Water demand management research: A psychological perspective

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[1] The availability of fresh water for human consumption is a critical global issue and one that will be exacerbated by the impacts of climate change. Water demand management has an important role to play in reducing the vulnerability of freshwater supplies to climate change impacts. In this paper, we argue that the field of psychology and environmental psychology in particular can make a vital contribution in understanding further the drivers of residential water demand. A growing body of literature in environmental psychology has examined the determinants of water conservation behavior, and this research has many potential applications for water demand policy. In this paper we offer a review of current psychological research that examines the five broad causes of residential water conservation behaviors: attitudes, beliefs, habits or routines, personal capabilities, and contextual factors. We assess how psychologists have studied water conservation behavior to date, identify shortcomings, and indicate how this research can be used to further promote residential water conservation and to inform evidence-based policy and practice.

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1. Introduction

[2] The availability of freshwater resources for urban populations has become a focal issue in recent years. The Intergovernmental Panel on Climate Change (IPCC) has predicted that "freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems" [*Bates et al.*, 2008, p. 3]. Indeed, Bates et al. suggested that existing stressors on water demand including population growth, land use change and urbanization will be exacerbated by climate change. Although water shortages are likely to impact a range of sectors including industry and agriculture, IPCC predictions suggest that residential water demand is an important area for focus given projected and actual population growth in relatively water scarce urban areas [*Bates et al.*, 2008]. Thus, future reductions in water supply and increasing water demand will be critical issues worldwide [*Bates et al.*, 2008], requiring policy and strategies that specifically address urban water demand management [*Brooks*, 2006; *Jeffrey and Gearey*, 2006].

[3] In an effort to secure urban water supply into the future, demand-side management has emerged as an essential component of a total water cycle management approach, and a complement of more traditional supply side approaches to the management of fresh water [*Arbués et al.*, 2003; *Baumann et al.*, 1984; *Brooks*, 2006; *Jeffrey and Gearey*, 2006]. The importance of demand management is heralded by the IPCC as a "no-regrets option" to cope with increasing vulnerability of fresh water in the face of climate change impacts [*Bates et al.*, 2008, p. 136]. Demand-side management is distinguished from supply side management in that it focuses on the amount and patterns of water use by consumers [*Bates et al.*, 2008; *Brooks*, 2006]. In this way, demand management involves as much attention on water use behavior as it does on technology or infrastructure [*Baumann et al.*, 1984; *Brooks*, 2006].

[4] Recognition that water use behavior is a critical aspect of water demand management highlights a need for a better understanding of the psychological processes that underlie residential water demand. We argue that only through identifying the key psychological and social drivers of water use and conservation, can effective policy be developed to address urban water demand management [*Abrahamse et al.*, 2005; *Steg and Vlek*, 2009]. Despite the clear need for research in this area, scant attention has been paid to the contribution and potential of the field of psychology in understanding and promoting water conservation behavior [*Trumbo et al.*, 1999]. A growing body of literature in environmental psychology has examined the underlying mechanisms of conservation behaviors (e.g., behaviors that conserve resources such as water or energy) and this research has many potential applications for water demand policy. We argue that integration of the environmental psychology literature into the broader domain of water resources research can make an important contribution to furthering our understanding of residential water demand and, hence, provide valuable information to policymakers working in this space.

[5] As a first step toward these goals, the current paper reviews the environmental psychology literature on residential water demand management. Although there is a

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growing literature within environmental psychology on conservation behaviors, there has been relatively less focus on water conservation in comparison to energy conservation [*Bamberg and Möser*, 2007; *Vining and Ebreo*, 2002]. Nevertheless, the current findings can provide valuable information about the factors that influence residential water conservation behavior. Therefore, the major aim of this paper is to provide an overview and analysis of environmental psychology research on residential water conservation and in so doing help to inform water resources management and planning.

[6] The current paper reviews the environmental psychology literature on residential water demand management. The findings of the review provide valuable information on the factors that influence water conservation behavior. In section 2, water demand management is defined and two types of conservation behaviors are identified: curtailment behaviors and efficiency behaviors. In section 3, we review research that examines five broad causes of water conservation behavior: attitudes, beliefs, habits, personal capabilities, and contextual factors [cf. *Stern*, 2000]. Through the review we highlight (section 4) the main drivers of residential water conservation while at the same time recognizing the limitations of the existing literature. Finally, in section 5 we suggest ways that policy makers may be able to promote more sustainable residential water consumption. Readers may wish to initially skip the detailed review of literature in section 3 for the overview in section 4 and then return for detail.

2. Defining Water Demand Management

[7] Water demand management is defined as any actions that reduce the amount of water used or enable water to be used more efficiently [*Brooks*, 2006]; hence, the term water conservation is often used synonymously with water demand management [*Baumann et al.*, 1998]. Consistent with this definition we adopt the term "water conservation behavior" to define and measure the broader concept of water demand management. Using this term has two advantages. First, the definition clearly encompasses actions that aim to conserve water and thus captures the behavioral aspects of water demand management. Second, the focus on water conservation behavior maintains consistency with research from environmental psychology. In further defining water conservation, we differentiate between two types of water conservation behaviors: efficiency behaviors and curtailment behaviors [*Gardner and Stern*, 1996]. Efficiency behaviors refer to one-off behaviors such as installing water-saving shower heads or rainwater tanks that facilitate ongoing water savings. In contrast, curtailment behaviors refer to individuals' actions that conserve water such as only washing full loads of clothes, taking shorter showers and turning off the tap while brushing teeth. The distinction between efficiency and curtailment behaviors is one that is adopted in psychological studies of resource conservation such as energy [e.g., *Abrahamse et al.*, 2005] and transport [e.g., *Kaiser et al.*, 2003]. Distinguishing between these two types of behaviors is important because they are argued to be underpinned by different social and psychological drivers [*Gardner and Stern*, 1996], a proposition that has been supported by *Lam* [1999], who found that the drivers of water efficiency behaviors were significantly different to those of water curtailment behaviors. Therefore, delineating between efficiency behaviors and curtailment behaviors is an important consideration in understanding the determinants of water conservation behaviors.

[8] In making the distinction between efficiency and curtailment behaviors, it is also apparent that there is some overlap between efficiency behaviors (i.e., installation of water efficient appliances) and supply side management strategies. For example, an efficiency behavior may include the installation of a rainwater tank or reusing gray water in the garden. Both of these behaviors are supply side strategies, narrowly defined [*Brooks*, 2006]. In the present review, however, we argue that local forms of supply side management can be considered water conservation behaviors, e.g., the use of recycled water for nonpotable end uses. *Brooks* [2006] makes a similar argument and suggests that demand management may include all behaviors and strategies at the local household level. Therefore, in this review, behaviors involving the water consumer are considered within the realm of water demand management and, thus, are defined as water conservation behaviors.

3. Causes of Behavior

[9] Using *Stern* [2000] as a guide, the determinants of water conservation behaviors can be categorized into five underlying causes: attitudinal factors, beliefs, habits or routines, personal capabilities, and contextual forces. These causal categories are presented in Table 1. Although Stern conceives of beliefs as an attitudinal factor, we have separated out beliefs as the research often explores these factors separately and beliefs may be conceived as a precursor to attitudinal factors [*Eagly and Chaiken*, 1993; *Ajzen and Fishbein*, 2000]. In sections 3.1–3.5, research that examines each of these behavioral determinants is reviewed. A summary of the key determinants of water conservation behaviors and supporting literature is included in Table 2.

3.1. Attitudes

[10] Within the psychological literature, attitudes are defined as an evaluation of an entity such as an object or a behavior [e.g., *Eagly and Chaiken*, 1993; *Ajzen and Fishbein*, 2000]. Thinking unfavorably about water conservation or favorably about recycled water reflects negative and positive attitudes respectively. One of the most widely used theories investigating the relationship between attitudes and action is the theory of planned behavior (TPB) [*Ajzen*, 1988, 1991]. The TPB has been used to understand decisions to engage in a broad range of behaviors including water conservation [*Clark and Finley*, 2007; *Harland et al.*, 1999; *Kantola et al.*, 1983; *Lam*, 1999, 2006]. According to this theory, the most immediate predictor of behavior is an intention (i.e., a motivation or plan) to engage in the behavior. Intentions are in turn predicted by three main factors: attitudes, subjective norms and perceived behavioral control. Figure 1 illustrates the variables of the TPB and presents the behavioral example of installing water efficient appliances.

[11] Consistent with the usual definitions of attitudes, in the theory of planned behavior attitudes refer to the overall evaluation of performing the behavior as positive or negative. For example, viewing water conservation as a favorable action reflects a positive attitude toward water conservation. Subjective norms assess whether people perceive social

Table 1. Determinants of Water Conservation Behavior

Determinants	Explanation	Example
Attitudinal factors	evaluations of water-specific behaviors, general environmental attitudes, norms (personal and social), values	"Conserving water is beneficial"
Beliefs	broad beliefs about the environment, water specific beliefs	"Water is an unlimited resource"
Habits or routines	standard practices relating to water use	doing full loads of washing
Personal capabilities	knowledge and skills, availability of time, literacy, money, social status and power	having money available to purchase and install water efficient appliances
Contextual factors	household composition, physical infrastructure, availability of efficient technology, water pricing	whether home is rented or owned

support from important others in their life to engage in a behavior. If people perceive that their family and friends think that water conservation is a worthwhile activity then they will feel that they have social support for water conservation behaviors and this makes it more likely for them to engage in water conservation actions. Perceived behavioral control reflects the extent to which people think that a behavior is something they can easily do. Perceived behavioral control also picks up on *actual* control over an action. If someone is not able to install a water efficient device such as a rainwater tank because of a lack of money, then they do not have actual control over the behavior and this lack of control will impact directly on intentions to install a rainwater tank (i.e., efficiency intentions). Thus, according to the TPB if people have a positive attitude toward water conservation, if they perceive that important others in their life think that it is a good thing, and if they think that it is something they can easily do, then they will intend to engage in water conservation and their intentions should in turn translate into water conservation actions.

[12] Research conducted using the TPB consistently demonstrates a positive relationship between attitudes and behavioral intentions [*Armitage and Conner*, 1999]. The match in specificity of attitudes and behavioral intentions accounts for the association. For example, if the focal behavior is installing a rainwater tank then it is attitudes toward installing rainwater tanks that is the important driver of this behavior rather than more global attitudes toward environmental protection or water conservation in general.

[13] In relation to water conservation behavior, there is support for the positive impact of attitudes on behavior. Across a range of studies drawing on the TPB, attitudes consistently predicted intentions to engage in water conservation curtailment and efficiency behaviors [*Clark and Finley*, 2007; *Harland et al.*, 1999; *Kantola et al.*, 1983; *Lam*, 1999, 2006]. *Clark and Finley* [2007] investigated curtailment intentions (e.g., taking shorter showers, sweeping terraces instead of washing them with water) and efficiency intentions (e.g., replacing existing shower heads and toilets with fixtures designed to use less water). In addition to the finding that people who had more positive attitudes to these actions had stronger intentions to engage in them, they also found that subjective norms (i.e., perceptions of social pressure to engage in water conservation), and perceived behavioral control (i.e., perceptions of control over conserving water) were also statistically significant predictors of water conservation intentions. That is, people were more likely to intend to engage in water conservation actions and install water efficient appliances if they thought that other important people in their life supported these actions and they felt that they were things that they could easily do. Similarly, *Harland et al.* [1999] showed that stronger intentions to turn off the tap when cleaning teeth were associated with more positive attitudes toward this behavior, a sense that it was an easy thing to do, and personal norms that reflected a sense of moral obligation to engage in the behavior.

[14] Research by *Lam* [1999] showed that attitudes and perceived behavioral control were the most important drivers of efficiency intentions (i.e., intention to install water-saving appliances), and curtailment intentions (i.e., intention to use less water), however, in more recent research *Lam* [2006] found that attitudes and subjective norms were the most important drivers of intentions to install a dual-flush toilet. Similarly, *Kantola et al.* [1982] and *Trumbo and O'Keefe* [2001, 2005] found that attitudes and subjective norms were statistically significant positive predictors of water conservation intentions. Note that the research by Kantola et al. and Trumbo and O'Keefe was framed by the theory of reasoned action and, therefore, no measure of perceived behavioral control was included in the studies. From these studies, it is clear that more positive attitudes to water conservation were associated with higher water conservation intentions.

[15] Overall, the studies described above demonstrate that, when measured at the appropriate level of specificity, attitudes are an important determinant of water conservation intentions. The key message is that developing positive attitudes toward water conservation behaviors may be a crucial factor in any program promoting residential water conservation. The TPB research also highlights the role of social norms and perceptions of behavioral control as important predictors of water conservation intentions, a finding that accords with other research investigating conservation behaviors more generally [*Cheung et al.*, 1999; *Fielding et al.*, 2008a, 2008b]. These latter findings also suggest that water conservation programs should seek to gain widespread support in the community for water conservation and provide strategies that ensure that people find it easy to engage in water conservation behaviors.

3.2. Beliefs

[16] Within the environmental psychology literature beliefs are often conceptualized as a person's worldview which reflects beliefs about the relationship of people with the natural world [*Schultz et al.*, 2004]. Research investigating the relationship between beliefs and water conservation behaviors has predominantly drawn on a survey scale called the new ecological paradigm (NEP) [*Dunlap et al.*, 2000]. The NEP scale seeks to measure people's general

Table 2. Significant Predictors of Residential Water Conservation

Determinant Category	Water Conservation Behavior	Significant Predictors[a]
Attitudinal factors	efficiency intentions, e.g., intention to install efficient shower heads, intention to install dual-flush toilets	attitudes [*Lam*, 1999, *Lam*, 2006], subjective norms [*Lam*, 2006], perceived behavioral control [*Lam*, 1999]
	curtailment intentions, e.g., intention to take shorter showers, intention to turn off tap while cleaning teeth	attitudes [*Harland et al.*, 1999; *Lam*, 1999], perceived behavioral control [*Harland et al.*, 1999; *Lam*, 1999], personal norms [*Harland et al.*, 1999]
	water conservation intentions[b]	attitudes [*Clark and Finley*, 2007; *Kantola et al.*, 1982; *Trumbo and O'Keefe*, 2001, 2005], subjective norms [*Clark and Finley*, 2007; *Kantola et al.*, 1982; *Trumbo and O'Keefe*, 2001, 2005], perceived behavioral control [*Clark and Finley*, 2007]
Beliefs	water conservation behaviors, e.g., taking shorter showers, or installing low flow shower head, as measured by self reported behavior, observations or actual water meter readings[b]	environmental beliefs and ecological world view [*Corral-Verdugo et al.*, 2008], water-specific beliefs [*Corral-Verdugo et al.*, 2003]
	water conservation intentions	environmental beliefs and ecological world view [*Clark and Finley*, 2007]
	efficiency intentions	water-specific beliefs [*Lam*, 1999; *Lam*, 2006]
Habits or routines	water conservation behaviors	clothes washing habits [*Aitken et al.*, 1994; *Gregory and Di Leo*, 2003], showering habits [*Gregory and Di Leo*, 2003]
	water conservation intentions	general water use habits [*Trumbo and O'Keefe*, 2005]
Personal capabilities	water conservation behaviors	age: older residents more likely to conserve [*Clark and Finley*, 2007; *Gilg and Barr*, 2006; *Gregory and Di Leo*, 2003], older residents high water users [*Lyman*, 1992], working adults demonstrated more conservation and teenagers demonstrated less conservation [*Mayer et al.*, 1999]; education: greater education increased water conservation [*Gilg and Barr*, 2006; *Lam*, 2006], lower-educated households report greater conservation [*Gregory and Di Leo*, 2003]; household income: higher income households conserve less water [*Gregory and Di Leo*, 2003; *Jeffrey and Gearey*, 2006]
	water conservation intentions	age: older residents less likely to report conservation intentions [*Kantola et al.*, 1982; *Clark and Finley*, 2007]; education: lower-educated households report greater conservation intentions [*Clark and Finley*, 2007]; climate change knowledge [*Clark and Finley*, 2007]
	efficiency intentions	household income: higher income results in greater intention to purchase dual-flush toilet [*Lam*, 1999]
Contextual factors	water conservation behavior	number of residents in household [*Aitken et al.*, 1991; *Aitken et al.*, 1994; *Gregory and Di Leo*, 2003; *Jeffrey and Gearey*, 2006]; home ownership [*Randolph and Troy*, 2008]; water pricing: providing information on water pricing improved price elasticity [*Gaudin*, 2006]; community identification important determinant under conditions of fixed rate pricing structure [*van Vugt*, 2001]
	water conservation intentions	type of home: householders in detached home have greater intention to conserve water [*Clark and Finley*, 2007; *De Oliver*, 1999; *Gilg and Barr*, 2006]; type of home is cultural specific: householders in detached homes have less intention to conserve water in Taiwan [*Lam*, 2006]

[a]Unless otherwise indicated, significant predictors have a positive relationship with water conservation behavior.
[b]This category includes behaviors where curtailment and efficiency were not distinguished by the researchers.

environmental beliefs and their ecological worldview. The scale measures beliefs about the limits of nature and resources, human impacts on the balance of nature, humans' right to dominate over nature, and the potential for ecological catastrophe. The NEP has been used to predict behaviors such as recycling [*Johnson et al.*, 2004], support for environmental policies [*Rauwald and Moore*, 2002], environmental group membership [*Schuett and Ostergre*, 2003], and influencing the environmental actions of organizations [*Stern*, 2000].

[17] The work of *Corral-Verdugo et al.* [2008] and *Clark and Finley* [2007] have used the NEP survey scale to investigate the relationship between environmental beliefs and water conservation behavior. In both studies, participants

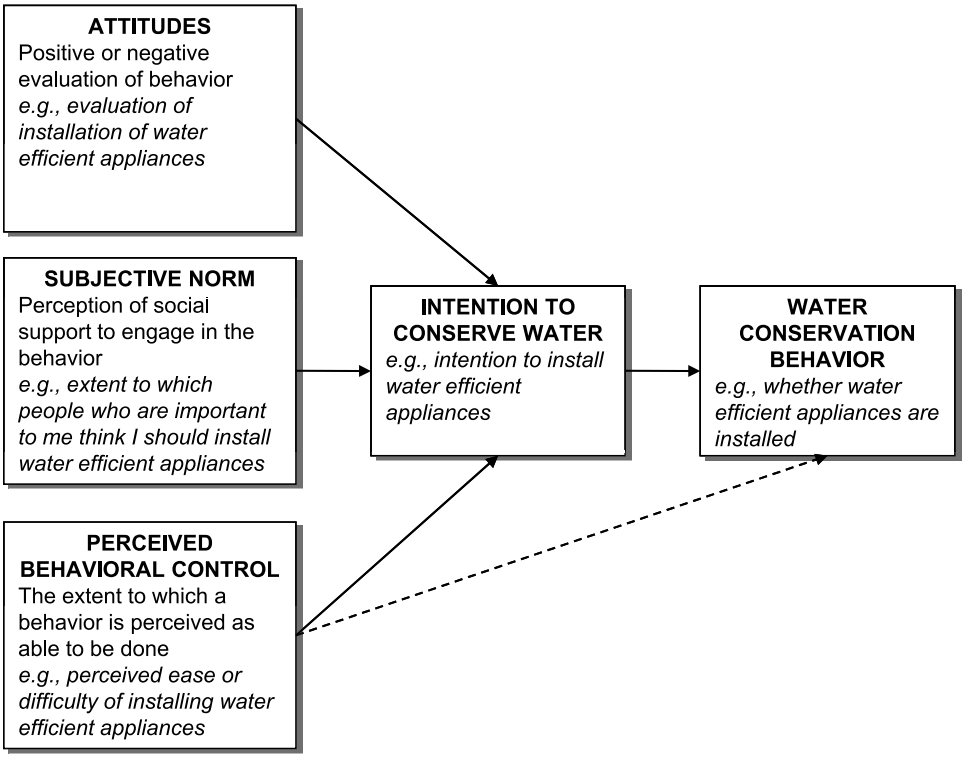

Figure 1. Theory of planned behavior, with water saving examples.

responded to a survey where they were asked questions about their environmental beliefs (as measured by the NEP) and water conservation behaviors (e.g., turning off taps while soaping, reducing shower time, reusing water from washing machine and sink). Results from both studies showed that general environmental beliefs predicted self-reported water conservation behaviors [*Corral-Verdugo et al.*, 2008] and water conservation intentions [*Clark and Finley*, 2007].

[18] Other research by *Corral-Verdugo et al.* [2003] demonstrated that it is more specific beliefs about water rather than general environmental beliefs that are the most immediate drivers of water conservation behaviors. *Corral-Verdugo et al.* [2003] found that when people had more utilitarian water beliefs, that is, they thought of water as an unlimited resource, they engaged in less water conservation behaviors. In contrast, when people thought about water as a limited resource that should be conserved, this was related to engaging in more water conservation behaviors. These findings are consistent with the attitude literature; just as it is specific attitudes about water conservation behaviors rather than broad environmental attitudes that are important for predicting water conservation behavior, specific beliefs rather than general environmental beliefs are the important drivers of water conservation behaviors [cf. *Fishbein and Ajzen*, 1975].

[19] Further evidence for this conclusion comes from research by *Lam* [1999]. In his research people who perceived that they should be able to use as much water as they want had lower intentions to install water efficient devices. Later research by *Lam* [2006] also showed that intentions to install water efficiency devices increased when people believed that they were more vulnerable to drought, when they had greater belief that the community as a whole would take action, and when they perceived greater benefits of installing a dual-flush toilet. Intentions to install water efficient devices were lower on the other hand when people believed that other alternatives (e.g., having shorter showers, only doing full loads of washing) would be more effective.

[20] In summary, the studies described above [*Corral-Verdugo et al.*, 2003, 2008; *Lam*, 1999, 2006] suggest that beliefs people hold about water conservation play a role in determining water conservation intentions and behavior, although specific water-related beliefs are more predictive than generalized worldviews about the environment. The finding that beliefs play a role in predicting water is consistent with psychological theories such as the TPB [*Ajzen*, 1988] and the value-belief-norm model [*Stern*, 2000], that argue that beliefs will be important drivers of people's environmental intentions and behavior. The challenge for policy makers is to identify the most important and salient beliefs associated with water conservation. If these beliefs are identified, they can help guide programs aimed at promoting water conservation. For example, the installation of water efficient devices could be promoted through information and demonstrations that foster positive beliefs about the multiple benefits of the devices (e.g., water savings, long-term cost savings) and counter negative beliefs (e.g., that low flow shower heads are not as effective).

3.3. Habits or Routines

[21] The dominant perspective in environmental psychology suggests that individuals make rational and rea-

soned choices [*Bamberg and Möser*, 2007; *Hines et al.*, 1986; *Vining and Ebreo*, 2002], an assumption that is equally evident in water resources policy literature [*Burness et al.*, 2005; *Espey et al.*, 1997]. Within psychology, however, there is a growing recognition that behavior is also guided by automatic processes such as habits or routines [*Steg and Vlek*, 2009; *Stern*, 2000; *Verplanken and Holland*, 2002]. As defined by *Verplanken and Holland* [2002, p. 287], habits are "relatively stable behavioral patterns, which have been reinforced in the past… [and] are executed without deliberate consideration, and result from automatic processes, as opposed to controlled processes like consciously made decisions." Habitual behaviors are thereby guided by an automatic response, rather than deliberative reasoning. Habits are usually conceptualized and measured as the frequency of past behavior as it is thought that behaviors that are performed frequently form habitual patterns that become automatic responses in future situations [*Ouellette and Wood*, 1998].

[22] *Aitken et al.* [1991, 1994] investigated the role of habits in predicting water conservation behaviors, as measured by actual water consumption data. In Aitken's work, habits were measured as self-reports of usual water using behaviors; e.g., usual number of showers and baths per week, number of dish and clothes washing loads per week. Results showed that habits were a less important driver of actual water consumption than were the contextual variables of number of residents per household and net annual property value.

[23] In a later study, *Aitken et al.* [1994] examined habits in more detail by measuring the usual number of clothes washing loads per week, and a collective measure of a range of other water using behaviors (e.g., frequency of leaving the tap running while brushing your teeth). Their results showed that self-reported number of clothes washing machine loads per week was a significant predictor of actual water use.

[24] A more recent study by *Gregory and Di Leo* [2003] also investigated the influence of habits on water conservation behavior. Gregory and Di Leo measured habits as the frequency of past water using behaviors. Comparison of high and low water users showed that low water users did fewer loads of washing and took fewer showers per week than high water users. Moreover, regression analyses showed that the number of showers and the number of times the washing machine was used each week and habits related to washing clothes (e.g., only doing full washes) significantly predicted levels of actual water use with low water users more likely to take less showers, do less loads of washing and only do full loads of washing.

[25] The work of *Trumbo and O'Keefe* [2005] is also relevant in examining the effect of habits on water conservation behavior. While they did not aim to measure habits per se, they measured self-reported behaviors and intentions in relation to water conservation across a 2 year time frame. What they found was that self-reported water conservation behavior in 1998 was a significant predictor of conservation intentions in a follow-up survey in 2000. These findings therefore suggest that habits, when measured as the frequency of past water conservation behaviors, may be an important driver of future intentions.

[26] In summary, scholars have argued that the role of habits is particularly important when designing policies and intervention strategies aimed at changing behavior [*Gardner and Stern*, 1996; *Steg and Vlek*, 2009]. As *Ouellette and Wood* [1998] argue, behaviors that are habitual and automatic will require intervention strategies that encourage conscious decisions to do things differently. At this juncture, our review suggests that the studies investigating the role of habits in water conservation do not provide conclusive evidence of the influence of habits on water conservation. There is some suggestion that habits relating to clothes washing impact on actual household water use [*Aitken et al.*, 1994; *Gregory and Di Leo*, 2003] and that the frequency of past water conservation efforts influence future conservation intentions. Past studies, however, have not assessed habits relating to outdoor water use and this is a limitation when considering the volume of water that can be used in garden irrigation [*Kenney et al.*, 2008]. Clearly, there is a need for further research that systematically and comprehensively examines the relationship between habits, intentions and actual water using behavior before strong conclusions can be drawn about the role of this factor. Nevertheless, the existing findings suggest two important factors for water conservation policies and interventions: First, there may be a need to design interventions that help people to break established patterns of water using behavior that result in high water use. Second, there is a need to understand the household water using habits that have most impact on overall consumption so that these aspects of behavior can be targeted by water conservation interventions.

3.4. Personal Capabilities

[27] Personal capabilities have been shown to be an important factor in understanding conservation behaviors in general [*Stern*, 2000] and water conservation behavior in particular [*Clark and Finley*, 2007; *Kantola et al.*, 1983; *Lam*, 2006]. *Stern* [2000] argues that personal capabilities such as knowledge and skills can facilitate conservation behaviors and he also argues that sociodemographic variables such as age, education, and income may be proxies for personal capabilities. For example, those with higher education and income may have greater awareness of the need for water conservation and greater capacity to install water efficient appliances that can significantly reduce household water use.

[28] Researchers who have examined age and education as determinants of water conservation have demonstrated mixed results, a finding that is echoed in other environmental psychology research [*Tarrant and Cordell*, 1997]. While some researchers have found that older people are more likely to be water conservers [*Clark and Finley*, 2007; *Gilg and Barr*, 2006; *Gregory and Di Leo*, 2003] others have found the opposite. For example, *Kantola et al.* [1982] found that older people were *less* likely to report water conservation intentions. *Lam* [2006] found no statistically significant relationship between age and water conservation intentions. Still other research suggests that particular age groups may vary in their water consumption patterns. *Lyman* [1992], for example, found that retired residents are higher water users, and *Mayer et al.* [1999] found that teenagers in a household increased water usage, whereas adults working full time decreased water usage.

[29] These findings underscore the complexities in the relationship between age and water conservation behavior.

The relationship between age and water conservation may not be linear and instead it may vary as a function of the demands associated with particular life stages and the different experiences of generations. *Gregory and Di Leo* [2003] argue that if older householders have had early experience of relying on dams and tank water for their everyday water this may lead them to care more about water conservation. The discrepancies in research findings emphasize the importance of examining actual behavior, rather than intentions. Indeed, results in relation to age suggest that while age may be positively related to water conservation behavior [e.g., *Clark and Finley*, 2007; *Gilg and Barr*, 2006; *Gregory and Di Leo*, 2003], the relationship between age and behavioral intention may be reversed [cf. *Kantola et al.*, 1982] or very weak [cf. *Lam*, 2006].

[30] Similar inconsistencies are evident in studies that examine education as a determinant of water conservation behavior. For example, *Gilg and Barr* [2006] and *Lam* [2006] found that participants who were more committed to conservation were also more highly educated. In contrast, other researchers have shown that it is lower educated households that demonstrate higher water conservation intentions [*Clark and Finley*, 2007] and more water conservation behaviors [*Gregory and Di Leo*, 2003]. These contrasting findings further highlight the problems arising from relying heavily on measures of water conservation intentions rather than measures of actual water use. One possible explanation is that people with higher levels of education may have greater awareness of what they should be doing, even if that awareness does not translate into action. Thus, there may be a disconnection between what people say and what they actually do [*Anker-Nilssen*, 2003; *Guerin et al.*, 2000].

[31] Although most studies rely on education as a proxy for knowledge capability, *Clark and Finley* [2007] attempted to identify the relationship between specific knowledge of climate change impacts and water conservation behavior. They found that individuals who self-reported greater awareness of climate change and global warming also reported greater water conservation intentions. These results suggest that it may be specific knowledge, rather than the more general measure of education, that is important in determining water conservation behaviors. Indeed, *Hamilton* [1985] argued that a lack of knowledge can result in an inability to accurately report water conservation behaviors.

[32] Results in relation to income are more consistent and research generally shows that higher income households consume more water [*Gregory and Di Leo*, 2003; *Jeffrey and Gearey*, 2006]. *Lam* [1999], however, showed that higher income households had a greater intention to purchase a dual-flush toilet. These results seem to suggest that households with greater income use more water than other households, but they also have the financial capability to purchase retrofit appliances, thus resulting in stronger retrofit intentions. The question that this research does not answer, however, is whether the intentions of these higher income households are translated into action.

[33] *De Oliver* [1999] found that residents who were more educated and had higher incomes responded better to conservation measures. However, he also found that water conservation initiatives were effective only to the extent that they reduced water consumption of higher socioeconomic status households and brought them into line with the water consumption patterns of other households. It could be argued that households in this demographic bracket have greater ability to respond to conservation signals.

[34] In summary, clear findings do not emerge from the research investigating the impact of personal capabilities on residential water conservation. The exception is the findings for income level: households with higher income levels consume more water despite their greater capability to install water efficient devices. More research is needed to delineate the relationship between personal capabilities and water conservation behaviors. Although there is merit in examining sociodemographic factors as proxies for personal capabilities, further research examining the impact of water and climate-related knowledge is also warranted. One of the main limitations of the research described above is reliance on measuring the demographics of the head householder, rather than on the collective household characteristics. *Sharp* [2006] and *Grønhøj* [2006] criticized past research for its individualistic focus. Indeed, both scholars argue that it is likely that the interactions and relationships within the household determine household water use. Despite the lack of clear findings, an important message emerging from these findings is that a "one size fits all" approach to water conservation is unlikely to work as households that vary demographically (i.e., in terms of personal capabilities) also seem to differ in their water use. There may be more or less capacity for households to respond to water conservation programs depending on their personal capabilities. This is a critical consideration when designing programs to encourage and promote widespread residential water conservation within communities.

3.5. Contextual Factors

[35] Contextual factors are important considerations in examining water conservation behaviors because of their potential to facilitate or constrain behavior [*Steg and Vlek*, 2009; *Stern*, 2000]. *Steg and Vlek* [2009] describe contextual factors as the physical infrastructure and technical facilities that exist in a household (e.g., water saving shower heads, rainwater tanks) and the availability of products, and product characteristics. *Stern* [2000] goes further and also includes monetary incentives and costs (e.g., rebates for installing water efficient devices), the physical difficulty of specific actions (e.g., bucketing water from the shower to the garden), and other features of the broader social, economic and political context. Within the environmental psychology literature, contextual factors have not yet been examined systematically [*Steg and Vlek*, 2009]. Indeed, most studies tap into contextual factors by assessing perceived behavioral control, that is, how easy or difficult people perceive it is to engage in an action [see, e.g., *Lam*, 2006; *Trumbo and O'Keefe*, 2005].

[36] There is a large body of literature in water resources management that examines the influence of contextual factors on water conservation behavior (for reviews, see *Arbués et al.* [2003], *Espey et al.* [1997], and *Olmstead and Stavins* [2009]). Although the focus here is on reviewing environmental psychology research, relevant water resources research is drawn upon in order to examine contextual factors as they relate to human behavior.

[37] Past research has identified that the number of residents is an important contextual variable in assessing

water consumption [*Aitken et al.*, 1991; *Aitken et al.*, 1994; *Gregory and Di Leo*, 2003; *Jeffrey and Gearey*, 2006]. *Aitken et al.*'s [1991, 1994] research clearly demonstrates that a significant proportion of water use can be explained by the number of residents in a household. *Gregory and Di Leo* [2003] showed similar results, with significantly more residents in households that were high water users compared to households who were low water users. In relation to water conservation intentions, *Gilg and Barr* [2006] found that households with fewer residents were more often categorized as committed environmentalists and thereby more likely to enact water conservation behaviors.

[38] Although the research evidence clearly shows that numbers of residents per household is positively related to water use behavior, *Hoglund* [1999] has shown that increases in water use is less than proportional to increase in household size. This finding demonstrates that larger households are able to achieve economies of scale in water consumption [see also *Randolph and Troy*, 2008]. *Gilg and Barr* [2006] also found that household size (i.e., number of residents) may present a barrier to establishing a water conserving household, whether because of the increased difficulty of establishing conservation norms among more people, or the limited physical or financial capacity that may be associated with larger family size.

[39] The kind of homes people live in and whether they own or rent not only influences overall water consumption levels, but also how people think about water use [*Randolph and Troy*, 2008]. Researchers have shown that households who live in detached houses report greater intentions to conserve [*Clark and Finley*, 2007; *De Oliver*, 1999; *Gilg and Barr*, 2006]. *Lam* [2006], however, has suggested that this finding may be culturally specific. In his study of residents in Taipei and Kaohsiung, Taiwan, residents in detached houses had less intention to retrofit because they did not have to share water tanks with their neighbors, as did apartment residents. These findings suggest the need to be sensitive to cultural differences in how people use and conserve water.

[40] Home ownership is another factor likely to influence water conservation behavior. *Randolph and Troy* [2008] argued that home owners are likely to have direct control over their homes and are in a better position to undertake retrofitting through the installation of efficiency devices. In contrast, residential tenants have less control over the installation of water efficient devices and also do not necessarily receive a water bill as it is often a hidden cost as part of rental payments. These assertions suggest that home owners may be more likely to engage in efficiency behaviors, compared to tenants. Existing research does not explore whether the influence of psychosocial variables such as attitudes and beliefs differ as a function of household tenure, nor does it investigate whether dynamics within households (e.g., between parents and children) impacts on residential water conservation. Indeed, *Randolph and Troy* [2008] and *Grønhøj* [2006] argued that household dynamics may play an important role in conservation behaviors through social norms and family dynamics, however, these propositions are yet to be tested empirically.

[41] Water pricing is also a significant contextual issue. Research has shown that the price of water is a determinant of residential water demand, along with other contextual factors such as the number of residents per household [*Espey et al.*, 1997; *Arbués et al.*, 2003]. Although price influences water demand, past research has shown that water demand is relatively price inelastic (i.e., demand responds disproportionately to changes in water pricing) [*Espey et al.*, 1997; *Arbués et al.*, 2003]. Furthermore, the use of pricing mechanisms disproportionately affects low income households. That is, price elasticity is likely to be greater in low income households where water costs form a greater proportion of household income. Hence, the influence of water pricing raises issues of equity and fairness [*Olmstead and Stavins*, 2009; *Gaudin*, 2006].

[42] Research has also shown that the relationship between water pricing and water demand can be further understood by including psychological variables in predictive models. Research by *Randolph and Troy* [2008] and *Gaudin* [2006] has shown that knowledge of water pricing has a strong influence on the amount of water used.

[43] *Randolph and Troy* [2008] showed that few consumers understood how water was priced, nor how much water they used. Their results further suggested that most participants were inaccurate in estimating how much water they used. Most participants also estimated that their household used below the average amount of water. The results of the study by *Randolph and Troy* [2008] suggest that water demand may be insensitive to price changes because of a lack of awareness by consumers of the price of water, a point that *Gaudin* [2006] has demonstrated empirically.

[44] *Gaudin* [2006] has further demonstrated the efficacy of including psychological variables when examining water pricing. Gaudin showed that the provision of detailed water pricing information on residents' bills significantly increased the price elasticity of water demand. That is, when residents were presented with detailed and clear pricing information on their bill, they were much more sensitive to increases in water pricing. According to these results, the use of price mechanisms can be much more effective by increasing resident's knowledge and awareness of water prices [*Gaudin*, 2006].

[45] Research by *van Vugt* [2001] has also examined the interaction between psychological variables and water pricing mechanisms. *van Vugt* [2001] showed that whether residents identified with their community was an important determinant of water demand, but only in certain pricing conditions. Specifically, when residents were on a fixed-rate water tariff (i.e., charges were independent of consumption) those who identified strongly with the community used less water than those who did not. In contrast, when residents were on a variable-rate tariff (i.e., charges increased as consumption increased), community identification did not play a significant role. These findings suggest that when price is not relative to consumption, psychological variables such as a sense of shared responsibility or awareness of community norms plays an important role in water conservation. *Bonaiuto et al.* [2008] have also demonstrated that identification with the local community can have a significant impact on self-reported water conservation.

[46] To summarize, the research reviewed in this section demonstrates that contextual factors such as the dwelling people live in, family size, and household tenure (i.e., whether a home is owned or rented) can play an important

role in residential water conservation. Thus, just as we argued that differences in personal capabilities suggest the need to tailor water conservation programs to suit different demographic groups, the literature in this section also highlights the need for a more tailored approach to water conservation that takes into account the different contexts in which people live.

[47] The review also suggests a need to further explore the interrelationships between social and psychological variables and contextual factors. Research by *van Vugt* [2001] and *Randolph and Troy* [2008] demonstrates that the importance of psychological factors differs according to the context in which water conservation is enacted with commitment to the community (as measuring by community identification) only emerging as an important driver of water conservation when price was not related to consumption. Such interrelationships are not often examined, with psychological variables falling within the domain of psychology and contextual factors more often examined within economics and policy research. Few researchers have broadened their research focus to include the other domain. An interdisciplinary focus would therefore be beneficial in order to understand the interactions between psychological variables and contextual factors and their combined influence on water conservation behaviors.

4. Assessing Current Research

[48] The current review provides insight into the key drivers of residential water conservation intentions and behaviors. The review suggests, consistent with the theory of planned behavior, that residents who are committed to conserving water (i.e., have higher water conservation intentions) have positive attitudes to water conservation, perceive social pressure, either from important others such as friends and family or from their own sense of moral obligation, and have a sense that water conservation is within their control. Commitment to water conservation is also underpinned by water specific beliefs, such as thinking of water as a finite resource and feeling vulnerable to drought. In addition, residents who express greater commitment to water conservation are more likely to live in detached houses, have higher education levels and have engaged in water conservation in the past. What is not clear from the existing literature is the extent to which water conservation intentions translate into actual water conservation behavior.

[49] The review also provides some indication of the profile of households who actually conserve water. Water conservers are more likely to have lower levels of income, less residents living in the dwelling and more environmental knowledge. They are also more likely to prioritize environmental issues and they may have developed water conserving habits such as taking shorter showers and doing less clothes washing. Note however, that the predictors of water conservation intentions may vary depending on whether the focus is curtailment or efficiency behaviors.

[50] Although the limitations of existing literature must be acknowledged, the review highlights the practical importance of understanding the key drivers of residential water conservation behaviors. Gaining a comprehensive understanding of the key determinants of residential water conservation provides social scientists with valuable information to inform policy makers about water demand management strategies. The review not only highlights the social and psychological factors that can promote water conservation but also emphasizes the role of context and differences in households' capability to bring about changes in their water consumption. An understanding of the impact of context and personal capabilities brings to the fore the need to avoid a "one size fits all" approach to water conservation and instead highlights the need to tailor water conservation policies and programs to address the different contexts and needs of households. Thus, psychological research is well placed to make a significant contribution to the domain of water demand management and water resources policy in general.

[51] Despite the contribution that the psychology literature makes to our understanding of residential water conservation, it is also evident that there are limitations to the existing literature. One limitation is the lack of differentiation in many studies between efficiency behaviors (e.g., installing a low-flow shower head) and curtailment behaviors (e.g., turning off the tap while brushing teeth) [*Gardner and Stern*, 1996]. It is clear from the present review that few researchers attend to this distinction in their studies, with many studies focusing only on curtailment behaviors [*Corral-Verdugo et al.*, 2003, 2008; *Kantola et al.*, 1983] or combining both types of behaviors within the one measure of water conservation [*Clark and Finley*, 2007; *Kantola et al.*, 1982; *Trumbo and O'Keefe*, 2001, 2005]. This is problematic in light of research that shows differences in the underlying drivers of efficiency and curtailment behaviors [*Lam*, 1999]. Future research in this area therefore needs to treat efficiency behaviors and curtailment behaviors as distinct sets of behaviors [*Gardner and Stern*, 1996; *Stern*, 2000].

[52] A second important limitation of past research is the measurement of water conservation behavior. Past research can be generally classified into three dominant modes of behavioral measurement, including (1) measuring water conservation intention, (2) using self-reported behavioral measures of water conservation, and (3) measuring actual water use, with the majority of studies only measuring water conservation intentions [e.g., *Clark and Finley*, 2007; *Lam*, 1999, 2006] or using self-reported measures of water conservation [e.g., *Corral-Verdugo et al.*, 2008; *Trumbo and O'Keefe*, 2005]. As *Hamilton* [1985] and *De Oliver* [1999] highlight, self-reports of water conservation behavior are often not strongly linked to actual water consumption. While each method has its relative strengths and weaknesses, future research needs to move toward measuring both water conservation intentions and measuring actual water use. This approach provides the most theoretically sound and rigorous approach and it is therefore likely to yield the most useful results for water policy research.

[53] A third limitation of the existing research is the failure to recognize that water conservation usually involves the actions of multiple household members and thereby takes place in a group setting. Hence, household dynamics may play an important role in residential water conservation. Findings from the review give some indication of the importance of the social setting on water conservation. The studies that used the theory of planned behavior (see Figure 1) to frame the research [*Clark et al.*, 2003; *Kantola et al.*, 1983; *Lam*, 1999, 2006; *Trumbo and O'Keefe*, 2001, 2005] showed that water conservation intentions were higher when

individuals perceived social support from important others. In the case of water conservation, this may refer to family and fellow residents, as well as other community members. Indeed, *Lam* [2006] suggested that beliefs about what others in the community would do to address water conservation positively impacted on efficiency intentions.

[54] Further indication of the importance of group level variables such as household or family dynamics on water conservation comes from the research of *Grønhøj* [2006]. In her case studies, Grønhøj found that family communication affected water using behavior and, moreover, that conservation behavior had often been started by one family member and subsequently adopted by others. She further suggests that the relationships and interactions between household residents can provide a form of normative influence, that is, householder members communicate to each other what water conservation behaviors are expected. Indeed, Grønhøj suggests that household conversations can have a direct influence on conservation behaviors. Giving due consideration to the role of household dynamics in water conservation is also an important consideration for policy makers; it may be critical for water conservation interventions to target a "household champion" of water conservation [*Taylor*, 2008] or to design programs that try to involve the whole household in water conservation.

5. Promoting Residential Water Conservation

[55] We argue in this paper that the environmental psychology literature has much to offer water policy makers who are seeking to understand urban water demand and develop strategies to address growing urban water consumption. Tables 1 and 2 outline the key determinants and the significant predictors of residential water conservation behavior. Although our focus in the current review has been on the contribution of the psychological literature for further understanding the key determinants of residential water conservation, it should also be acknowledged that the environmental psychology literature can also make a substantial contribution to the development of evidence-based water conservation policies and programs. There is a large literature on the development and evaluation of behavioral interventions aimed at promoting sustainable environmental behavior broadly [*Abrahamse et al.*, 2005; *Geller*, 2002], and water conservation more specifically [*Aitken et al.*, 1994; *Trumbo and O'Keefe*, 2001].

[56] Within this literature there are a number of approaches to changing behavior. *De Young* [2000] makes a distinction between "antecedent" and "consequence" approaches. Antecedent strategies are proposed to bring about change by influencing the determinants of behavior, e.g., by seeking a commitment to water saving, setting goals, or providing information. An antecedent approach promotes conservation by attempting to change attitudes to water conservation. Research by *Kurz et al.* [2005], for example, showed that prompts about conserving water placed at the point where water is used resulted in households reducing their water use by 23 percent. On the other hand, consequence strategies are said to change behavior by influencing determinants *after* the enactment of behavior. In this way, consequences (positive or negative) are linked to the outcome of the behavior. For example, providing rewards for saving water may reinforce water conserving practices. Similarly, giving households feedback about the level of water consumption in their community can provide information about what is "normative" and thus influence individuals' attitudes and behavior.

[57] In addition to approaches that target the antecedents or consequences of behavior, other scholars distinguish between informational (aimed at changing attitudes, beliefs, motivation, and norms) and structural approaches (aimed at changing contextual factors, such as availability of products and services, regulations, or financial incentives) [*Steg and Vlek*, 2009]. The focus on changing contextual factors is one that is referred to by *Kaplan and Kaplan* [2008, 2009] as the reasonable person model. According to this perspective, people are more likely to act in a reasonable and constructive manner if the environment supports their needs for information, the need to participate in the world in meaningful ways, and the need to feel effective and competent. Similarly, *De Young* [2000] proposes that strategies that promote intrinsic satisfaction with conservation behaviors will be successful at motivating greater engagement in conservation and that satisfaction can be gained from the sense of competence that people gain by enacting conservation behaviors.

[58] Another way in which resource use is often framed is in terms of the "tragedy of the commons" [*Hardin*, 1968], a metaphor that refers to the self-interested overuse of natural resources by individuals that ultimately harms the collective resource through its ultimate depletion and destruction. The crux of this "commons or social dilemma" framing is that individuals gain short-term rewards by "harvesting" from a common pool (e.g., using water for their own purposes) but this short-term individual focus undermines the long-term sustainability of the resource. Broadly speaking, there are two ways in which social dilemmas can be addressed: through structural or psychological approaches [*Messick and Brewer*, 1983]. Structural approaches are aimed at reducing the conflict between self and collective interests. Introducing water meters that charge people for their water use rather than having fixed charges is an example of this. Psychological approaches can change the way people value and think about resources. As an example, when people feel a sense of shared common identity, they are less likely to act out of the collective interests and use resources sustainability [e.g., *van Vugt*, 2001; *Kollock*, 1998].

[59] The group or community focus of the commons dilemma research is also echoed in recent approaches to resource conservation that use teams or neighborhood groups to promote water and other types of resource conservation [*Staats et al.*, 2008; *Lawrence and McManus*, 2008]. The EcoTeam Program, for example [*Staats et al.*, 2004], involves the provision of information and feedback with a focus on the environmental consequences of household behavior in a socially interactive setting. In a study by *Staats et al.* [2004] groups of householders met monthly to follow a workbook focusing on six issues (i.e., water, waste, gas, electricity, transport and consumer behavior) and at each meeting they discussed their experiences and achievements in relation to their household environmental behavior (e.g., any reductions in water use and ways they achieved the reductions). The EcoTeams also received feedback about the performance of their team and all other EcoTeams around the world. In a 3 year longitudinal evaluation of the program *Staats et al.* [2004], reported that

participants had reduced their water use by approximately 3 percent during the intervention period and this increased to almost 7 percent 2 years after the completion of the program.

[60] A full review of the intervention literature is beyond the scope of this paper. Our intention here, however, is to demonstrate how psychological research on the determinants of behavior can be used to guide the development of effective interventions to reduce water use. We have aimed to emphasize that the contribution of environmental psychology to water policy development does not stop at the point of identifying the key determinants of residential water use; it also provides valuable information to inform evidence-based policy in this area. As *Steg and Vlek* [2009] argue, intervention strategies need to be focused on the most important drivers of the behavior. The psychological research reviewed in this paper therefore plays a key role in identifying the most important drivers of water conservation behavior which can be used to inform policy makers about what types of strategies might be most effective to influence these drivers.

6. Conclusion

[61] The field of psychology has an important role to play in understanding further the major drivers of water demand management and, hence, it can make a significant contribution to water policy development. In this review, we have provided an overview of the psychological literature investigating the key drivers of water conservation behaviors. In doing this we aimed to highlight the contribution of environmental psychology findings to the broader domain of water resource management and planning. We examined current research from environmental psychology and classified current research into five broad categories of causes: attitudes, beliefs, habits, personal capabilities, and contextual factors. Current research examining each of these causes was identified and assessed in light of existing limitations. In section 5 of this review, our aim was to demonstrate how current knowledge from environmental psychology might be used to promote residential water conservation behavior and inform evidence-based policy and practice.

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