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Abstract

In spite of the focus on improving treatment methods and determining the economic and environmental impacts of medical waste management, little research has been conducted to understand consumer perceptions of medical waste reduction. In healthcare setting, our research seeks to address this urgent need by investigating how visual cues can be used to elicit healthcare professionals’ willingness to reduce medical plastics. By employing the vignette-based experimental method, we collected data from 1,139 healthcare professionals to examine how visual characteristics (i.e., visual clutter, colorfulness, the presence of human face, the presence of animal) in images of medical plastic pollution were used to arouse moral shock and emotional energy in healthcare professionals. The results of our study suggest that visual displays should be cluttered, colorful, and characterized by human presence. By displaying these visuals in an image of anti-plastic pollution, healthcare professionals are most likely to express their sadness, rage, and despair, and enhance their intention to refuse medical plastics to the fullest extent. By contrast to the previous study, we found that healthcare professionals’ moral shock and willingness to refuse medical plastics were not significantly impacted by the presence of animals on the images.

Keywords: Medical plastic waste, visual elicitation, moral shock, experimental design, healthcare
1. Introduction

Globally, healthcare accounts for one of the highest percentages of employment and the highest percentage of gross domestic product (GDP). Healthcare expenditure as a percentage of GDP in the US was 18%, and 6.6% in China in 2019 (Jia et al., 2021). In the meantime, approximately 5.9 million tons of medical waste are produced annually in the US (Ghersin et al., 2020), and over 9 million tons per year are produced in China (Wei et al., 2021). While the growing healthcare industry is providing better healthcare services, it has also increased the amount of medical waste produced by hospitals due to factors such as the development of medical technology and aging population and the increase in medical spending (Su et al., 2021). Medical waste, as infectious, toxic, and pathogenic waste, would have significant impacts on the health and well-being of the general population and the environment.

A recent outbreak of Coronavirus 2019 (COVID-19) has caused dramatic growth in medical service demand and a dramatic increase in disposable personal protective equipment (PPE) such as face masks, plastic gloves, and insulation garments. According to recent reports, more than 116 million disposable masks were produced per day in China in February 2020 in addition to 129 billion disposable masks being used globally (Chen et al., 2021). This results in a dramatic explosion of medical waste generation all over the world. Moreover, in healthcare professionals’ mind, using single-use plastics is a legitimate way of preventing infectious diseases, particularly single-use protective equipment is viewed as the safer option (Ngo, 2020). Indeed, sustainability in healthcare is difficult to consider when healthcare professionals must put it up against patient safety. As a result, it has been a global challenge to reduce and manage medical waste while addressing the environmental impact of healthcare and raising awareness about plastic reduction among healthcare professionals.

Medical waste research is currently focused on 1) disposal and treatment of medical waste (e.g., Achak et al., 2021; Jiang et al., 2012; Maamari et al., 2016; Mudgal et al., 2017; Sapuric et al., 2016; Zhang et al., 2020); 2) medical waste management, including reverse supply chain for medical waste (Mantzaras and Voudrias, 2017; Mohamed Faizal et al., 2020) and 3) economic and environmental assessments of medical waste (e.g., Dharmaraj et al., 2021; Ilyas et al., 2020). Yet there is relatively little research on consumer involvement in medical waste management. There have been very few studies exploring the ways to educate consumers (e.g., patients and healthcare providers)
on medical waste (e.g., Afanasjeva and Gruenberg, 2019; Alqahtani et al., 2019; Ikeda, 2014). Research gaps in the existing medical waste literature are identified as follows: (1) no research on healthcare professionals’ perceptions of medical waste, which makes it harder for the government to adopt good policies for medical waste reduction; (2) no research into the effect of visual communication on healthcare professionals’ intentions to reduce medical waste.

To address these research gaps, using the emotion-symbol theory proposed by Barberá-Tomás et al. (2019), we answer the following research questions.

**RQ1:** Are healthcare professionals morally shocked by images of medical plastic pollution?

**RQ2:** In what ways can visual cues be used to engage healthcare professionals in reducing medical plastic waste?

Toward this end, we first review the literature related to medical waste management and then develop the research model and associated hypotheses. In the following sections, we describe the research methods, which include data collection, measurement, and experimental design. A series of experiments was then conducted to test the hypotheses. Finally, the theoretical and practical implications, as well as the research limitations and future research directions were discussed.

### 2. Literature review on medical waste

Medical waste is defined as “*any intervention that has no possible benefit for the patient or in which the potential risk to the patient is greater than potential benefit*” (Fuchs, 2009, p. 2481). Medical waste is likely to be infectious, toxic, and pathogenic, but it can also refer to non-hazardous waste from any medical practice (Lee and Huffman, 1996). The disposal and improper management of medical waste not only pose high risks to healthcare professionals and patients, but also to human health and the environment (Hong et al., 2018). In the medical waste literature, there have been five main research streams: (1) medical waste disposal and treatment, (2) medical waste management, (3) reverse supply chain for medical waste, and (4) assessment of medical waste management, and (5) consumers’ roles in fighting medical waste.

#### 2.1 Medical waste disposal and treatment

A vital part of any waste management system is the treatment of medical waste (Liu et al., 2021), which has gradually gained value across a wide variety of countries...
(Tsakona et al., 2007). Research in this stream continues optimizing methods to improve the efficiency and performance of medical waste treatment. In the past, medical waste has been eliminated through incineration (Windfeld and Brooks, 2015). However, during the incineration process, ash generated from burnt materials contains hazardous metals (Fang et al., 2020), inorganic emissions and organic waste (PCDD/Fs and organic acids). In comparison to traditional incineration, pyrolysis of medical waste offers more benefits in terms of producing value-added products, improving energy efficiency, and reducing pollution (Fang et al., 2020). Pyrolysis continues to be researched to improve its efficiency and performance (Mudgal, 2017; Sapuric et al., 2016). For example, using a Cr3C2-NiCr coating, Mudgal (2017) improved the performance and lifetime of pyrolysis incinerators, and Zhang et al. (2020) demonstrated improved emissions reductions from batch fluidized-bed incinerators.

Research on value-added products (e.g., liquid oils, syngas, hydrogen gas as well as hydrocarbons and char) transferred from plastic medical waste ash has attracted researchers’ attention. Fang et al. (2020) pyrolyze dried and pulverized medical waste to obtain pyrolysis oil that may serve as a future substitute for fossil fuels. Moreover, the ash recovered from the incineration chamber contains several heavy metals, including Ba, Zn, Ag, Cd, and As, which are considered sources of value-added products (Papamarkou et al., 2018).

An incinerator generates heat by pyrolysis and combustion with coal, which can be used to fuel rotary kilns (Bujak, 2015), remodel and implement new incinerators for use by medical waste (Chaiyat, 2021). However, the organic waste generated during pyrolysis can cause the secondary pollution, which is detrimental to human health and environment (Jangsawang et al., 2005). In addition, polyvinyl chloride (PVC) waste comprises a large proportion of medical waste, and dioxin emission, in particular, is a critical problem in pyrolysis (Hu et al., 2019). Researchers (e.g., Li et al., 2017) have assessed the total suspended particle and dioxin output from medical waste pyrolysis in different regions to determine how best to manage and control the secondary pollution. Additionally, some methods to remove elements such as chlorine (Cl) have been investigated to further reduce secondary pollution (Ma et al., 2019).

Comparing landfilling with pyrolysis, landfilling produces fewer carbon dioxide emissions. However, unsanitary landfills and dumping yards can cause a lot of space to occupy as well as leach harmful chemicals, leading to the creation of hidden hazards
(Dharmaraj et al., 2021). Medicinal waste contains pathogens; therefore, it should be handled in a bio-safe manner before being disposed of or recycled. Due to its non-hazardous nature, steam sterilization is considered the most reliable and widely used method in pre-treatment of medical waste before landfilling. A current focus of research is to maximize the efficiency of steam sterilization by increasing the vacuum degree and the time to reach a higher temperature (Jin et al., 2011) and providing suitable conditions (Maamari et al., 2016). Moreover, an improved method of chemical sterilization is by using Cl2, ClO2, NaClO, and O3 combined with UV irradiation (Achak et al., 2021). Chemo-sterilization is generally employed in conjunction with a mechanical crushing treatment for small amounts of medical waste (Wang et al., 2020).

2.2 Medical waste management

There has been a focus in recent studies on developing practices to manage medical waste in order to reduce environmental and economic concerns (Hong et al., 2018). Using life cycle assessments, Hong et al. (2018) quantified the economy and environmental impacts of three medical waste treatment methods. They point out that energy recovery is viewed as the key to mitigating environmental and economic burden caused by energy and chemical consumption. As a result of the COVID-19 pandemic, general population and medical personnel have generated significantly more medical wastes on a global scale (Patrício Silva et al., 2020). Medical waste management has been extensively investigated since the COVID-19 pandemic and the infectiousness of SARS-CoV-2. Approximately 16,659.48 tons of medical waste are generated daily in Asia according to Sangkham (2020). Based on current utilization rates, Wei et al. (2021) predicted that hospital waste in China would increase by 76% over the next ten years. Furthermore, they recommended ways to address the medical waste management crises, including: 1) improving the efficiency of medical waste treatment; 2) expanding the ratios of beds to health service institutions; and 3) enhancing the related technical research.

2.3 Reverse supply chain for medical waste

Medical waste generated by hospitals is usually transported and treated by third-party professional companies (Birchard, 2002). There are high costs associated with disposing of medical waste in developed economies, for example, UK landfills charge £450/tonne (Blenkharn, 2007) and US landfills charge $790/tonne (Lee et al., 2004) 15
years ago. To protect the health and environment of residents, a proper logistic network and supply chain will lower this cost. According to Rahimi and Ghezavati (2018), a reverse logistics network design determines a logistic system's construction and operation as well as the performance of the medical waste management process in the long run. Recent studies have focused on the location and routing selection of medical waste management (e.g., Aydemir-Karadag, 2018). Medical waste accumulation poses a significant threat to the environment, which is why reverse medical supply chain design is viewed as crucial to planning (Alizadeh et al., 2020). At the same time, it is equally important to develop a cost-effective, environmentally friendly and safe solution (Lee et al., 2004). Lizadeh et al., (2020) designed a reverse supply chain for medical supplies in Iran comprised of end-to-end stakeholders, from suppliers to annihilation and recycling centers. Defective supplies will be treated as medical waste and sent directly to the medical waste collection centers to reduce the storage and costs of hospital medical waste. An analysis of a case study in district 4 of Tehran showed an improvement in profitability and enhancement of health performance.

2.4 Assessment of medical waste management

Medicinal waste is largely comprised of infectious and radioactive waste and a large quantity of pathogenic bacteria. The proper management of medical waste is essential to the safety of the general public and healthcare professionals (Makajic-Nikolic et al., 2016). Recently, several studies have investigated the procedures and practices for managing medical waste (e.g., Aung et al., 2019; Behera, 2021). However, since the COVID-19 pandemic hit, managing medical waste has become challenging. Thus, there is a need for stricter medical waste management and related strategies to be implemented.

There does not seem to be a widely accepted management procedure for COVID-19 medical waste. PPE and other medical waste generated during pandemics are regarded as hazardous waste in the EU (Das et al., 2021). In China, centralised disposal and on-site emergency disposal of medical waste are combined to eschew the accumulation of waste generated during the pandemic period (Singh et al., 2020). Yet, in the US, it is not necessary to treat COVID-19 medical waste (Das et al., 2021). Even though the degree of procedures varies between countries, there is no doubt that the amount of medical waste increases dramatically during this period due to the increased consumption of personal protective equipment (Tripathi et al., 2020). For COVID-19
related medical waste, pyrolysis is considered to be the most environmentally friendly and cost-effective disposal method. However, small-scale hospitals may not be able to afford pyrolysis (Dharmaraj et al., 2021). Furthermore, the exorbitant costs of transportation of medical waste, as mentioned in the previous section (e.g., Faizal et al., 2020; Nikzamir and Baradaran, 2020), have called for future research.

Dioxins are one of the most widely studied pollutants in this area. Dioxins are primarily released into the atmosphere through the combustion of plastics, which will then be deposited into the soil or underlying sediments of a variety of water bodies (Wagrowski and Hites, 2000). Li et al. (2017) evaluated the dioxin emissions from medical waste incinerators in Colombia and China, respectively. The results of both studies indicated that the emission of PCDD/Fs is significantly associated with improper medical waste incinerators, which will increase contamination risks for local residents and the environment. Researchers have recently tried to reduce the generation of dioxins by dichlorination by applying near-critical methanol (Qi et al., 2018) and increasing the feeding interval (Zhang et al., 2020). Furthermore, as part of medical waste management, heavy metals and other pollutants, such as polycyclic aromatic hydrocarbons and antibiotic resistance, need to be assessed and controlled. (Chi et al., 2020; Zhao et al., 2008).

2.5 Consumers’ roles in fighting medical waste

In the stream where the consumer role is considered, the integration of medical waste management into medical education has been considered a significant research topic. Ikeda (2014) investigated the status of nurses educating patients on how to separate and store medical waste at home. Over half of the nurses educated patients on how to recover medical waste, according to Ikeda (2004), which led to storing the waste separately at home and achieving waste recovery. Afanasjeva and Gruenberg (2019) indicated that pharmacists can be trained to use, store, and dispose of medications safely, thereby reducing the impact of medical waste on the environment. Medical professionals were surveyed on their knowledge and practices regarding medical waste management by Alqahtani et al. (2019). The results revealed that although the participants had the necessary knowledge, they exhibited many mistakes in their daily practices in managing medical waste, calling for more training and tightened regulations.
A summary of current studies in the management of medical waste highlights the importance of improving treatment methods, managing medical waste procedures, and assessing medical waste management. Despite this, very little research has been conducted on how consumers perceive medical waste and how they can be encouraged to refuse medical plastics. Therefore, we visualize the research streams on medical waste and identify the research gaps, as shown in Figure 1.

**Fig. 1.** Mapping medical waste research streams and identifying key research gaps

### 3. The Use of Visual Images for Managing Plastic Waste

Visuals play a crucial role in social change campaigns and movements (Barberá-Tomás et al., 2019). In line with the picture superiority theory, human beings are more likely to remember images than other types of descriptive information because their symbolic significance is greater than that of written words (Paivio, 2013). Furthermore, visuals can strongly affect an audience by triggering their emotions (Dixon, 2016), and influence stakeholder attitudes and engagement (Brubaker and Wilson, 2018; Dhanesh and Rahman, 2021). For example, the public opinion of Europeans towards accepting refugees migrating to Europe was heavily affected by a news photograph showing a drowned Syrian boy on a Turkish beach (Hellmueller and Zhang, 2019). As a result of
such shocking images, the public becomes more aware of children's safety and migration crises, as well as becomes more engaged in social movements.

The marketing communication literature asserts that visual imagery is a highly effective way to elicit emotional reactions from consumers, alter their intentions, and inform their product choices (Geise and Baden, 2015). Specifically, marketing campaigners and social entrepreneurs have used visual symbols for decades to grab the attention of potential supporters and convince them to reject single-use plastics (e.g., Barberá-Tomás et al., 2019; Bresciani and Eppler, 2020; Septianto and Lee, 2020). As Bresciani and Eppler (2020) observe, visualization can be used by social enterprises to better communicate social impact created with stakeholders. Barberá-Tomás et al. (2019) argue that an image with a dead animal posted by activists during an anti-plastic movement can boost individuals’ emotional energy and thereby lead to them refusing plastic products or packaging. Septianto and Lee (2020) further suggest that when an image depicts plastic waste, it can evoke disgust, while seeing a portrait of victims of waste plastic provokes sadness.

Despite some studies demonstrating the value of visual imagery for social causes, little research has been conducted on how imagery can be used to elicit moral shock and inspire commitment. The omission of this issue in literature on plastic waste management is notable, since images with emotional appeal could significantly change attitudes toward social causes of reducing plastic waste. In particular, a lack of research has been done on how individuals' emotional reactions are affected by the characteristics of visual cues in the context of medical plastic waste.

4. Theoretical Basis and Hypothesis Development

The emotion-symbolic work is defined as “the deliberate production and use of symbols, often multimodally, to manage the emotions and emotional energy of target actors in order to influence their actions” (Barberá-Tomás et al., 2019, p. 1797). The emotion-symbolic work is an activity in which visual images are used to influence individuals’ emotions and actions as a consequence of meaning making (Barberá-Tomás et al., 2019). This work is tied to emotional resonance, in which the recipient is moved by a framing or shaken by it (Giorgi, 2017). A variety of emotion-symbolizing interventions employing verbal, visual, and audio interactions have been widely used in campaigns intended to convert target audiences into active supporters (Hambrick and
Lovelace, 2018; Meyer et al., 2018). Anti-plastic activists, for example, emotionally resonant with stakeholders, investors, and audiences by stating the dangers of plastic pollution and demonstrating its damaging effects on the environment.

From the literature and theories in the field of communication, visuals are an effective approach to communicate ideas, manipulate emotional expression, and promote action (Geise and Baden, 2015). The features of visual images such as color, composition, texture, and content (Matz et al., 2019) can “to generate an immediate and powerful impact that surpasses a purely cognitive processing of its content, whereby audiences become engaged affectively, aesthetically, and corporeally” (Meyer et al., 2018, p. 395). The emotion-symbolic work proposed by Barberá-Tomás et al. (2019) explains how visuals can evoke target recipients’ moral stock, such as sadness, rage, and despair, and ultimately lead to more commitment and change in behavior. Moral shock is an affective reaction to an unexpected situation that causes a moral paradigm shift (Jasper, 2011). Specifically, the visual information is presented in a way that does not match the expectations of the individual, causing moral shock, which can not only cause an individual to reconsider his or her moral commitments but also lead to the conversion of bystanders into supporters (Barberá-Tomás et al., 2019; Jasper, 2011).

By using emotion-symbolic work of Barberá-Tomás et al. (2019) as a theoretical basis, this study examines how the visual characteristics of anti-plastic pollution images trigger healthcare professionals’ emotional responses. Specifically, four visual characteristics are examined in this study: visual clutter, colourfulness, presence of a human face, and presence of an animal, which are evaluated in regards to their ability to trigger healthcare professionals’ moral shock and determination to refuse medical plastic products. The research model is shown in Figure 2.
Visual clutter is a visual measure to describe “the busyness of an image” (Matz et al., 2019). It can be described as visual complexity in advertising that negatively impacts or obscures product and brand information (Pieters et al., 2010). Clutter makes it difficult to collect visual information and reach decisions quickly and accurately (Rosenholtz et al., 2006). As described above, we define high levels of visual clutter as the presence of more objects on an image of medical plastic waste.

Prior research indicate that visual clutter reduces attention-drawing (e.g., Baldassi et al., 2006; Van den Berg et al., 2009) and negatively impacts on attitude toward marketing information (Pieters et al., 2010). According to the emotion-symbolic work, we argue that heavy clutter in visuals will likely depict the emotional transformation process in healthcare professionals that will elicit moral shock and motivate them to refuse to use medical products made of plastic. We therefore propose:

**H1:** Visual displays with high levels of visual clutter compared to displays with a low level are more likely to evoke (a) moral shock and (b) a refusal of healthcare professionals to use medical plastics.

Visual characteristics play a role in how images affect attention and attitudes (Li and Xie, 2020). When exposures are brief and blurred, color can consistently improve viewers’ attention (Finn, 1988) and allow viewers to better comprehend the delivered
meaning (Wedel and Pieters, 2015). However, in some cases, consumers’ engagement may be encouraged by monotonic pictures posted on social media (Li and Xie, 2020). In the context of plastic waste, Barbera-Tomás et al. (2019) reported on their study of strong moral shock induced by an image of a gray outlined decaying albatross whose stomachs contained brightly colored plastic waste. We therefore propose:

\[ H2: \text{Visual displays with a high level of color compared to the one with a low level of color triggers the moral shock of healthcare professionals and leads them to refuse medical plastic products.} \]

In advertising, it is common to use a human endorser to promote a brand or product (Xiao and Ding, 2014). The presence of a human face significantly affected viewers' reactions to an ad. Despite viewers' preferences for facing present, there is substantial heterogeneity for different categories of products (Li and Xie, 2020; Xiao and Ding, 2014). Overall, the presence of a human face can improve the effectiveness of an advertisement (Cyr et al., 2009; Li and Xie, 2020; Xiao and Ding, 2014). For instance, it has been proven that ad content containing the presence of a human face increases engagement among viewers (their sharing and liking on social media) (Li and Xie, 2020). However, it is unlikely to encourage viewers to interact on social media through a classification of "happy" facial expression (Li and Xie, 2020). In this research, we assume that the presence of a human face will increase healthcare professionals’ engagement by eliciting moral shock and refusal intention, so our hypothesis is as follows:

\[ H3: \text{In comparison to a display without human faces, a visual display with human faces induces moral shock in healthcare professionals and prompts them to refuse medical plastic products.} \]

The choice of animals is always made as an element in the logo or advertisement of a brand (Kim et al., 1998), for example, dancing bears in Pepsi advertisements, fighting bulls in Lamborghini, and snakes in Gucci advertisements. Using animals in advertising is aimed at associating a brand with some potential stimulus, although the stimulus cannot fully reflect the product itself (Kim et al., 1998). Consumers are even
more likely to connect with the brand because of the animal's attention-grabbing traits than an endorser who is human (Lancendorfer et al., 2008). Lancendorfer et al. (2008) state that the presence of animal has a positive effect in advertisement, while the emotion-symbolic work conducted by Barbera-Tomás et al. (2019) demonstrated that the moral shock evoked by an image of a decaying albatross whose stomachs were filled with plastic wastes was transformed into emotional energy. Thus, by presenting a visual with an animal in anti-medical plastic pollution campaigns, we argue that healthcare professionals are more likely to experience a moral shock, thereby increasing their likelihood of refusing medical plastics. We propose the following hypothesis:

\[ H4: \text{In comparison to a visual display without an animal, a display with an animal produces a moral shock in healthcare professionals and their intention to refuse medical plastic products.} \]

5. Research Method

5.1 Experimental design

Aguinis and Bradley (2014) detail two major types of vignette methodology: paper people studies and policy capture analyses. The chosen images pertaining to medical plastic pollution is examined in this study in order to understand how visual characteristics influence the emotions of healthcare professionals (i.e., moral shock and refusal intention), which in turn helps them to answer implicitly rather than directly to the hypothetical scenarios. In terms of the type of research design, we opted for within-person mixed designs. This study consists of eight groups of experiments. A detailed description of the experimental design can be found in Table 1 and Figure 3.

We recruited different groups of participants in three tertiary hospitals in Henan Province, China in 2021, each of whom received their own set of vignettes. The three tertiary hospitals studied were chosen for several reasons. First, the selected tertiary hospitals are among the prestigious government hospitals in Henan Province. Generally, tertiary hospitals have more than 500 ward beds and provide comprehensive medical services and complex treatment for patients, accepting referrals from lower-level hospitals. Tertiary hospitals also conduct scientific research and higher education. Such hospitals are capable of providing reliable government data and are an integral part of China's healthcare system by providing healthcare professionals with specialized
training at lower levels. Second, in Henan Province, medical waste is being disposed without proper treatments. Even more concerning is that only four hospitals have contracted with a facility in Henan Province designed to handle eight tons of medical waste from 700 hospitals according to Health Care Without Harm’s (2011) report. This implies that healthcare professionals in Henan Province may not fully recognize the importance of managing medical waste. Thus, the selected case is suitable for us to explore how visual elicitation of medical waste can engage healthcare professionals.

The participants were randomly assigned to each group. A total of 1,139 healthcare professionals were recruited from the three hospitals. Of these, 70.90 % were male and 85.40% were over 30 years old. We also conducted a Chi-Square analysis to examine the randomization. The results indicate the gender ratio \( \chi^2(7, N=1139) = 234.809, p = .680 \) and the respondents’ age group \( \chi^2(7, N=1139) = 1114.026, p = .399 \) across eight vignettes are not significantly different.

Table 1 experimental design

<table>
<thead>
<tr>
<th>Group</th>
<th>Measurement</th>
<th>Valid respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High level of visual clutter</td>
<td>The busyness of an image</td>
<td>N=149</td>
</tr>
<tr>
<td>Low level of visual clutter</td>
<td></td>
<td>N=136</td>
</tr>
<tr>
<td>Experiment 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High level of colorfulness</td>
<td>The percentage of the top three colors; the image is colorful when a low pixel percentage of the top three colors is detected</td>
<td>N=136</td>
</tr>
<tr>
<td>Low level of colorfulness</td>
<td></td>
<td>N=141</td>
</tr>
<tr>
<td>Experiment 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The presence of human face</td>
<td>The image content contains at least one human face detected</td>
<td>N=145</td>
</tr>
<tr>
<td>The absence of human face</td>
<td></td>
<td>N=137</td>
</tr>
<tr>
<td>Experiment 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The presence of animal</td>
<td>The image content contains at least one animal detected</td>
<td>N=149</td>
</tr>
<tr>
<td>The absence of animal</td>
<td></td>
<td>N=146</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>N=1139</td>
</tr>
</tbody>
</table>

(a) High level of visual clutter  (b) Low level of visual clutter
5.2 Manipulation check of experiments

The Google Cloud Vision API was used to process the images. Specifically, we manipulate the visual characteristics of an image and enhance the accuracy of experimental cues by utilizing the Google Cloud Vision API.

To manipulate the visual clutter of an image, we calculated the number of objects by performing the “feature detection” function in Google Cloud Vision API (Rosenholtz et al., 2005). 7 significant objects (i.e., packaged good) are detected in Figure 3a and thus it is classified as a high visual clutter image, whereas a low visual clutter image contains 2 objects detected in Figure 3b.

**Fig. 3.** Images for the four experiments
To manipulate the colorfulness of an image, we calculate the percentages of the top three predominant colors using the properties function (Li and Xie, 2020). The image that demonstrates a high level of colorfulness has a relatively low percentage of pixels for the top three colors (color #DEC35C, 22%; color #EAE3E9, 18%; color #B59E84, 7%) (see Figure 3c), while the selected image that demonstrates low level of colorfulness has a relatively high pixel percentage of the top three colors (color #97999A, 23%; color #E9ECF2, 20%; color #E9ECF2, 20%) (See Figure 3d).

Using the “objects” and “labels” functions provided by Google Cloud Vision API, we check whether the image contains at least a face (see Figure 3e and 3f) or an animal (see Figure 3g and 3h). In Figure 3g, feature detection function identifies cartilaginous fish specifically and animal in general. In Figure 3e, objects such as person face, divemaster, goggles and eyewear are detected.

In order to determine the qualified respondents, we developed a set of filter questions and ensured that the respondents were familiar with the presented scenario (Aguinis and Bradley, 2014). Participants were also asked to determine whether certain visual characteristics were presented. In our experiment, all participants could distinguish between two images (e.g., high v.s. low colorfulness, and human face presented v.s. human face absent), so we achieved success in manipulating visual characteristics.

5.3 Dependent variables

The scale of moral shock was adopted from Barberá-Tomás et al. (2019). In the survey, participants were asked to recall the images they saw at the beginning of the survey and describe how the images made them feel: (1) sadness, (2) rage, and (3) despair. Participants responded using a 5-point scale with the equivalent point labels as follows: not at all, slightly, moderately, much, and very much.

Emotional energy can be described as the intensity with which a person's feelings are expressed and communicated (Barsade, 2002). Verbal pitch, loudness, and tempo are all ways of expressing energy intensity, as well as nonverbal signals. As a measure of emotional energy, we adopted a refusal intention scale developed by Church and Thambusamy (2018), which expressed the willingness to refuse medical plastics. We modified the items from refusal intention scale to fit our research context. Three items were included: (1) In the future, I would refuse to use medical plastic products, (2) In
the future, I would probably refuse to use medical plastic products, and (3) In the future, I would say it is possible I might refuse to use medical plastic products.

6. Results and discussions

6.1 Reliability test

For two dependent variables, factor loadings were calculated to evaluate the reliability of the measurement items. Loadings are higher than 0.7, which met the recommended tolerance (Hair et al., 2006). To demonstrate the internal consistency, the Cronbach’s alpha was calculated for two dependent variables. As shown in Table 2, all variables met the requirement.

<table>
<thead>
<tr>
<th>Measurement items</th>
<th>Factor loadings</th>
<th>Rotation sums of squared loadings</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>% of variance</td>
</tr>
<tr>
<td>Moral Shock_1</td>
<td>0.933</td>
<td>2.633</td>
<td>43.885%</td>
</tr>
<tr>
<td>Moral Shock_1</td>
<td>0.924</td>
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<td></td>
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<tr>
<td>Moral Shock_1</td>
<td>0.917</td>
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<tr>
<td>Refusal intention_1</td>
<td>0.914</td>
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<tr>
<td>Refusal intention_2</td>
<td>0.901</td>
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</tr>
<tr>
<td>Refusal intention_3</td>
<td>0.865</td>
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<td></td>
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<td>2.460</td>
<td>40.999%</td>
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</table>

6.2 Hypothesis tests

A descriptive analysis and an ANOVA analysis were conducted in order to examine the effects of visual characteristics on moral shock and refusal intention. The results are shown in Table 3 and Table 4. In Experiment 1, the results show that the healthcare professionals who saw an image with a high level of visual clutter are more likely to elicit their moral shock ($M_{\text{high clutter}} = 4.045$, $M_{\text{low clutter}} = 3.313$, $F=30.559$, $p=0.000$), and trigger their intention to refuse the medical plastics ($M_{\text{high clutter}} = 4.432$, $M_{\text{low clutter}} = 4.272$, $F=3.544$, $p=0.061$). Thus, hypothesis 1 is supported.

In Experiment 2, high colorfulness group’s moral shock is significantly higher than that in the low colorfulness group ($M_{\text{high colorfulness}} = 4.197$, $M_{\text{low colorfulness}} = 3.929$, $F=5.017$, $p=0.026$). However, there is no significant difference in the refusal intention between the high colourfulness and low colourfulness groups ($M_{\text{high colorfulness}} = 4.380$, $M_{\text{low colorfulness}} = 4.428$, $F=0.244$, $p=0.622$). Thus, hypothesis 2 is partially supported.

In Experiment 3, the results show that healthcare professionals who saw an image with human face are more likely to elicit their moral shock ($M_{\text{human face presented}} = 3.981$, $M_{\text{human face absent}} = 3.720$, $F=4.974$, $p=0.027$) and their intention to refuse medical
plastics (M_{human face presented}=4.477, M_{human face absent}=4.269, F=4.535, p=0.034). Thus, hypothesis 3 is supported.

Surprisingly, in Experiment 4, there is no significant difference in moral shock and refusal intention between the animal presence and animal absence groups. Hypothesis 4 is thus not supported.

Table 3 Descriptive analysis

<table>
<thead>
<tr>
<th>Experiment 1 (Visual clutter)</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Std. Error</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Std. Error</th>
</tr>
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<tbody>
<tr>
<td>High</td>
<td>149</td>
<td>4.045</td>
<td>1.008</td>
<td>0.083</td>
<td>149</td>
<td>4.432</td>
<td>0.678</td>
<td>0.556</td>
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<tr>
<td>Low</td>
<td>136</td>
<td>3.313</td>
<td>1.222</td>
<td>0.105</td>
<td>136</td>
<td>4.272</td>
<td>0.754</td>
<td>0.645</td>
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<tr>
<td>Total</td>
<td>285</td>
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<td>1.172</td>
<td>0.069</td>
<td>285</td>
<td>4.356</td>
<td>0.719</td>
<td>0.043</td>
</tr>
<tr>
<td>Experiment 2 (Colorfulness)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>136</td>
<td>4.197</td>
<td>0.730</td>
<td>0.063</td>
<td>136</td>
<td>4.380</td>
<td>0.719</td>
<td>0.062</td>
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<tr>
<td>Low</td>
<td>141</td>
<td>3.929</td>
<td>1.191</td>
<td>0.100</td>
<td>141</td>
<td>4.428</td>
<td>0.887</td>
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<td>Total</td>
<td>277</td>
<td>4.060</td>
<td>0.999</td>
<td>0.056</td>
<td>277</td>
<td>4.404</td>
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<tr>
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</tr>
<tr>
<td>Absent</td>
<td>145</td>
<td>3.720</td>
<td>1.110</td>
<td>0.092</td>
<td>145</td>
<td>4.269</td>
<td>0.917</td>
<td>0.076</td>
</tr>
<tr>
<td>Present</td>
<td>137</td>
<td>3.981</td>
<td>0.825</td>
<td>0.070</td>
<td>137</td>
<td>4.477</td>
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<tr>
<td>Total</td>
<td>282</td>
<td>3.846</td>
<td>0.989</td>
<td>0.058</td>
<td>282</td>
<td>4.370</td>
<td>0.825</td>
<td>0.049</td>
</tr>
<tr>
<td>Experiment 4 (Animal)</td>
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<td></td>
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<tr>
<td>Absent</td>
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<td>3.631</td>
<td>1.011</td>
<td>0.083</td>
<td>149</td>
<td>4.369</td>
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<tr>
<td>Present</td>
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<td>0.087</td>
<td>146</td>
<td>4.450</td>
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<tr>
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<td>1.030</td>
<td>0.060</td>
<td>295</td>
<td>4.409</td>
<td>0.682</td>
<td>0.040</td>
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</table>

Figure 4. Visualizing the study results
Table 4 ANOVA summary table

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
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</thead>
<tbody>
<tr>
<td><strong>Outcome: moral shock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 1 (Visual clutter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>1</td>
<td>37.996</td>
<td>30.559</td>
<td>.000</td>
<td>1</td>
<td>1.814</td>
<td>3.544</td>
<td>0.061</td>
</tr>
<tr>
<td>Within</td>
<td>283</td>
<td>1.243</td>
<td>1.814</td>
<td>0.512</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>284</td>
<td></td>
<td>1.243</td>
<td>0.512</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Experiment 2 (Colorfulness)</td>
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<td></td>
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<td>5.017</td>
<td>0.026</td>
<td>1</td>
<td>0.159</td>
<td>0.244</td>
<td>0.622</td>
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<tr>
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<td>0.159</td>
<td>0.064</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>276</td>
<td></td>
<td>0.984</td>
<td>0.064</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 3 (Human Face)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
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<td>4.798</td>
<td>4.974</td>
<td>0.027</td>
<td>1</td>
<td>3.045</td>
<td>4.535</td>
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<tr>
<td>Within</td>
<td>280</td>
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<td>3.045</td>
<td>0.672</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Error</td>
<td>281</td>
<td></td>
<td>0.965</td>
<td>0.672</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Experiment 4 (Animal)</td>
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<tr>
<td>Error</td>
<td>294</td>
<td></td>
<td>1.064</td>
<td>0.465</td>
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<td></td>
</tr>
</tbody>
</table>

7. Discussion and conclusion

By examining the effect of visual elicitation on moral shock and emotional energy in the context of medical plastic waste, this study extends the literature on medical waste management. Importantly, we not only demonstrate that visuals of plastic medical pollution can provoke emotional responses, but also identify specific characteristics of visuals that trigger moral shock when used to illustrate the pollution of medical waste. A variety of visual features of images were analyzed by healthcare professionals to obtain our findings, as summarized in below.

The first finding revealed that images with high level of visual clutter perform better in triggering healthcare professionals’ emotional responses and energy. This finding is consistent with Pieters et al. (2010), who argues that visual clutter creates negative attitude toward brands and products. Although a few other studies suggest that visual clutter reduces individuals’ attention (Baldassi et al., 2006; Van den Berg et al., 2009), our findings indicate that pictures with heavy clutter evoke emotional responses and cause behavioral changes.

In addition, healthcare professionals exhibit moral shocking toward the colorful images compared to those receiving the low-colored images. This finding confirms the view of several studies in marketing (e.g., Finn, 1988, Wedel and Pieters, 2015) that they contend that colorfulness of an image is an effective way to stimulate consumers’ attention and engagement. However, when it comes to the effect of colorfulness on refusal intention, our samples show the opposite: healthcare professionals seem not to
increase the likelihood of refusing medical plastics when high-color images are displayed.

The third finding is that images with the presence of human face are more likely to elicit healthcare professionals’ moral shock and their refusal intention. This finding reaffirms the results of studies by Li and Xie (2020) in which the presence of human face in the images trigger consumers’ emotional responses and improve their engagement.

While prior research has found that images with the presence of animal tend to attract more consumers’ moral shock (Barberá-Tomás et al., 2019), our results indicate that an image with an animal does not significantly elicit moral shock and the intention to refuse medical plastics among healthcare professionals. One possibility is that animal presence has the imaginative impact on consumers based on their context and that it is not universal, especially for healthcare professionals who have strong preferences for medical plastics.

Taken altogether, this study contributes to the management of medical waste and has implications for hospitals and non-profit organizations (NPOs) that combat plastic medical pollution.

7.1 Theoretical implication

In this study, we examine the consumers’ perspective on medical waste, which has been overlooked in prior research and receives relatively little attention in this area. Particularly in the healthcare setting, medical professionals are crucial to spreading anti-plastic pollution messages (Windfeld and Brooks, 2015). Literature on the views of healthcare professionals on reducing medical waste is noticeably lacking. By failing to understand their views regarding medical waste management, we may miss opportunities to provide more comprehensive insights into the anti-plastic pollution initiatives. The study shows that imaginative appeals incorporating specific image elements can cause moral shock and other emotional reactions in healthcare professionals. Therefore, the results of our work provide empirical support for the emotion-symbolic work proposed by Barberá-Tomás et al. (2019).

Medical waste studies have often focused solely on the technical aspect of medical waste. Yet, research has not yet explored what specific communication can be used and what impact those different forms of communication have on reducing consumers'
intentions to use medical plastics. Instead of focusing on textual communication of anti-plastic pollution, this study focuses on visual displays that convey anti-plastic pollution messages. Visual displays of an image need to be presented in "visual clutter", "colourful" "human face presence" ways. Consumers are likely to feel sadness, rage, and despair when seeing images of anti-plastic pollution, which will increase their intention to refuse medical plastics to the greatest extent.

7.2 Practical implication

The findings demonstrate two practical implications. First, it is crucial that hospitals or NGOs rethink what form of communication they use to promote anti-plastic campaigns. Practitioners can increase target audiences’ emotional responses and energy through the use of visuals in their marketing campaigns. We recommend developing visual displays for promoting anti-plastic campaigns by using A/B testing and scenario analysis, which will assist them in better understanding the effectiveness of visual characteristics.

Second, for NGOs to achieve their organizational goals, social media platforms are a great way to stay in contact. We found that social media marketing can identify important visual characteristics and develop effective visual posts for medical waste reduction initiatives based on our findings. NGOs should take advantage of visual communication by attaching images to their social media posts to attract attention.

7.3 Limitations and future research

This study is not without its limitations, but there exist several opportunities to develop a deeper understanding of medical waste management through future research. As a first limitation, the single country of this study may limit the generalizability of its results. Future research should explore the scope of observation in order to validate the current findings by collecting data from a wider range of countries or regions.

Second, the selected visual characteristics are valuable for achieving our research objective, but they do not cover all types of visual characteristics. There is a great need to continue researching how potential visual characteristics, like detail level, coarseness, contrast, and directionality, as well as hue, saturation, and value (HSV) impact consumer emotional reactions (Matz et al., 2019).
Third, while this study empirically examines how visual characteristics affect emotional reactions, developing an analytical framework to automatically process a large number of images would be helpful for practitioners. In particular, the content of visuals (e.g., objects and geometrical features) can be analyzed in a meaningful way to assist practitioners in improving visual marketing campaigns.

References


