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Standardization of Chargers for Portable Electronic Devices in the Saudi Market

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***Abstract*:** In recent years, portable devices such as mobile phones, tablets, digital cameras, headphones, and portable speakers have been used more commonly. These devices usually come with a particular type of charger that may or may not be suitable for use with other devices. The incompatibility issue of chargers has garnered much attention worldwide in the last few years, including in Saudi Arabia. The main points of investigation are the environmental, economic, and social impacts of having many types of chargers for portable electronic devices. Due to the massive size of the electronic market in Saudi Arabia, this paper aims to survey consumers' opinions about the current situation of chargers and assess the potential impact of standardizing chargers in the Saudi market. The descriptive analytics approach is used in this study through an electronic questionnaire. The study received 1,527 responses from 13 provinces within Saudi Arabia. The results demonstrate serious challenges associated with electronic device chargers and the significant need to standardize them. The environmental, social, and economic benefits of this standardization are outlined. The findings of this paper recommend that policymakers in Saudi Arabia embrace the standardization of chargers for all portable electronic devices.

Keywords: portable electronic devices, standard chargers, electronic waste.

1. Introduction

Today, people utilize their mobile phone devices frequently in their everyday routines for a wide range of services and activities, including, for example, bookings, social media, web surfing, navigation, and shopping. The number of mobile users globally reached 7.1 billion in 2021, which is forecasted to rise to approximately 7.5 billion by 2025 [1].

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A charger is one of the main accessories associated with the mobile phone. At present, certain mobile phones are only compatible with certain types of chargers. This incompatibility issue results in customer inconvenience and electronic waste. In most cases, customers cannot charge their mobile phones with other phone chargers or use old chargers to charge new phones. In addition to customer inconvenience, this practice causes additional financial burdens to the customers. Furthermore, this issue could cause old chargers to accumulate if they are no longer used, resulting in different environmental-related issues. The production of chargers requires raw materials, and emissions are generated by their transportation. Thus, when chargers are no longer used, this results in electronic waste and environmental impact. Each year, chargers are accountable worldwide for approximately 11,000 to 13,000 tons of electronic waste and emissions of roughly 600 to 900 kt CO_2 [2]. Therefore, it is imperative to study the current situation of chargers for mobile phones and other portable electronic devices. Their social, financial, and environmental impacts must be evaluated to introduce more sustainable and effective charging solutions.

The Saudi market is one of the largest in the Middle East and is widespread with various electronic devices. By 2025, the number of mobile internet users in Saudi Arabia is anticipated to reach 36.2 million, up from the current figure of 31.88 million [3]. At the current pace, the number of chargers for mobile phones and other electronic devices may also increase accordingly. In 2016, Saudi Arabia launched Vision 2030 to make the country a successful and pioneering model in the world at all levels [4]. Since then, numerous research efforts have been introduced to help achieve Vision 2030 goals in many areas [5]– [25]. One goal of Vision 2030 is to improve the quality of life in the country so that residents can live a happy and fulfilling life with a standard of living that guarantees a healthy and safe environment. To help fulfill this goal, this paper aims to survey consumers' opinions about the current situation of chargers for mobile phones and other portable electronic devices and assess the potential impact of standardizing chargers in the Saudi market.

The paper is structured as follows: A summary of the relevant literature is provided in Section 2. In Section 3, the methodology employed is presented. The results of the data analysis are discussed in Section 4. Finally, Section 5 concludes the paper.

2. Related Work

The European Union (EU) has been working to establish a standard charger for portable devices for over a decade. To ensure compatibility between chargers and mobile phones on the market, key manufacturers signed a memorandum of understanding (MoU) in 2009, sponsored by the European Commission (EC). The MoU led to a sharp decline in the supply of chargers and a shift toward Universal Serial Bus (USB) Micro-B connectors on phones. In contrast to the over 30 proprietary chargers available on the EU market in 2009, by 2012, 9 out of 10 new gadgets had USB Micro-B capability. Nonetheless, no replacement MoU has been signed since the previous one expired in 2014. The parliamentary initiative to alter the 2014 Radio Equipment Directive on the standardization of the rules of the Member States relevant to the production of radio equipment that is available for sale gained a conditional agreement by the EU Parliament and the Council on June 7, 2022. The revised rule, put forth by the EC in September 2021, is the initial phase toward requiring a standard charger for cell phones and other light portable devices. This charger must include a USB Type-C socket and support the USB Power Delivery data transmission. Customers may purchase phones with or without a charger. Co-legislators agreed that the amendments should include details on the

charging capacities and hardware compatibility. Customers and other end users should be notified if a charger is included along with a product [26], [27].

A study was conducted by Vencovsky et al. [28] to assess the possibility of standardizing chargers for mobile phones, evaluate the effects these measures have had on the market for several other portable devices, and determine the likelihood of further harmonization. The study consists of three parts: (1) an evaluation of the MoU's effects on the smartphone and charger market; (2) an assessment of the MoU's potential collateral effects on the market for other devices; and (3) a former evaluation of the prospective effects of several legislative alternatives for further standardization of charging devices such as smartphones and other portable devices. The study indicates that the MoU agreed upon in 2009 proved beneficial in standardizing charging issues and boosting consumer comfort. The study also demonstrates that the compliance rates with the MoU expanded from over 80% in 2012 to approximately 99% in 2013. The report, however, acknowledged that decoupling had not been effectively accomplished. The anticipated environmental benefits were limited, with few European companies allowing customers to purchase phones without chargers. According to research by Apple-backed Copenhagen Economics, the cost to consumers of a regulator-imposed switch to a standard charger would be at least €1.5 billion, outweighing any environmental benefits of €13 million [29].

Additionally, an evaluation study of the effects of typical portable device chargers was conducted in 2019. The study intended to gather information for the EC impact assessment accompanying a new proposal to prevent possible technological advancement from being hampered while limiting the diversity of charging options for cell phones and other portable devices. The proposed program primarily aims to solve the issues of customer discomfort brought about by the continued presence of various charger fragmentation and the adverse environmental effects brought on by the enormous number of chargers created and ultimately thrown away. To address customer dissatisfaction issues brought on by the continuous fragmentation of chargers, the study advises pursuing standard connectors combined with an interoperable external power supply (EPS) [2].

Furthermore, the significance of mobile phone chargers is discussed in [30], as well as the ongoing efforts by the Global System for Mobile Communications Association (GSMA) and top manufacturers to develop a brand-neutral standard for a universal charging solution (UCS) for recently released mobile devices. The study uses the system engineering methodology to analyze the current process and outlines the compatibility and environmental design issues that UCS aims to address or mitigate. The essential elements of the conventional and unconventional concepts are discussed in the study, along with the potential connections to other systems. Additionally, the authors describe the project's status, discuss anticipated influences, and make some recommendations for the future. The study emphasizes the need for a standardized mobile phone charger and the possible advantages of a brand-independent solution overall.

3. Research Methodology

The descriptive analytics approach is used in this study through a public survey to collect evidence and opinions on the current situation of chargers for mobile phones and other portable electronic devices. As shown in Figure 1, the methodology involves three main tasks: 1) prepare the survey questions using an electronic questionnaire developed for the study; 2) send the questionnaire to the target audience and collect the responses; and 3) analyze the responses and discuss the results. The spatial scope of the study is over the 13 provinces of Saudi Arabia. The questionnaire contains 14 questions covering the essential related demographic data for the participants, consumer characteristics relative to current electronic devices and chargers, current issues with chargers from consumers' viewpoint, consumer preferences relative to new chargers, and consumer perspectives toward standardizing chargers in the Saudi market. The survey was sent to all Saudi government universities targeting all age groups for males and females from February 23 to May 16, 2023.

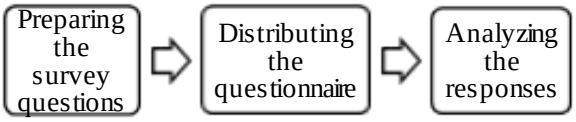

Figure 1. Research Methodology.

4. Results and Discussion

4.1. Overview of the respondents

The study received 1,527 responses from 13 provinces within Saudi Arabia, representing the opinions and viewpoints of consumers in the Saudi market. Most responses came from Makkah, Riyadh, Asir, Eastern Region, Tabuk, Medina (Al-Madinah al-Munawwarah), Hail, and Qassim provinces, as depicted in Figure 2. The survey reflects a satisfactory proportion of the viewpoints held by the residents of these provinces.

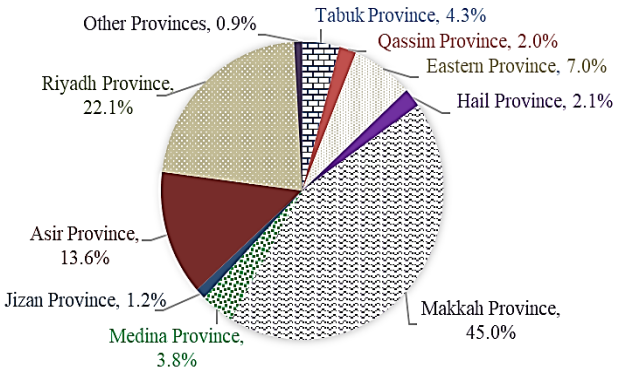

Figure 2. The distribution of respondents according to the province of origin.

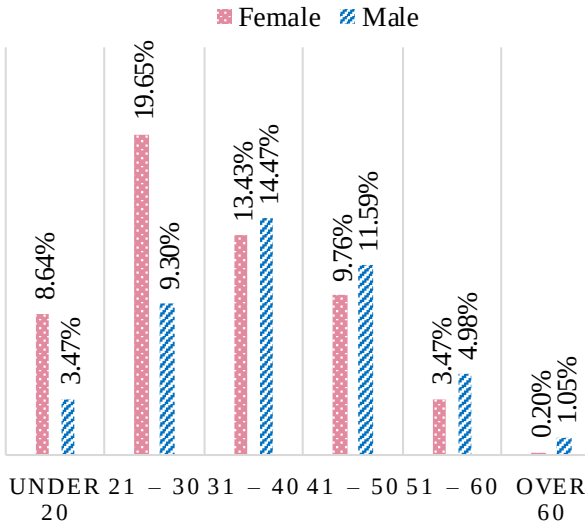

Figure 3. The distribution of respondents according to age grouping

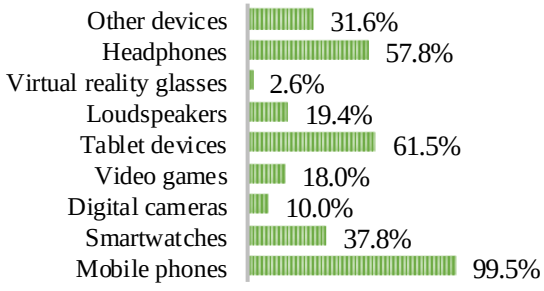

Figure 4. The distribution of personal portable electronic devices used by the respondents

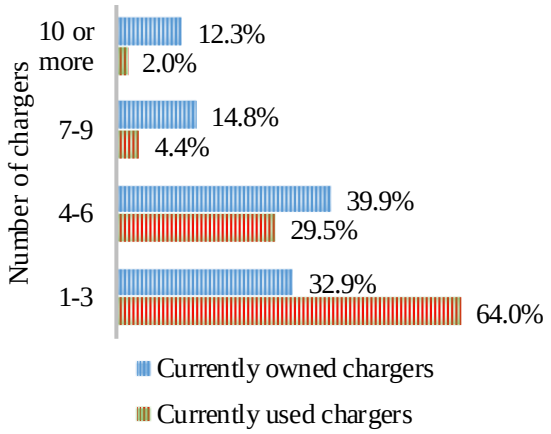

Figure 5. Number of owned/used chargers

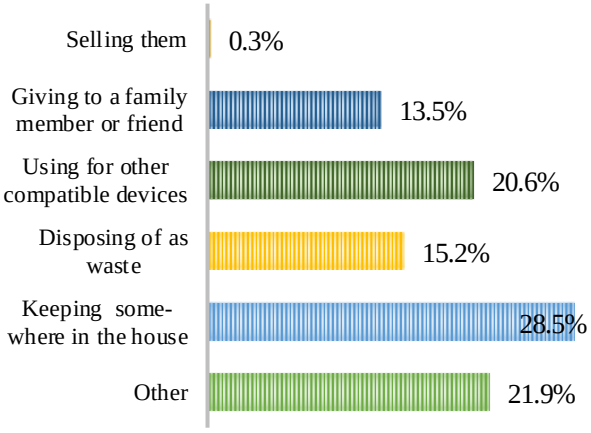

Figure 6. Respondents' use of old chargers

The proportion of female and male participants are 55.1% and 45.9%, respectively. The distribution ratio of respondents' genders according to their age grouping is shown in Figure 3, which reveals that females aged 30 years and younger were more interested than males in participating in the survey. On the other hand, the proportions of participating males in other age groups are higher than that of females.

4.2 Consumer characteristics relative to current electronic devices and chargers

4.2.1 Types of electronic devices

Figure 4 shows the main types of rechargeable portable electronic devices currently used by the respondents, and the percentage of users using each type. The figure illustrates that mobile phones are first at 99.5%, followed by tablets, headphones, and smartwatches at 61.5%, 57.8%, and 37.8%, respectively. Digital cameras and virtual reality glasses are the least used devices by respondents, at 10.0% and 2.6%, respectively.

4.2.2 Number of owned and currently used chargers

The number of chargers currently used by the participants to charge their electronic devices and the number of chargers owned by the participants, regardless of whether they are currently used or not, are depicted in Figure 5. Customers tend to use as few chargers as possible to charge their electronic devices. The results show that 64% of participants currently use one to three chargers, 29.5% use four to six chargers, and only 6.4% use seven or more chargers. This tendency is generally inconsistent with the current situation where customers either tend to own more chargers. The results show that 67% of participants own at least four chargers. The question here is what causes customers to own more chargers.

4.2.3 Compatibility of currently used chargers with different devices

Furthermore, the results reveal that only 8.7% of the respondents can use one type of charger to charge all their current electronic devices. The results show that 38.1% of the respondents use a dedicated charger for every electronic device, while 53.2% can charge some of their electronic devices with the same charger. This means that many electronic devices in the market may not be compatible with standardized charging methods or may lack universal charging capabilities.

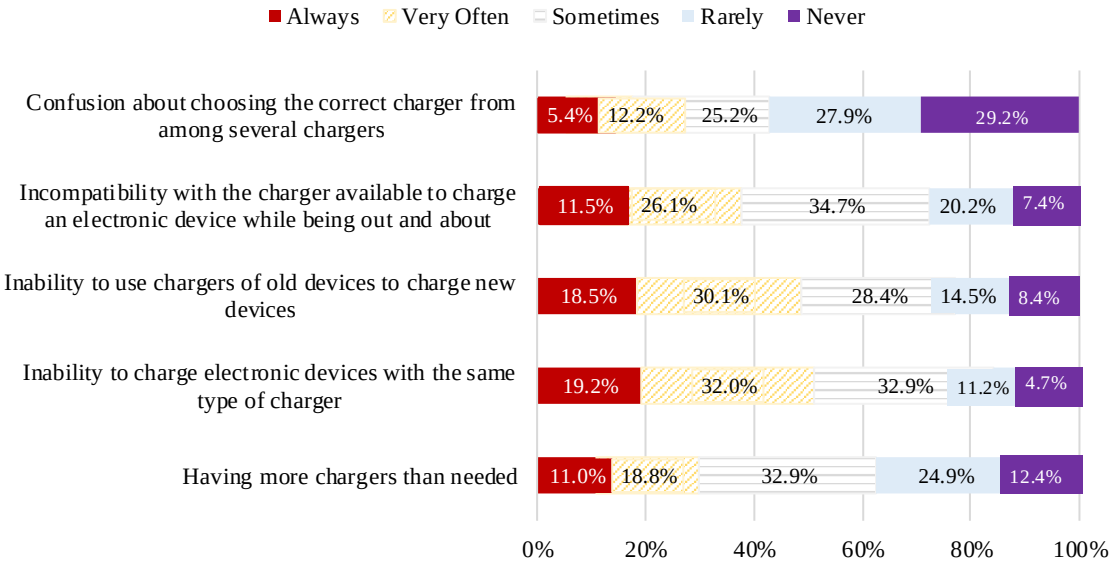

Figure 7. Frequency occurrence of charger-related issues

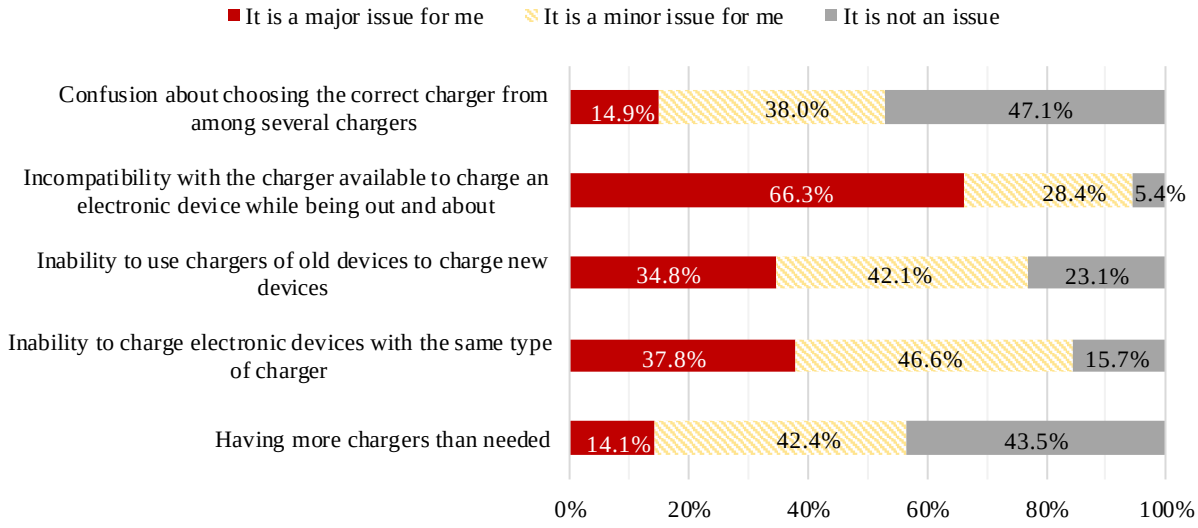

Figure 8. Severity degree of charger-related issues

4.2.4 The behavior of consumers toward old and used chargers

Figure 6 presents the behaviors of respondents toward their old and used chargers, including selling them, keeping them somewhere in the house, disposing of them as waste, using them for other compatible devices, and giving them to a family member or a friend. Keeping chargers somewhere in the house was the most popular choice among respondents, with 28.5% tending to hold on to chargers even if they are no longer actively used. This indicates that respondents may keep old chargers for future use. This finding is further supported by the results showing that 20.6% of respondents use old chargers for other

compatible devices. Disposing of old chargers as waste is third at 15.2%, indicating a potential concern for the negative environmental impact this practice may cause. This observation emphasizes the need to increase awareness and foster a sense of individual responsibility regarding sustainability and environmental preservation. Giving old chargers to a family member or a friend or selling them are the least preferred options, at only 13.5% and 0.3%, respectively. This indicates that a small percentage of respondents choose to sell their old chargers, possibly to recoup some of the cost, while a slightly higher percentage choose to give them to someone they know.

4.3 Current issues with chargers

The respondents were asked about several general issues they may have experienced in the last two years before the survey. These issues include confusion about choosing the correct charger from among several chargers, incompatibility with the charger available to charge an electronic device while being out and about, inability to use chargers of old devices to charge new devices, inability to charge multiple electronic devices with the same type of charger, and having more chargers than needed. The frequency and severity of these issues to the respondents are depicted in Figure 7 and Figure 8, respectively.

4.3.1 Frequency of the issues

The five-point Likert frequency scale employed in this part comprises Always, Very Often, Sometimes, Rarely, and Never to determine the frequency of occurrence of these issues [31]. The results show that a significant proportion of respondents (51.2%) experience difficulty charging their electronic devices with the same type of charger (19.2% always, 32% very often). Additionally, the results show that 48.6% of respondents are consistently unable to use chargers of old devices to charge their new devices (18.5% always, 30.1% very often). These findings indicate that many respondents often encounter ongoing challenges that may cause them inconvenience. These challenges appear to be a prevalent concern among the surveyed individuals. Compared to the other issues identified, choosing the correct charger from among several chargers was the minor common issue.

4.3.2 Severity of the issues

Figure 8 illustrates the severity of charger-related issues from the consumers' perspective, classified as major issues, minor issues, and not an issue. The findings reveal that respondents consistently encounter challenges in all issues, indicating the severity of these challenges as major or minor. The results show that a significant proportion of respondents, specifically 94.7%, reported encountering compatibility issues when attempting to charge their electronic devices outside their homes or in different locations. Among these respondents, 66.3% consider this issue a major concern, while 28.4% categorize it as minor. Additionally, the inability to charge electronic devices with the same type of charger is denoted as a major issue by 37.8% of respondents, and the inability to use chargers of old devices to charge new devices is identified as a major issue by 34.8% of respondents. These findings underscore the widespread challenges consumers experience regarding the compatibility of chargers; this highlights the need to address these issues to improve user experience and convenience. On the other hand, 47.1% and 43.5% of the respondents believe that confusion about choosing the correct charger from among several chargers and having more chargers than needed, respectively, is not an issue for them.

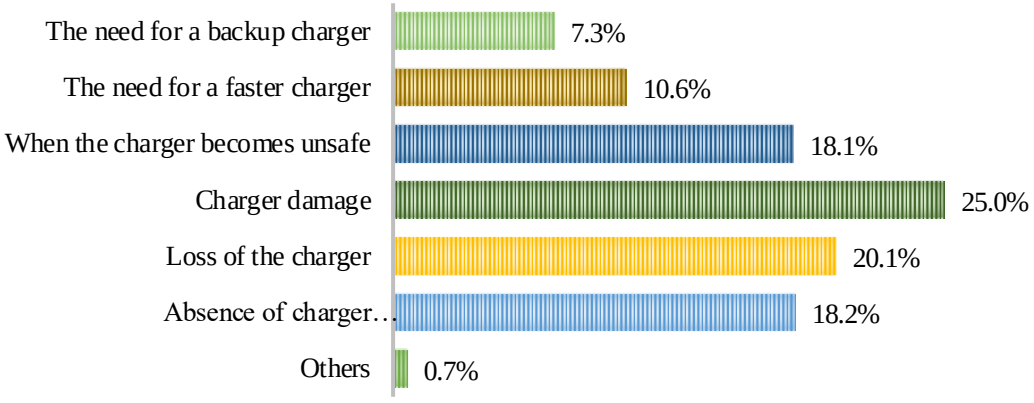

Figure 9. Reasons to purchase a new charger

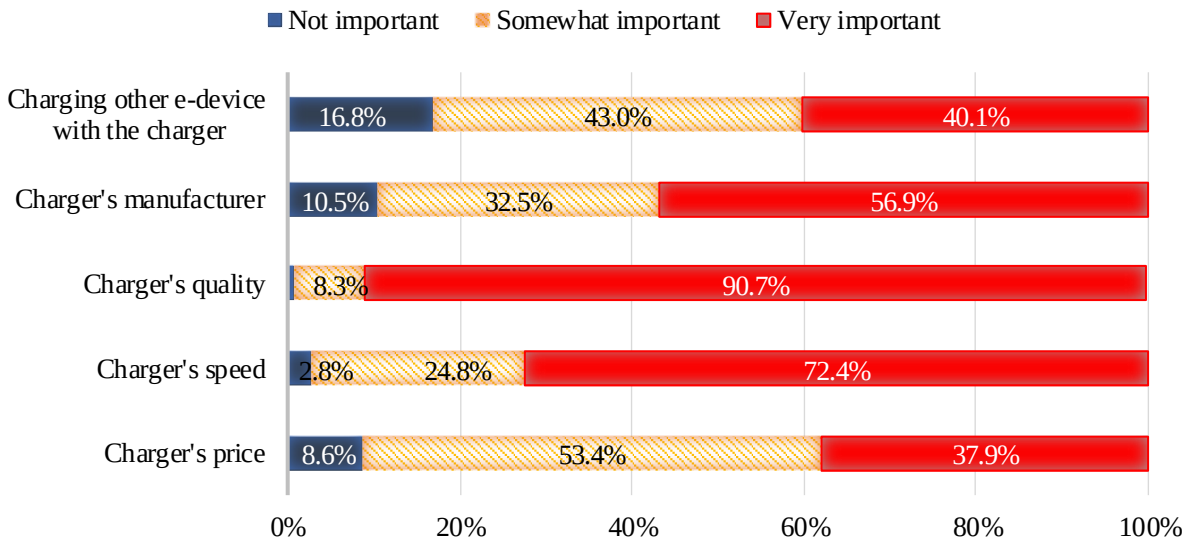

Figure 10. Important characteristics of a new charger

4.4 Consumer preferences relative to new chargers

4.4.1 Reasons to purchase a new charger

The participants were asked about the reasons to purchase a new charger. A suggested list of reasons was provided, including when the charger is not included in the box of the device, when the current charger is lost, when the current charger is damaged, when the current charger becomes unsafe, when a faster charger is needed, and when a backup charger is needed. Among these reasons, charger damage, charger loss, and the lack of including a charger in the device box are the most common reasons for purchasing a new charger for electronic devices, with percentages of 25.0%, 20.1%, and 18.2%, respectively, as shown in Figure 9. Having backup chargers represents a lower percentage of only 7.3%. These results indicate that respondents are more likely to

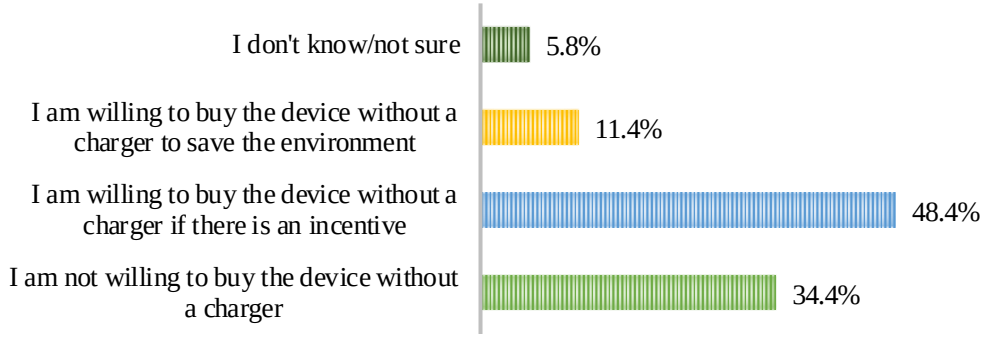

Figure 11. Respondents' willingness to purchase new electronic devices without chargers

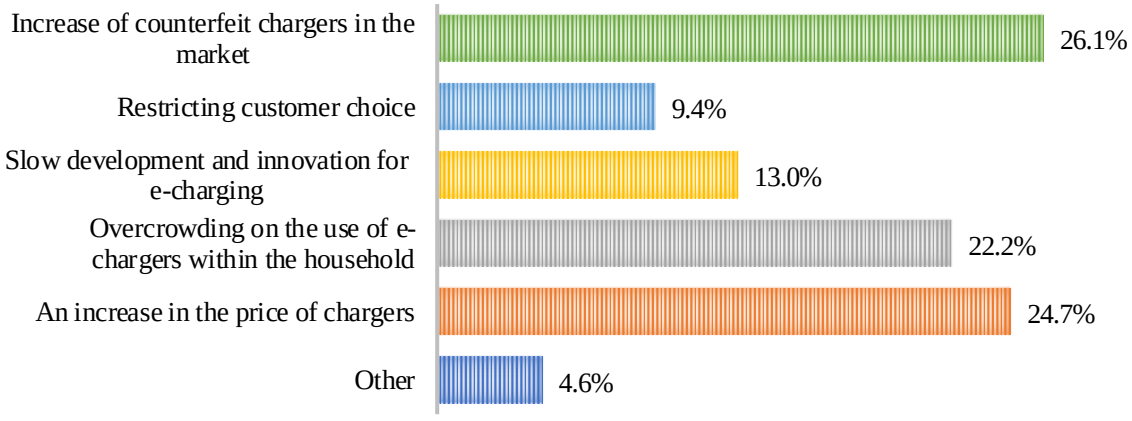

Figure 12. Potential challenges associated with standardizing chargers

seek a replacement charger due to existing charger issues (damage or loss) or the absence of a charger rather than proactively purchasing backup chargers. This highlights the significance of functional and practical considerations in the decision-making process when acquiring new chargers for electronic devices.

4.4.2 Characteristics of a new charger

This study investigates the main characteristics of a new charger when a consumer needs to purchase one. The participants were provided with a suggested list of characteristics including the price of the charger, the speed of charging, the quality of the charger, the manufacturer of the charger, and the ability to charge other electronic devices with the same charger. The results indicate that the primary factor respondents care about when purchasing a new charger is the quality of the charger, with a significant percentage of 90.7% considering this to be the most important factor. Following closely behind, the charging speed is important to respondents with a percentage of 72.4%, while the manufacturer of the chargers is third with a percentage of 56.9%. Chargers' compatibility with different electronic devices represents a considerable percentage at 83.1% (43% somewhat important and 40.1% very important). Figure 10 depicts the percentage

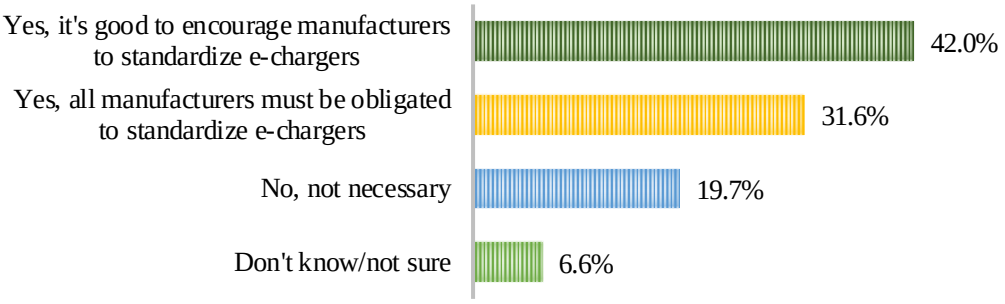

Figure 13. The necessity of standardizing e-chargers

of important characteristics a new charger should have according to consumer preferences.

4.4.3 Willingness of consumers to purchase a new electronic device without a charger

Figure 11 illustrates the percentage of respondents' perceptions regarding purchasing new devices without chargers if they already have compatible chargers. The results indicate that a significant proportion of respondents, specifically 48.4%, are willing to buy an electronic device without a charger under specific circumstances. These circumstances may include incentives such as special promotions or price discounts. On the other hand, 34.4% of respondents expressed that they are not willing to purchase an electronic device without chargers, indicating that those individuals still consider accompanying chargers essential when purchasing new devices, even in the presence of discounted prices and promotions. Furthermore, a small portion of respondents, specifically 11.4%, prioritize environmental considerations and are willing to purchase an electronic device without a charger to contribute to environmental conservation efforts. However, since only a small proportion of respondents care about the negative environmental impact of chargers, this indicates a lack of awareness about this environmental-related issue, and further serious actions should be taken by policymakers to raise the level of awareness.

4.5 Consumers' perspectives toward standardizing chargers in the Saudi market

4.5.1 Challenges that may arise due to standardizing chargers

The challenges that may arise after standardizing chargers of electronic devices include an increase in counterfeit chargers in the market and a restriction of customer choice. Additionally, there may be slower development and innovation in charging technologies, overcrowding of chargers within households, and an increase in the price of chargers. The results depicted in Figure 12 demonstrate that the highest percentages of respondents expressed their concerns regarding an anticipated increase in the presence of counterfeit chargers in the market, a rise in the price of chargers, and overcrowding of chargers within households, with proportions of 26.1%, 24.7%, and 22.2%, respectively. On the other hand, the lowest percentages of respondents expressed their concerns regarding the anticipated restriction of customer choice and the slow development and innovation of charging technologies, with proportions of 9.4% and 13.0%, respectively, which indicates that most respondents consider these issues insignificant.

4.5.2 The necessity of standardizing chargers for electronic devices

The participants were asked whether they believe it is necessary to standardize electronic device chargers for one type of charger. Figure 13 presents the respondents'

opinions, categorized into the following four options: “Yes, it’s good to encourage manufacturers to standardize chargers for electronic devices,” “Yes, all manufacturers must be obligated to standardize chargers for electronic devices,” “No, not necessary,” and “Don’t know/not sure.”

The results indicate that most respondents, accounting for 73.6%, supported standardizing chargers in the Saudi market. Among these respondents, 42.0% believed that encouraging manufacturers to standardize chargers would be a good idea, while 31.6% believed that manufacturers must be obligated to standardize chargers for electronic devices. These findings highlight the strong support for standardization among the surveyed respondents. On the other hand, it is worth noting that 19.7% of respondents disagreed with the idea of standardizing chargers, stating that it is unnecessary. This perspective represents a minority viewpoint among the surveyed individuals. Furthermore, 6.6% of respondents did not provide their opinion and responded, "Don’t know/not sure." Overall, the results suggest a strong inclination toward standardizing chargers among the surveyed respondents, with a significant majority supporting the idea.

5. Conclusion

This paper studies and analyzes the current situation of chargers for mobile phones and other portable electronic devices and assesses the impact of standardizing chargers in the Saudi market. The results reveal that customers tend to own more chargers than they need, as 64% of participants use one to three chargers for their portable electronic devices, while 67% own at least four chargers. This finding is unsurprising since only 8.7% of participants can use a standard charger for all their portable electronic devices.

The results also show that using old chargers for other compatible devices and keeping them somewhere in the house for future use represents more than 20% and 28.5% of respondents, respectively. Moreover, even without a public recycling-related incentive program for unused chargers, recycling unused chargers by selling them or giving them to a friend or a family member represents approximately 14% of the current situation for unused chargers. That is, consumers are willing to use old chargers. Nonetheless, more than 15% of unused chargers are disposed of as waste, indicating an environmental-related severe concern.

Generally, respondents experienced difficulty and inconvenience with the incompatibility of chargers. The results show that 51.2% of respondents have trouble (always and very often) when charging their electronic devices as they cannot charge their electronic devices with the same type of charger, and 84.4% of respondents consider this an issue that must be resolved. The inability to use the chargers of old devices to charge new devices is regarded as an issue for almost 77% of the participants, whereas the difficulty associated with finding a compatible charger while being outside the home is an issue for 94.7% of the participants. The findings clearly show the inconvenience consumers experience due to the incompatibility of chargers.

Based on the study’s findings, the authors of this paper recommend that policymakers in Saudi Arabia embrace the transition toward standardizing chargers for all portable electronic devices in the Saudi market by requiring all electronic device manufacturers to produce standard chargers. This transition would be a primary effort to preserve resources and reduce emissions, especially with the current behavior of consumers who tend to re-use old chargers. Moreover, the inconvenience experienced by consumers with the incompatibility of chargers would be mitigated by a standard charger that can be used for old and new devices and easily found outside the home. In addition, manufacturing standard chargers for electronic devices with

higher quality and fast-charging characteristics would reduce the number of new chargers purchased since approximately 60% of respondents are willing to purchase a new electronic device without a charger if they already have a compatible charger. This shift to a standard charger would consequently have a positive economic impact on consumers. The obtained findings of the analysis are supported by the opinion of 73.6% of the respondents who support the standardization of chargers for portable electronic devices. Nevertheless, as expressed by respondents, the challenges associated with standardizing chargers should be addressed carefully, the most important of which are the increase in counterfeit chargers in the market and the increase in chargers' prices. This paper highlights the significance of the need to standardize chargers in the Saudi market; however, the type of charger for standardization has not been discussed. Further in-depth technical assessment of standard charger type should be carried out in future work.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the committee of biomedical ethics of Umm Al-Qura University (protocol code HAPO-02-K-012-2023-03-1536).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data supporting this study's findings are available to the editor and reviewers from the corresponding author upon request.

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Conflicts of Interest: The authors declare no conflict of interest.

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توحيد شواحن الأجهزة الإلكترونية المحمولة في السوق السعودي

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مستخلص. في السنوات الأخيرة، أصبحت الأجهزة المحمولة مثل الهواتف المحمولة والأجهزة اللوحية والكاميرات الرقمية وسماعات الرأس ومكبرات الصوت المحمولة أكثر شيوعًا. تأتي هذه الأجهزة عادةً مع نوع معين من الشاحن الذي قد يكون أو لا يكون مناسبًا للاستخدام مع الأجهزة الأخرى. لقد حظيت قضية عدم توافق أجهزة الشحن باهتمام كبير في جميع أنحاء العالم في السنوات القليلة الماضية، بما في ذلك في المملكة العربية السعودية. النقاط الرئيسية للبحث هي الآثار البيئية والاقتصادية والاجتماعية لوجود أنواع عديدة من أجهزة الشحن للأجهزة الإلكترونية المحمولة. ونظرًا للحجم الهائل للسوق الإلكترونية في المملكة العربية السعودية، تهدف هذه الورقة إلى استطلاع آراء المستهلكين حول الوضع الحالي لأجهزة الشحن وتقييم التأثير المحتمل لتوحيد أجهزة الشحن في السوق السعودية. تم استخدام المنهج الوصفي التحليلي في هذه الدراسة من خلال الاستبيان الإلكتروني. تلقت الدراسة 1,527 ردًا من 13 منطقة داخل المملكة العربية السعودية. توضح النتائج التحديات الخطيرة المرتبطة بشواحن الأجهزة الإلكترونية والحاجة الكبيرة إلى توحيدها. تم توضيح الفوائد البيئية والاجتماعية والاقتصادية لتوحيد شواحن الأجهزة الغلكترونية. توصي نتائج هذه الورقة بأن يقوم صناع القرار في المملكة العربية السعودية بتبني توحيد أجهزة الشحن لجميع الأجهزة الإلكترونية المحمولة.

الكلمات المفتاحية: الأجهزة الإلكترونية المحمولة، الشواحن القياسية، النفايات الإلكترونية.

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