

Mobile Phone Usage and Battery Disposal in Lagos, Nigeria

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Abstract Since the advent of mobile telecommunication services into Nigeria in 2001, profound increase in the consumer's electronic market for mobile phones has been continually witnessed. However, this remarkable progress has resulted in the generation of large quantities of e-waste. This paper studies mobile phone usage behaviours and battery disposal among Nigerians. Certain hypotheses are formulated highlighting variables like sex, age, occupation, level of education, responsibility to the environment, knowledge of the respondents towards proper waste disposal and their relationships with mobile phone usage behaviour, and the intention for proper mobile battery disposal are tested. Results show that mobile phone users with higher levels of education have better mobile phone usage behaviours than those with lower levels of education. Also, majority dispose their phone battery indiscriminately which is an indication that there is no proper regulation on battery disposal. Moreover, relationship exists between occupation and the intention for proper battery disposal with corporate workers having the highest percentage of respondents willing to recycle used batteries without compensation for the act. Based on the outcome of the study, the need for consumer awareness, domestication of international conventions or enactment of local legislation to deal with the e-wastes, and the provision of infrastructure for the collection and processing of the wastes generated are recommended.

Keywords Mobile phone usage behaviour, Battery disposal, Electronic wastes, Waste disposal behaviour, Environment

1. Introduction

Mobile phones have become an indispensable accessory in the daily affairs of many Nigerians. This device pervades open stalls and electronic malls scattered across major cities and urban centers in the country. Taking a cursory look at the activities of street vendors, electronic merchants and retailers within the electronic consumer market in Lagos, one of Nigeria's most populated metropolises with over nine million inhabitants [1], reveals a market replete with various brands of mobile phones and assortment of accessories. These branded phones come in different models and a variety of form factors. They include: flip-phones, candy bars, slider phones and swivel phones. Sanou [2] estimated that there were 6.8 billion mobile cellular subscriptions around the world, most of which could be found in developing countries.

Nigeria is Africa's largest mobile market with more than 110 million subscribers. Until August 2001, Nigeria had the lowest Tele-density rate in the world. However, following the liberalization of the Telecom sector in 2001 when GSM services were rolled out in the country, total Tele-density

was at 0.4% with a total of 400,000 subscriptions in fixed lines and mobile lines. As at 2013, the country's total number of subscriptions for fixed lines and mobile lines was put at 117 million with a Tele-density of 83%, and it is expected to reach 98% by 2015 [2]. The rise in number of mobile phone subscribers has been exponential and phenomenal. As a result, the country is identified as being one of the fastest growing Telecom markets in the world. Nigeria's large population and business-friendly legal and regulatory environment has been cited as one of the key factors contributing to the growth and investment in her telecommunication sector [3]. Owing to its burgeoning telecommunications industry and increasing mobile phones ownership, the country continues to witness a proliferation of various mobile phone models cutting across several product manufacturers in Europe and Asia. Large quantities of mobile phones and accessories including second-hand and remanufactured products are being imported to satisfy the growing demand. These products continue to flood the shelves of telecommunication products' distributors and resellers across the country. Any keen observer on a visit to the popular computer village in Lagos will attest to this.

Researchers posited that the phenomenal progress in information technology and mobile telecommunication uptake has resulted in the generation of large quantities of electronic waste (e-waste) in the country [4]. Another factor that contributed to augmented e-waste production was the

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fact that mobile phones had relatively short lifecycles and were quickly seen as obsolete by many users within little over a year [5]. Electronic waste, e-waste, e-scrap or Waste Electrical and Electronic Equipment (WEEE) describe discarded electrical or electronic devices [6]. WEEE has received growing attention as a secondary source of metals [7-11]. Globally, it has been estimated that some 20 to 50 million metric tonnes of e-waste are generated by electronic consumers annually, comprising more than 5% of all municipal solid waste [12].

In the UK for instance, 15 billion primary batteries are thrown away every year, all of which end up in landfill sites. Rechargeable batteries are said to be reusable, and help mitigate the impacts disposable batteries have on the environment. Some 20,000-30,000 tonnes of waste general purpose batteries are being generated annually in the UK, out of which less than 1000 tonnes are recycled. Currently, only a very small percentage of consumer disposable batteries are recycled (less than 2%) and most waste batteries are disposed of in landfill sites. The rate for recycling of consumer rechargeable batteries is estimated to be 5%. Whilst the exact chemical make-up varies from type to type, most batteries contain heavy metals, which are the main causes for environmental concern. When disposed incorrectly, these heavy metals can leak into the ground when the battery casing corrodes. This can contribute to soil and water pollution and endanger wildlife. One misplaced mobile phone battery could potentially pollute 600,000 litres of water [13, 14].

Cadmium, for example, can be toxic to aquatic invertebrates and can bio-accumulate in fish, which makes them poisonous for human consumption. Some batteries, such as button cell batteries, also contain mercury which has similarly hazardous properties. Mercury is no longer being used in the manufacture of non-rechargeable batteries, except button cells where it is a functional component, and the major European battery suppliers have been offering mercury-free disposable batteries since 1994 [15].

In Nigeria, survey indicates that on the average, mobile phone users will replace a mobile phone battery and charger at least twice a year. This amounts to a total waste generation estimated at 3000 tonnes and 9500 tonnes respectively for the period 2001-2006 [4]. Excessive solid waste production has become both an environmental and economic burden. Re-use of wastes for production consumes less energy and produces less emissions than use of raw materials [16, 17].

There have been many studies on consumer attitudes to recycling [18-20]. Many factors have been considered to impact recycling behaviour, from personal attitude and experiences to the quality of recycling systems that are in place. Recycling is a global subject that needs local execution. Different ways to communicate, incentivize and motivate consumers are effective in different countries. To better understand what people think about phone recycling, Nokia has conducted two global consumer studies on the topic. The results for the studies are being used in planning

phone recycling programs. Based on the first consumer survey on recycling behaviour and attitudes in 2007, it was found that each household on average owned five phones and few of the phones have been recycled once no longer in use. Nearly half of the consumers were unaware that it was even possible to recycle a mobile phone. Two-thirds said they did not know how to recycle an unwanted device and 71% were unaware of where to do it. Only 3% said they had recycled their old phone. The survey was based on interviews with 6,500 people in 13 countries including Finland, Germany, Italy, Russia, Sweden, UK, United Arab Emirates, USA, Nigeria, India, China, Indonesia and Brazil; and in the second study, Argentina, Spain and Nigeria were included, however, Sweden, Brazil and Russia were not included. According to the consumer study done in 2011, majority of old phones are kept at home or given to somebody else for further use [20]. Research shows that about 44% of unused mobile devices are sitting around in the bottom of drawers. Globally, Nokia Corporation reports that approximately 44% of retired phones are stockpiled [21]. The habitual act of storing obsolete electrical and electronic equipment (EEE) has been described as hoarding or stockpiling [22]. Nokia's Survey in 2008 showed that only 4% of the old phones had ended up into landfill, which raises important environmental concerns [20, 21].

A tonne of used cell phones for example or approximately 6,000 handsets (a tiny fraction of today's 1 billion annual production) contain about 3.5 kg of silver, 340grams of gold, 140 grams of palladium, and 130grams of copper. The average mobile phone battery contains another 3.5 grams of copper. Experts estimate that recycling one million cell phones can recover about 24 kg (50 lb) of gold, 250kg (550 lb) of silver, 9kg (20lb) of palladium and more than 9,000 kg (20,000lb) of copper [12]. If WEEE is not recycled, raw materials need to be processed into new products, which are a waste of resources [23, 24].

One major challenge for campaigners of sustainable environment lies in the low level of awareness of mobile phone consumers as many users are yet to realize that a rechargeable battery that no longer works can be recycled since it cannot be reconditioned the way old cell phone parts may be. In reality, it is important to recycle them. According to the advocacy group Californians against Waste, more than 80% of rechargeable batteries contain the hazardous heavy metals nickel and cadmium — these are materials we do not want seeping into our water supply. However, as of only a few years ago, less than 20% of rechargeable batteries were recycled. In California alone, more than 34,000 tonnes of batteries were sent to landfills in 2004 [25].

In Nigeria for instance, researchers opine that since there are no material recovery facilities for e-waste or appropriate solid waste management infrastructure, these wastes will end up being discarded in open dumps and unlined landfills. A practice that will create a potential for the release of toxic metals and halocarbons from batteries, printed wiring boards, liquid crystal display and plastic housing units [4].

With regards to end-of life management options, options suggested by studies in addressing the waste management challenges posted by wastes from mobile phones include: (1) development of programmes that keep used phones out of the waste stream by collecting them for re-use and recycling, (2) redesigning of mobile phones and their accessories to eliminate or reduce the hazardous chemicals contained in them [26], and (3) enactment and enforcement of laws to aid recycling of wastes [27]. Recycling of the electronic scrap of mobile phone networks have been shown to have obvious environmental benefits [28].

The major concern remains how efforts can be galvanized for Nigerians to put in place the right strategies that will ensure that the negative effects associated with waste generation from used mobile phones and batteries does not outstrip the benefits that consumers stand to derive from their use.

This paper examines aspects of mobile phone ownership which are strictly linked to user behaviour. The results presented, are based on the findings of a survey conducted among mobile phone users in Lagos, Nigeria to understand the extent of use of the accessory, analyze mobile battery performance as well as study the end-of life battery disposal methods among consumers. Lagos State is the centre of commerce; it is home to every major mobile phone and accessory distributor with record volumes traded daily.

1.1. Research Objectives

The research is initiated to:

- a. survey mobile phone battery charging pattern among users
- b. study how mobile phones batteries are disposed at their end-of-life
- c. recommend proper disposal methods of mobile phone battery
- d. suggest ways by which end-of-life mobile phone batteries can be collected and recycled

1.2. Research Hypotheses

The following hypotheses are tested:

1. There is a relationship between sex and proper mobile phone usage behaviours and the intention for proper mobile phone-battery disposal.
2. There is a relationship between age and proper mobile phone usage behaviours and the intention for proper mobile phone-battery disposal.
3. There is a relationship between occupation and proper mobile phone usage behaviours and the intention for proper mobile phone-battery disposal.
4. There is a relationship between the level of education and proper mobile phone usage behaviours and the intention for proper mobile phone-battery disposal.
5. There is a relationship between responsibility to the environment and the intention for proper mobile phone-battery disposal.
6. There is a relationship between knowledge towards

proper battery disposal and its environmental effects and the intention for proper mobile phone-battery disposal.

1.3. Limitations of the Research

The type of wastes considered in this research is limited to mobile phone battery wastes. Also, the study is focused on the sociological aspects of mobile phone battery use and battery disposal.

2. Method

2.1. Sample Group

Nigeria has a population of 174,507,539 (July 2013 est.) and is made up of the age structure of 0-14 years (43.8%), 15-24 years (19.3%), 25-54 years (30.1%), 55-64 years (3.8%) 65 years and over (3%) [29].

In order to mirror the general population to a large extent, the sample groups which included 150 secondary students, 350 university students, 200 government workers, 100 market traders, 50 private business owners, 50 corporate workers, 80 rural dwellers and 20 unemployed graduates totaling 1000 people were surveyed.

2.2. Research Instrument

In order to achieve the objective of this research, questionnaire was the research instrument used for data collection. The questionnaire, which comprised of twenty questions, was administered to 1,000 respondents in paper form. The questions were closed in order to make it easier and faster for respondents to fill and to also allow easier coding and analysis. The questions took respondents about five minutes to complete and there was no need to clarify the questions since they were simple enough.

The information contained in the questionnaires includes [30]:

- Measurement of mobile phone battery durability: This questionnaire elicits information on the number of hours respondents use their phones after the battery is fully charged, the battery lifespan, etc.
- Measurement of the charging pattern of mobile phone battery: This questionnaire measures how respondents charge their mobile phone batteries and the type of chargers used to charge them.
- Measurement of customers' satisfaction with mobile phone battery performance: This questionnaire measures the individual's satisfaction with the battery performance.
- Measurement of end-of-life mobile phone battery disposal methods: This questionnaire elicits information about individual's battery disposal means.
- Measurement of awareness on mobile phone battery disposal effects: This questionnaire measures individual's knowledge of environmental pollution caused by improper battery disposal.

- Measurement of responsibility to the environment: This questionnaire measures individual's concern about preserving the environment.
- Measurement of attitude toward end-of-life mobile-phone battery disposal without compensation for the act: This questionnaire measures individual's willingness to dispose used batteries in designated containers for recycling without compensation for the act.

2.3. Analysis of Data

The questionnaires were coded, and then entered into spreadsheet applications. Descriptive statistics such as frequency and percentage were used to describe the objectives of the survey. Chi-square test was used to analyse the relationship between the variables.

3. Results and Discussion

3.1. General Information

This shows the frequency distribution of selected variables describing the background characteristics of the respondents.

Table 1 reveals the general information of the respondents such as sex, age and levels of education. A little above half of the respondents were males; 52% are students; and 54% are less than 20 years old. Majority of the respondents have either completed their tertiary education or are currently students in tertiary institutions. Every segment of the entire population was captured in the survey.

3.2. Information on Mobile Phone Ownership and Use

This shows the frequency distribution of selected variables describing mobile phone ownership and usage characteristics of the respondents.

Figure 1 shows some information on the respondents' mobile phone use. Slightly above half of the respondents (53.3%) owned one phone while one-third (33.7%) owned two phones. Nokia phones were most widely used (63.4%)

and it was followed by Blackberry phones (27.6%). Other phones used include Samsung (15.3%), Techno (11.9%), LG (3.4%), HTC, Sony-Ericsson, Motorola, iPhone, T-mobile, Zedd etc. Two-fifth (39.6%) of the respondents have been using their phones for a year; 22.7% have been using theirs for two years; and 37.7% have been using their phones for three years and above. 30.7% of the respondents have not changed their phones in the past two years, followed by 23.3% who have changed theirs twice; 19% have changed their phones once in the past two years, while 10.7% of the respondents have changed their phones at least five times in the past two years.

3.3. Information on Mobile Phone Battery Use

Questions were asked to observe how mobile phone batteries were used. Forty-three percent of the respondents have changed their mobile phone batteries once in the past two years, 16% have changed their batteries twice and 19% have changed theirs at least 3 times. Twenty-two percent of the respondents left the question unanswered, probably because they haven't changed their batteries in the past two years.

Slightly above one-fifth of the respondents (23%) used more than one battery for a phone. This implies that a single battery even when fully charged may not be adequate to satisfy their phone energy demand, therefore there's a need to have a standby replacement battery. This behaviour can be attributed to inconsistent power supply as consumers are not always assured of constant power supply from the grid to guarantee continuous charging of their mobile phone batteries. Thirty-six percent of the respondents bought their phone batteries and chargers from accredited dealers; half of the respondents (49%) purchased theirs from mobile phone accessories shops and 13% purchased theirs from road-side sellers. Sub-standard batteries and chargers were sometimes sold at mobile phone accessory shops and from road-side sellers. Others (2%) purchased their phone batteries and chargers from friends or through the internet (such as amazon.com).

Table 1. General information and their percentage distribution

	Sex %	Age (Years) %		Occupation %	Level of Education %		
Male	57	< 20	54	Student	52	Primary	6
Female	43	20 - 30	27	Government worker	23	Secondary	24
		31 - 60	18	Market trader	11	Tertiary	70
		> 60	1	Private business owner	6		
				Corporate worker	5		
				Retired	1		
				Unemployed	2		
Total	100	Total	100	Total	100	Total	100

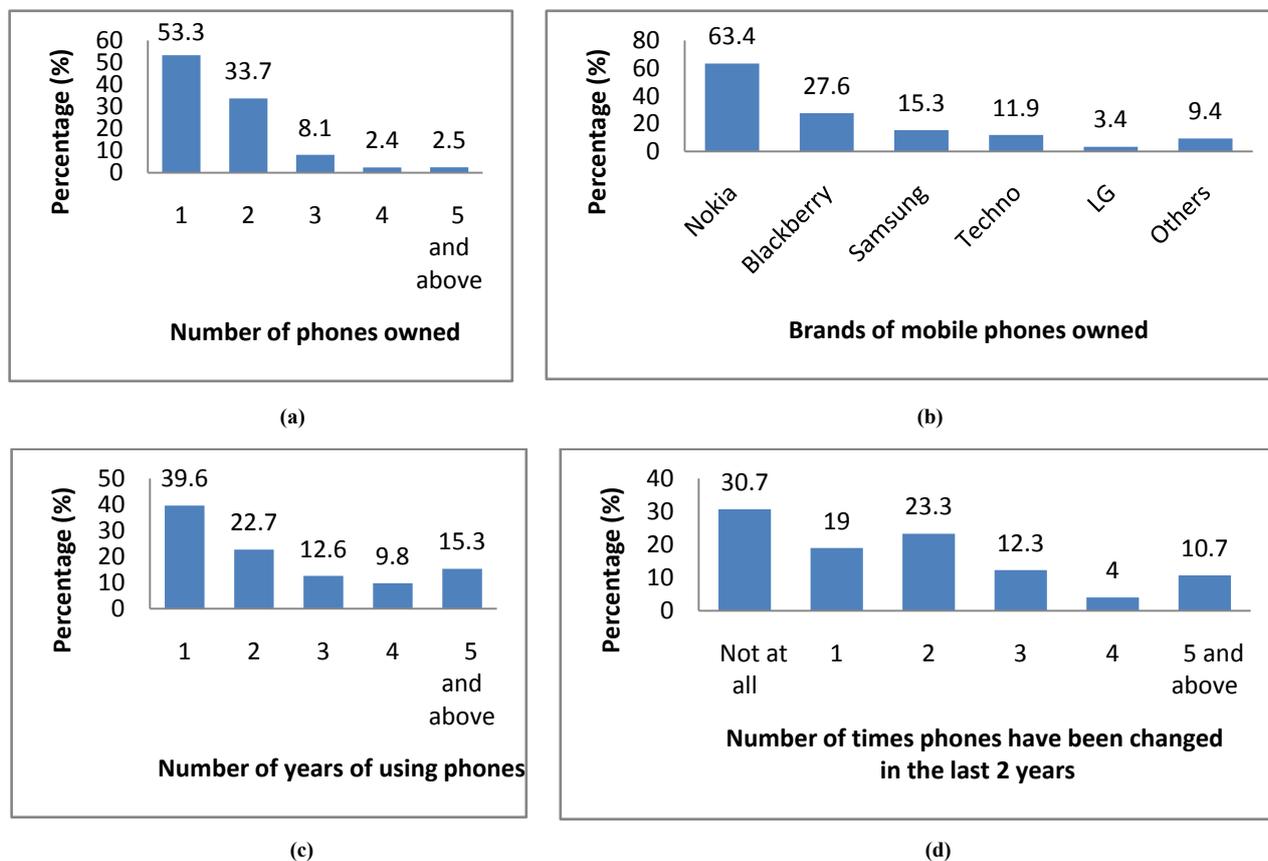


Figure 1. Mobile phone usage and their percentage distribution

Majority of the respondents (90%) used the chargers that are meant for the phones to charge them. When the chargers that came along with new phones got spoiled, respondents sometimes purchased desktop chargers and other multi-purpose chargers which might put their batteries at the risk of overcharge since the chargers were not rated specifically for the batteries.

Majority of the respondents (80%) did not switch off their phones when not in use. Consequently, their batteries were drained faster. Significant amount of energy consumption could be cut down by simply switching off phones when they are not needed for an extended period of time, such as when attending a meeting or sleeping [31].

Sixty-eight percent of the respondents recharged their phone batteries when the batteries were low while others recharged anytime there was power supply regardless of the level of the battery. However, waiting till the battery is low before recharging may have a negative effect on the battery. For Li-ion batteries, which are mostly used in mobile phones presently, the shorter the discharge (low Depth of Discharge), the longer the battery will last. If possible, full discharges should be avoided and the battery charged more often between uses in order to prolong the battery life [32].

3.4. Satisfaction with the Performance of Phone Battery

This revealed the percentage distribution of the respondents' satisfaction with mobile phone battery

performance. Sixty-three percent of the respondents were satisfied with the performance of their mobile phone batteries.

3.5. Knowledge towards Proper Battery Disposal and Its Environmental Effects

Questions were asked to find out respondents' knowledge towards proper battery disposal and the environmental effects of improper disposal. Majority of the respondents (91%) disposed their used batteries in the dustbins, 2% burned them, 2% disposed in rivers or streams, while others buried them, disposed them in the bush or kept them at home. In United States, Lithium ion batteries are not yet classified as hazardous wastes, but there are many reasons to recycle these batteries rather than throw them away where they might end up in a regular landfill. Exposure to the elements in these batteries could lead to respiratory problems and, in some cases, skin rashes. They could enter the solid waste stream and contaminate soil and water. In addition, if subjected to high temperatures, they might explode [33]. In Nigeria, Lagos Waste Management Authority (LAWMA) has provided four basic recycling banks in form of materials in the following categories: Paper, Can, Glass and Plastic [34]; however, battery disposal and recycling is not yet included in their projects.

Sixty-five percent of the respondents knew that batteries could be recycled and 67% were aware that there were

Table 4. Relationship between Level of Education and Mobile Phone Battery Use

Do respondents use the chargers that are meant for the phones to charge them?	Respondents with primary education (%)	Respondents with secondary education (%)	Respondents with tertiary education (%)	p-value
Yes	81.8	89.0	92.0	
No	18.2	11.0	8.0	0.027
Total	100	100	100	

3.12. Relationship between Responsibility to the Environment and the Intention for Proper Mobile Phone-battery Disposal

Research results supported hypothesis 5 that there is a relationship between responsibility to the environment and the intention for proper mobile phone battery disposal ($p=0.0055$). This is probably because responsibility to the environment makes people to safely dispose their batteries in order to ensure a clean and sustainable environment for all.

3.13. Relationship between Knowledge towards Proper Battery Disposal and Its Environmental Effects and the Intention for Proper Mobile Phone-battery Disposal

From the research results, there was a relationship between knowledge towards proper battery disposal and the intention for proper phone battery disposal ($p=0.00004$); also there was a relationship between knowledge of battery disposal environmental effects and the intention for proper phone battery disposal ($p=0.0000002$). Thus, hypothesis 6 was supported.

4. Conclusions

This paper discussed the behaviours of consumers in Nigeria with regard to mobile phone usage and their attitudes towards the disposal of the wastes of mobile phone batteries. It also established a link between several variables and how they influenced the intentions of mobile phone consumers towards proper waste disposal and sound environmental management.

This study showed that there's a need for mobile phone consumers to be educated on the potential environmental effects associated with improper mobile phone battery disposal. This can be achieved via promotion and advertising. A take-back scheme for the collection of wastes of batteries should be designed and consumers should be made aware of the service.

Also, there's a need to domesticate international conventions or enact local legislation to deal with wastes resulting from mobile phones and their accessories such as spent and unused batteries. These laws need to be well-publicized and enforced. Adequate Infrastructure and appropriate waste collection processes should be designed to manage wastes resulting from used batteries. Furthermore,

mobile phones and their accessories should be redesigned to eliminate or reduce the hazardous chemicals contained in them.

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