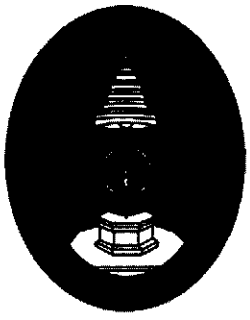


Used Battery Recycling: associated factors and intervention strategies

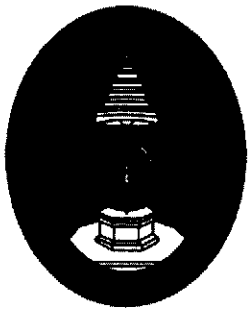
Chainarong Apinhapath* Chanuantong Tanasugarn** Paranee Vatanasomboon**
Natkamol Chansatitporn*** and Allan Steckler****

Abstract

Theories related to recycling behavior of hazardous metals in used battery were reviewed. The theory of Planned Behavior (TPB) which is concerned with the relations between beliefs, attitudes, subjective norms, perceived control, intentions, and behavior was the most often cited in recycling behavior studies. The Altruistic Behavior Model was the second most cited theory. The Health Belief Model and Neutralization Theory were reported only one time each. The predictive power of other factors was also demonstrated when added to TPB. In addition, factors at organizational and policy levels showed an association with recycling behavior. Demographic variables were reported inconsistently. TPB seems to be more effective in predicting recycling behavior. It can be argued that there are many levels of factors associated with recycling behavior. Antecedents and consequences were two groups of behavioral intervention strategies implicated in the reviewed studies. Commitment, barrier removal and feedback seem to be the effective strategies in promoting recycling behavioral change.

Keywords: Used batteries Associated factors Interventions Recycling behavior

* Faculty of Public Health Thammasat Uninversity Rangsit Campus Phaholyothin road Klong Luang Pathumthani 12121 Thailand corresponding e-mail: ap_chai@hotmail.com
** Department of Health Education and Behavioral Science Faculty of Public Health Mahidol University Rajavithi road Phayathai Bangkok
*** Department of Biostatistics Faculty of Public Health Mahidol University Rajavithi road Bangkok
**** Department of Health Behavior and Health Education Gillings School of Global Public Health University of North Carolina North Carolina USA



การหมุนเวียนนำซากแบตเตอรี่มาใช้ใหม่: ปัจจัยที่เกี่ยวข้องและกลยุทธ์ส่งเสริม

ชัยณรงค์ อภิณหพัฒน์* ชะนวนทอง ธนสุกาญจน์** ภรณี วัฒนสมบูรณ์**
ณัฐกมล ชาญสาธิตพร*** และ Allan Steckler****

บทคัดย่อ

จากการทบทวนทฤษฎีพฤติกรรมศาสตร์ที่เกี่ยวข้องกับการนำโลหะในซากแบตเตอรี่กลับมาหมุนเวียนใช้ใหม่ปรากฏว่า ทฤษฎีการกระทำอย่างมีแบบแผน (Theory of Planned Behavior - TPB) ซึ่งกล่าวอ้างความสัมพันธ์ระหว่างความเชื่อ ทัศนคติ บรรทัดฐานของสังคม ความเชื่อมั่นในตนเอง ความตั้งใจ และพฤติกรรม เป็นทฤษฎีที่ได้รับการทดสอบและอ้างอิงบ่อยที่สุดในการศึกษาเกี่ยวกับการนำวัสดุกลับมาหมุนเวียนใช้ใหม่ ทฤษฎีที่ได้รับการศึกษารองลงมา คือ Altruistics Behavior Model ส่วนแบบจำลองแบบแผนความเชื่อ และ Nerutralization theory ได้รับการศึกษาเพียงทฤษฎีละหนึ่งการศึกษาเท่านั้น การศึกษาแสดงให้เห็นความสามารถในการทำนายของปัจจัยอื่นที่เพิ่มเติมในทฤษฎีการกระทำอย่างมีแบบแผน รวมทั้งได้แสดงให้เห็นความเกี่ยวข้องของปัจจัยในระดับนโยบายและองค์กร และปัจจัยส่วนบุคคล กับพฤติกรรมการนำกลับมาหมุนเวียนใช้ใหม่ด้วย การทบทวนนี้แสดงให้เห็นว่าพฤติกรรมการนำกลับมาหมุนเวียนใช้ใหม่เกี่ยวข้องกับปัจจัยหลายระดับ มาตรการที่ใช้ส่งเสริมการนำกลับมาหมุนเวียนใช้ใหม่มีทั้งมาตรการที่ดำเนินการก่อนเกิดพฤติกรรม และหลังพฤติกรรมดำเนินไปแล้ว การให้สัตยบรรณ การลดอุปสรรค และการให้ข้อมูลย้อนกลับดูเหมือนจะเป็นมาตรการที่มีประสิทธิภาพสำหรับส่งเสริมให้นำกลับมาหมุนเวียนใช้ใหม่

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* คณะสาธารณสุขศาสตร์ มหาวิทยาลัยธรรมศาสตร์ ศูนย์รังสิต ถ.พหลโยธิน คลองหนึ่ง อ.คลองหลวง จ.ปทุมธานี 12121
** ภาควิชาสุขศึกษาและพฤติกรรมศาสตร์ คณะสาธารณสุขศาสตร์ มหาวิทยาลัยมหิดล ถ.ราชวิถี พญาไท กรุงเทพฯ ประเทศไทย
*** ภาควิชาชีวสถิติ คณะสาธารณสุขศาสตร์ มหาวิทยาลัยมหิดล ถ.ราชวิถี พญาไท กรุงเทพฯ
**** ภาควิชาพฤติกรรมศาสตร์และสุขศึกษา วิทยาลัยการสาธารณสุขโลกกิลลิงส์ มหาวิทยาลัยนอร์ธคาโรไลนา มลรัฐนอร์ธคาโรไลนา สหรัฐอเมริกา

Introduction

Dry cell batteries are also known as non-automotive, or consumer batteries, or household batteries. There are two basic types of dry cell batteries - primary and rechargeable. Most dry cells are primary batteries that must be replaced once discharged. The primary batteries are also classified as alkaline and "button-cell" types. Alkaline batteries are the everyday household batteries which are commonly used in flashlights, remote controls, and other appliances. Most "button-cell" type batteries, small and round, is normally found in items such as watches and hearing aids and contain mercury, silver, cadmium, lithium, or other heavy metals as their main component (1). Dry cell batteries contain various kinds of toxic metals, i.e. lead, cadmium, mercury, nickel, lithium, zinc, silver, and manganese (2). These metals are harmful to humans as well as to animals and plants (3). The compositions of dry cells and health hazard of some metals in batteries were summarized in Table 1 and Table 2.

Table 1 Compositions of household battery types (4)

Battery type (common name)	Cathode (-)	Anode (+)	Electrolyte	Typical mercury or cadmium weight per cell (%)
Alkaline	Manganese dioxide	Zinc	Potassium hydroxide	Mercury <1%
Carbon zinc	Manganese dioxide	Zinc	Ammonium chloride and/or zinc chloride	Mercury <0.01%
Mercury	Mercuric oxide	Zinc	Potassium hydroxide or sodium hydroxide	Mercury 35-50%
Silver	Silver oxide	Zinc	Potassium hydroxide or sodium hydroxide	Mercury approx. 2%
Zinc air	Oxygen taken from the air	Zinc	Potassium hydroxide	Mercury approx. 2%

Table 2 Potential health effects of metals (3-9)

Metals	Potential Health Effects
Lead	peripheral and central nervous systems, renal function, blood cells, and the metabolism of vitamin D and calcium, hypertension, reproductive toxicity, and developmental effects
Cadmium	high blood pressure, kidney tissue damage, and increased incidence of calcium kidney stones, and heart disease, depress some immune functions, increase lungs and prostate cancer risk, "itai-itai", emphysema, and anemia
Lithium	Parkinson's disease, hyperpyrexia, gastroenteritis, diabetes
Manganese	Liver cirrhosis, pneumonia, bronchitis, influenza
Mercury	Bronchitis, gingivitis, pulmonary edema, nervous system disorders
Nickel	Dermatitis, pneumonia, lung and nasal cancer
Silver	Blindness, skin lesions, pneumonoconiosis
Zinc	Cornea1 ulceration, esophagus damage, pulmonary edema

There is an estimate that the amount of dry cells disposed of in Thailand is more than 20 million kilograms per year. Since there are no special facilities for handling these wastes, the used dry cells generally are disposed of into the household waste bin and end up at landfill sites (10). These disposal behaviors promote the contamination of toxic metals in the batteries into the environment. Once they enter the environment, they will reach humans via water and/or the food chain.

To solve this problem, 3R measures - reduce, reuse, and recycle - are believed to potentially reduce contamination. Reducing the use of batteries is probably not effective since it contradicts the demand of convenience of the user. Reuse is implemented by promoting the use of rechargeable batteries but those rechargeable batteries also contain toxic metals. Recycling which means the collection of used batteries to extract some metals for the production of new batteries is considered to be the most effective measure of preventing toxins from entering the environment. This method requires the cooperation of users in the proper disposal of used batteries in specific separated waste bins. However, factors related to recycling behavior or proper disposal behavior need to be better understood. This article reviews the literature on behavioral theories applied on recycling behavior, factors influencing recycling behavior, and interventions promoting recycling behavior.

Behavioral theories applied on recycling behavior

Theories at intrapersonal level

1. Health Belief Model (HBM)

There is only one study that used the Health Belief Model framework in regards to recycling behavior. It found that variables in the Health Belief Model significantly predicted recycling behavior and accounted for approximately 27% of the variance of the dependent variable. (11) In this model, perceptions of the severity of the household waste problem was one of only two attitudinal variables (the other was intrinsic motivation to recycle) that distinguished between those who did and did not participate in a recycling program.

2. Neutralization Theory

Neutralization Theory of delinquency states that much delinquency is based on unrecognized extensions of defenses to crimes in the form of justifications that are seen as valid by the delinquent but not by the legal system or society at large. Hansmann et al. (12) presented the relationship between battery recycling and two of the neutralization strategies, namely: 1) the denial of responsibility by arguing that one's own behavior is the result of forces beyond one's control and 2) the denial of injury claiming that no one was hurt, which in the context of recycling corresponds to the claim that the environment is not harmed by non-recycling. These neutralization techniques are related to the concepts of 1) ascribed responsibility and 2) awareness of consequences in Schwartz's model of altruistic behavior.

Theories at interpersonal level

1. Theory of Planned Behavior (TPB)

The Theory of Planned Behavior is concerned with the relations between beliefs, attitudes, subjective norms, perceived control, intentions, and behavior. In this theory, the most important determinant of behavior is a person's intention which is determined by their attitudes toward performing a behavior, their subjective norm, and their perceived control associated with the behavior (13).

There are nine published research articles that studied TPB related to recycling behavior. Recycling behavior generally means the behavior of proper disposal of recyclable solid waste to a provided specific bin and from which those wastes will be collected and sent to a recycling process. These studies confirmed the relationship between intention and behavior. (14-21) However, one study found that intention was not associated with behavior (22).

Attitude: Attitude is determined by the individual's beliefs about outcomes or attributes of performing the behavior which is called behavioral beliefs weighted by evaluations of those outcomes or attributes. (13) While the definition of attitude is varied, it is defined in the TPB framework as affective (experiential) which is related to feelings, and cognitive (instrumental) which is based on knowledge of the outcomes or consequences (21, 23).

A significant relationship between attitudes toward recycling and intention to recycle was found in many studies which were analyzed using multiple regression (12, 17, 20-22, 24-27) The relationship between attitude

and intention was confirmed using structural equation modeling (SEM) analysis in which less error occurs than regression analysis (14). The results of a country-by-country analysis validated the TPB model cross-nationally. The model presented good fit in all of the countries (28).

Subjective norm: A person's subjective norm is determined by his or her normative beliefs, whether important referent individuals approve or disapprove of performing the behavior, weighted by his or her motivation to comply with those referents (13). Within the theory of Planned Behavior, subjective norm is a predictor of intention. This was confirmed by Knussen et al. (17) and Ewing (29). However, some researchers found that subjective norm did not exhibit a direct effect on intention (19, 21, 22).

Perceive behavioral control (PBC) or Self-efficacy: Perceived behavioral control is determined by control beliefs concerning the presence or absence of facilitators and barriers to behavioral performance, weighted by the perceived power or impact of each factor to facilitate or inhibit the behavior (13). Most research has found a strong association of perceived behavioral control with intention (17, 19, 22, 28). Controversially, Tonglet et al (21). found that PBC is not a significant predictor of recycling behavior. In addition, Cheung et al. (15) studied wastepaper recycling and found that can be replaced by Perceived Difficulty.

2. Altruistic Behavior Model (MAB)

In the Altruistic Behavior Model recycling behavior was directly predicted by social norms and personal norms, neither of these constructs is mediated by awareness of consequences or ascription of responsibility. Unlike the Altruistic Behavior model, TPB assumes that subjective norms, as well as personal attitudes, have a direct influence on behavioral intentions. Behavioral intentions result from a compromise between both sources of influence, which is moderated by the motivation to comply with the subjective norms. This assumption of TPB has been supported by empirical studies (12). In the Altruistic Behavior model, social norms are compared with subjective norms in TPB (12). Personal norms are strongly internalized moral attitudes (22). So, personal norm in MAB can be compared with attitude in TPB.

Theories at organizational

Tudor et al (26). studied the recycling behavior at the organizational level by selecting the Cornwall National Health Service as a case. They found that the influence of the hierarchical organizational structure on individual behavior was "strong." This influence was manifested in a number of ways, including the levels of bureaucracy, the impact of the centralized controls on the support of the managers and resource provision (e.g. finance) for environmental projects, and the degree of autonomy in decision making that was possible

at the local trust level. The organizational structure had a controlling influence not only on the functioning of the organization itself but also on the attitudes and behavior of employees. Finally, the structure affected the support of the managers for environmental management. Hence, the organizational structure affected the culture, employee attitudes, and beliefs, as well as the level of support and resources that was afforded to sustainable waste management. The factor of "department type and size" was a significant determinant of waste management practices, with large variations existing in the quantities of waste produced by each department.

Theories at policy level

Folz (36) studied the effect on waste recycling of various policies in the United States and found that recycling diversion rates were higher in cities that enjoyed a higher level of participation, collected a larger number of recyclable materials, and operated a composting program. He also suggested that when existing policies do not produce results that compare favorably with other cities, local officials changed or revised their policies in an effort to improve performance.

Factors influencing recycling behavior

In addition to constructs of those theories, Hornik et al. (32) reviewed the factors associated with recycling behavior and categorized them into 5 groups: extrinsic incentives, intrinsic incentives, internal facilitators, external facilitators, and demographic variables. They used meta-analysis technique to determine the relative influence of those predictors on recycling. The results led them to propose a model of consumer recycling behavior. In this model, internal facilitators are the most important in predicting propensity to recycle and relatively enduring effect on recycling. External facilitators, conversely to internal facilitators, have the lowest predictive power and short-lived effect on recycling. External incentives and internal incentives occupy the spots between the two facilitators.

Incentive: The consumer recycling behavior model was supported by a survey done by Li (33) who found that recycling for cash is one direct incentive to motivate public participation. Similarly, Noehammer and Byer (34) concluded from their survey data that incentives have a positive impact on the success of a recycling program. User fees, fines, and rewards are the general form of incentives that successful implication in promoting recycling behavior.

Social Influence or Motivation: The four studies on this factors support Hornik's model (30). Respondent's motives to recycle due to the influence of one's family and friends also were related to conservation and being concerned about the environment (30). This factor is equal to subjective norm in TPB.

Situational Factors (Convenience): Schultz et al. (23). found three specific attitudinal factors that contributed to non-recycling behavior: nuisance, location, and indifference. Nuisance included ideas that

recycling does not pay, it is too much trouble, it is too messy, and it requires too much space. Location included beliefs that the recycling center was too far away, that not enough trash was generated to make recycling worthwhile, and lack of knowledge about where to take materials. Indifference included never thought about it, and it makes no difference. This review indicated that situational factors also were a significant predictor of intention and was supported by other studies (16, 21).

Past behavior: Although past behavior or experience is a kind of attitude as mentioned above. It was added to TPB in some studies and contributed an additional increase in percent of variance explained (15, 17, 21, 22, 31, 35). Socio-demographic variables: A number of studies had ambiguous results as to both the existence and direction of the relationship between recycling and some socio-demographic variables, i.e. age, education, income, gender, and occupation (17). The average recycling efficiency for homeowners was significantly greater than that for renters (37). Larger households performed more pro-environmental behavior (38).

Interventions promoting recycling behavior

Schultz et al (23). summarized recycling behavioral intervention strategies into two groups: antecedent and consequence. An antecedent is any intervention designed to increase recycling behavior by altering a variable prior to performance of the behavior. These are prompting, commitment, normative influence, goal setting, and removal of barriers to recycling. Consequence is any intervention that attempts to modify recycling behavior by presenting a consequence, for example, feedback of information, a reward, or a punishment, contingent upon the behavior. Most studies suggested that prompting alone is not effective in increasing recycling behavior. However, a large group of studies indicated an enhanced effect when prompting was included with other interventions. Commitment tended to produce longer lasting effects than prompting or rewards. Written commitment produced greater increases than oral commitment in curbside participation and amount of recyclables collected and individual commitment yielded more participation than group commitment in a special recycling drive on a college campus. There were only two studies that found significant effects in increasing the amount of materials collected in special recycling drives at an elementary school and a college. However, the persistence of behavior change was not tested, and since both studies used special populations, questions remain regarding the generalizability of the results of goal setting to community residents.

In regards to barrier removal, three studies consistently indicated that the closer participants are to a collection center, the more likely they are to recycle. Removing the need to transport materials to a central location can increase participation rates. The schedule of collection may also affect recycling participation. These findings accorded to those in situational

factors as mentioned above. Barrier removal or facilitation is recommended as a basic method to change the behavior at individual level (39). Feedback is a basic method used to change behavior at the individual level (39). In order for feedback to be successful, people must be able to identify a relationship between their behavior and the feedback and the individual must be interested in change (23). Kim et al. (40). confirmed that posted feedback increased the recyclable products that were separated and collected in a public lounge at a University. Offering rewards significantly increases the amount of material people will recycle. However, the change in behavior was short-lived, the extent to which behavior change produced for rewards of one material. Reward interventions are only effective in increasing behavior related to the specific material targeted with the reward. Four studies (with one exception) indicated that using peer support to establish community recycling norms can increase and sustain recycling behavior. Personal contact by the block leader may also prompt public commitment which in turn could initiate recycling behavior. Furthermore, the use of volunteer block leaders in neighborhoods presents a cost-effective intervention for communities (23).

Discussion

Many levels of behavioral theories were studied. Intrapersonal level theories, Health Belief Model and Neutralization Theory, were less interested in recycling promoting studies since they have limitation in changeability, for each person only. Interpersonal level theories, higher level theories, such as Theory of Planned Behavior, were more interested in promoting recycling behavior studies.

Although the TPB provides a useful model for exploring the factors which influence householders' recycling decisions, many researchers argue that the inclusion of additional variables when applying the model to recycling behavior may be required (12, 14, 17, 19, 21, 22, 28, 30, 31).

Davies (22) found that the Altruistic Behavior Model is more predictive of recycling behavior than the TPB. However, addition of PBC and affective evaluation of recycling behavior substantially increased the explanation of variance in recycling behavior. Controversially, Ebreo (30) found the absence of any relation between the responsibility respondent's felt for the generation of solid waste and the product attributes to be telling.

However, the application of the TPB in any used battery disposal study was not found. All of them were studied with valuable recycling materials, i.e. paper, glass, metals, and plastics but used battery is invaluable especially in Thailand. In contrast with those materials, used batteries are toxic to all living things. It is concluded that TPB should be the most appropriate to study used battery disposal behavior in Thailand.

The reviews also indicated that not only interpersonal level theory predicted the recycle behavior but organization and policy level theories also predicted the behavior. Ecological model, a theory that consider all level of behavior, may be suitable to study recycling behavior, especially used battery disposal behavior.

In addition to the theories, other factors must be considered. Some factors in the previous studies were the same as some constructs in the theory. These were social influence, and past behavior as mentioned above. Incentive was presented effectiveness in predicting recycling behavior but its' effectiveness was lost when there was no incentive. So, incentive should not be a strategy for the long term promoting recycling. Situational factor or convenience factor such as specific recycle waste bins was an important factor in promoting recycling behavior. Lack of this factor, the recycling behavior will not be occurred.

Persuasion, commitment, barrier removal, feedback, and peer support were the strategies that can change the behavior in the previous studies. Persuasion is the low cost and effective strategy. However, only one strategy may not be enough to change the behavior of all target population. Multiple strategies are more effective in behavior changing (39).

Ecological model may be the most suitable theory in further study on recycling behavior especially used battery disposal behavior. Situational factor should be ignore both in study and in intervention planning to promote used battery disposal behavior. Multiple strategies including persuasion, commitment, barrier removal, feedback, and peer support, should be used in proper used battery disposal promoting intervention.

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