

Yet another interesting aspect seems to be the connection between cleanliness and smell. For example, several studies have identified individual concerns regarding sweat and odor as a guiding principle for dirty laundry evaluation [27,45,117], and the fear of smelling has also been stated as the main motivator to change clothes regularly [37]. This type of influence may not come as a surprise given that olfactory sensations seems to be used for first impression formation [52], personality assessment [54], and during formations of social identity [118]. Smell also seems to elicit social suspicion or cooperation [56], be used as a basis for social exclusion [57,58], and function as a signal for close social relationships [61]. Furthermore, sensitivity to smell seems to predict the harshness of purity violations [119], while in-group relations attenuate core disgust in relation to sweaty clothing [59].

In all, this indicates that people tend to make moral judgment regarding cleanliness automatically [120], while having an intuitive understanding of the importance of smell. Fear of smelling seem to drive and steer cleanliness practices regarding laundering. If so, engineers should be designing washing systems to eliminate this fear in the most sustainable way, focusing on hedonic masking or odor removal (e.g. aerating systems), rather than on the capacity for spot removal. With that said, some of the findings regarding effects of embodiment may only be applicable under certain conditions. Yet, looking at a broader picture

it is not unreasonable to assume that such psychological dynamics could influence, and to some extent normalize, social conventions.

5. Discussion

5.1. Limitations

It is evident that there is no single factor that drives consumer behavior nor determines what type of laundering practice flourishes in society. The answer to our research question is instead that domestic laundering is shaped by an interplay between social convention, individual concerns, and technology. With that said, we find that the general principles identified in our analysis stem from research literature that are heavily rooted in a modern (i.e. the last 10 years) western context, written predominantly by western researchers (including this article). Notably, 95 % of the studies with a technical perspective were published after 2010. This could be a result of a narrow filtering process or, more probably, that research concerning domestic laundering has traditionally been carried out by researchers from western universities. However, this means that there might be other prominent dimensions shaping laundering practices and consumer behavior in Asia, South America, or Africa that this mapping review fails to capture. For example, the suggestion that the fear of smelling could steer laundering assumes that olfactory sensations are important in the specific social context. One might speculate that odour is considered less of a problem in cultures that use more spices in their food (that provide hedonic masking) or are situated in humid climates (making sweating unavoidable).

5.2. Future research

As noted in the introduction, there are collaborative challenges associated with the scientific division between regarding laundering as a behavior or as a practice. Although a lot of work remains, we hope that this article can be used as a first step to overcome some of these difficulties. Merely creating a common vocabulary for industry and academia to describe sustainable textile life cycles is a basic need recognized in recent ISO committee work [121]. A natural continuation of this article would be to find a coherent epistemology for laundry research, especially since some argue that this is crucial for truly fruitful interdisciplinary collaborations [18]. A specific challenge in this regard would be to find common interdisciplinary ground for looking at laundering as a practice or as consumer behavior.

Even so, there are lessons to be learned from the findings. For example, most of the reviewed literature concerns the dimension of technology and social conventions, as well as technology and individual concerns (i.e. principle 1 and 2). This is not surprising since these studies often aim to reduce environmental impacts of laundering decisions, which in turn could be regarded as a technical aspect. Only a few of the articles in this review suggest interventions that also address the individual's fear of social judgment (i.e. principle 3). If there is a tension between these principles, some of the previous interventions may have forced consumers to choose between social risk and environmental emissions. Also, since few consumers acknowledge that laundering leads to environmental emissions, there is no incentive for change.

One avenue for future research could then be to investigate if such a tension exists, and to what extent it could be used to alter laundering practices or consumer behavior. As previously noted, two such examples have already been tried by Jack [45] and Sahakian [49] with promising results. Yet, it should be noted that the findings presented in this article concerning the psychological aspects of laundering are suggestive, based on circumstantial findings connecting articles from sociology and technology with psychological concepts of cleanliness and dirtiness. While sociological research suggests a connection between wash frequencies for laundering and social norms, actual psychological testing of operationalized hypotheses is missing.

Looking at the current literature, environmental impacts associated with alternative business models (such as private pay-per-use services) should be further investigated since such services seem to push consumers towards fewer washes at lower temperature. Another area for future research is to identify the reasons for consumer misperceptions regarding the cleaning capabilities of eco-programs installed in modern washing machines [122]. Lastly, more knowledge is needed about why some consumers think that short cycles lead to lower emissions [49], and why many consumers do not believe that laundering leads to environmental emissions [123]

6. Conclusions

This review identifies three guiding principles that underlie contemporary domestic laundering practices and consumer behavior: (1) technology changes conventions while social context dictates technology acceptance; (2) technological solutions are often suggested to influence consumers, but individual concerns seem to override the effect of such interventions; and (3) consumers are guided by social conventions, rooted in underlying psychological dynamics (e.g. moral dimensions of cleanliness).

Looking at these principles it is easy to understand why the majority of previous policy measures focusing on sustainable laundering has failed. Many interventions addressed only a part of a principle (often the first part of principle 1 or 2), while disregarding other important parts. For example, consumers are often informed of the importance of sustainability (e.g. "*washing at lower temperature is good for the environment*"), while questions of social belongings are left out (e.g. "*many of your neighbors and friends wash at lower temperature*"). To increase the possibility of a lasting change, it would be beneficial if instead all of the three principles are addressed.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

The search string was constructed by using the following eight blocks in this combination:

(5 OR 6 OR 7) AND ((1 AND 2) OR (3 AND 1) OR 4 OR (3 AND 2) OR 8).

1. Laundr* OR Clothes OR Apparel* OR Linen*
2. Wash* OR Clean* OR Laundr* OR "Soil removal"
3. "Washing machine" OR "Tumble dryer" OR "Drying cabinet" OR "Household appliance"
4. "Laundry room" OR Laundromat OR Launderette
5. Psycholo* OR Cleanliness* OR Driver* OR Barrier* OR "Psychological factor*"
6. Habit* OR Behaviour* OR Practice* OR Action* OR Pattern* OR Routine* OR Attitude*
7. Tradition* OR Culture* OR Convention* OR Inconspicious OR Conspicious
8. "Personal hygiene" OR "Shower*"

ProQuest

The search string was automatically translated by ProQuest to:

(((noft(Psycholo) OR noft(Cleanliness*) OR noft(Driver*) OR noft (Barrier*) OR noft(("psychological factor" OR "psychological factors"))) AND at.exact("Article") AND la.exact("English")) OR ((noft(Habit*) OR noft(Behaviour*) OR noft(Practice*) OR noft(Action*) OR noft(Pattern*) OR noft(Routine*) OR noft(Attitude*)) AND at.exact("Article") AND la. exact("English")) OR ((noft(Tradition*) OR noft(Culture*) OR noft (Convention*) OR noft(Inconspicious) OR noft(Conspicious)) AND at.exact ("Article") AND la.exact("English"))) AND ((((noft(Laundr*) OR noft (Clothes) OR noft(Apparel*) OR noft(Linen*)) AND at.exact("Article") AND la.exact("English")) AND ((noft(Wash*) OR noft(Clean*) OR noft (Laundr*) OR noft("Soil removal")) AND at.exact("Article") AND la.exact ("English"))) OR (((noft("Washing machine") OR noft("Tumble dryer") OR noft("Drying cabinet") OR noft("Household appliance")) AND at.exact ("Article") AND la.exact("English")) AND ((noft(Laundr*) OR noft (Clothes) OR noft(Apparel*) OR noft(Linen*)) AND at.exact("Article") AND la.exact("English"))) OR ((noft("Laundry room") OR noft(Laundromat) OR noft(Launderette)) AND at.exact("Article") AND la.exact ("English")) OR (((noft("Washing machine") OR noft("Tumble dryer") OR noft("Drying cabinet") OR noft("Household appliance")) AND at.exact ("Article") AND la.exact("English")) AND ((noft(Wash*) OR noft (Clean*) OR noft(Laundr*) OR noft("Soil removal")) AND at.exact ("Article") AND la.exact("English"))) OR ((noft("Personal hygiene") OR noft(Shower*)) AND at.exact("Article") AND la.exact("English")))*

The search in ProQuest was carried out on the 1st of February 2021. However, the initial result of 3112 articles was deemed too large and further limitations had to be introduced. In practice, this meant that a number of databases were excluded since these were assumed to index a limited number of articles relevant for this study. These databases were: Art, Design & Architecture Collection, Coronavirus Research Database, Early Modern Books, Ebook Central, Index Islamicus, Linguistics and Language Behavior Abstracts (LLBA), Literature Online, Periodicals Archive Online, Philosopher's Index, ProQuest Dissertations & Theses Global, PTSDpubs, Publicly Available Content Database, and the following sub-categories from the Social Science Premium Collection: Criminology Collection, Education Collection, International Bibliography of the Social Sciences (IBSS), Library & Information Science Collection, Linguistics Collection, Politics Collection. This exclusion generated a final list of 1493 articles on the 1st of February 2021.

Scopus

The same block combinations were used in Scopus. However, the initial result of 10,765 articles was deemed too large and further limitations had to be introduced. In practice, this meant that a number of subject areas were excluded by using Scopus own filtering option. The following 13 subject areas were deemed out of scope and excluded: Medicine, Physics and Astronomy, Agricultural and Biological Sciences, Immunology and Microbiology, Nursing, Earth and Planetary Sciences, Pharmacology, Toxicology and Pharmaceutics, Computer Science, Health Professions, Veterinary, Mathematics, and Dentistry. The translated search string in Scopus thus became:

((TITLE-ABS-KEY (psycholo* OR cleanliness* OR driver* OR barrier* OR "Psychological factor*")) OR (TITLE-ABS-KEY (habit* OR behaviour* OR practice* OR action* OR pattern* OR routine* OR attitude*)) OR (TITLE-ABS-KEY (tradition* OR culture* OR convention* OR inconspicious OR conspicious))) AND (((TITLE-ABS-KEY (laundr* OR clothes OR apparel* OR linen*)) AND (TITLE-ABS-KEY (wash* OR clean* OR laundr* OR "Soil removal"))) OR ((TITLE-ABS-KEY ("Washing machine" OR "Tumble dryer" OR "Drying cabinet" OR "Household appliance")) AND (TITLE-ABS-KEY (laundr* OR clothes OR apparel* OR linen*))) OR (TITLE-ABS-KEY ("Laundry room" OR laundromat OR launderette)) OR ((TITLE-ABS-KEY ("Washing machine" OR "Tumble dryer" OR "Drying cabinet" OR "Household appliance")) AND (TITLE-ABS-KEY (wash* OR clean* OR laundr* OR "Soil removal"))) OR (TITLE-ABS-KEY ("Personal hygiene" OR "Shower*"))) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "PHYS") OR EXCLUDE (SUBJAREA , "AGRI") OR EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "NURS") OR EXCLUDE (SUBJAREA , "EART") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "COMP") OR EXCLUDE (SUBJAREA , "HEAL") OR EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "MATH") OR EXCLUDE (SUBJAREA , "DENT"))

This exclusion generated a final list of 1554 articles on the 1st of February 2021.

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