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An Investigation of Factors Influencing Call-Drop among Wireless Cellular Network Users in Ghana

Komi Arnold Agbesi
Senior Lecturer, Department of Computer Science,
Accra Technical University, Accra, Ghana
Appiah Gyekye Louis
Principal Research Assistant, Department of Directorate for Research, Innovation,
Publication, and Technology Transfer (DRIPTT), Accra Technical University, Accra, Ghana

Abstract:
The aim of the study was to examine the factors influencing call-drops among wireless cellular network users in Ghana. A total of 1109 wireless cellular network users participated in the study. Exploratory and confirmatory factor analyses were used to find out the latent factors influencing the call-drops among wireless cellular network users in Ghana. The results of the exploratory and confirmatory factor analyses revealed eight-factor constructs. Among these factors, limited cell towers, cell tower overload, and general power problems were found to be the highest contributory factors. The combined three factors accounted for almost 57% of the total variance. The study's results reveal that network factors play a major role among the factors influencing call-drops in Ghana. This implies that in dealing with call-drop problems in Ghana, policymakers, regulators, and stakeholders should pay attention to the network factors of wireless cellular networks.

Keywords: *Call-Drop, exploratory factor analysis, confirmatory factor analysis, wireless cellular network, wireless cellular network users*

1. Background

Call-drop is one of the essential quality service criteria used to monitor the performance of cellular networks. Unfortunately, call-drop, which is common these days, is one of the most difficult issues for network operators to deal with. This issue has been more prevalent in recent years, particularly with the introduction of 3G and 4G technologies (Messina et al., 2013). Various subscribers are dissatisfied with wireless mobile network services provided by many global telecommunication networks (Jan & Lee, 2012). Quality of service, particularly call-drop rate, has become an issue to consider as a result of the enormous growth in the number of subscribers over time (Iraqi & Boutaba, 2005; Aalo & Efthymoglou, 2010).

The failure of a service provider to sustain a call after it has been established properly is referred to as call-drops. The call is lost or stopped before the user can finish it normally, and the reason for this is mostly due to a problem with the service provider's network. The network usually ends the call when a specified time has passed. Poor radio frequency (RF) conditions are typically the cause of such a failure (Tarkaa et al., 2011; Tarkaa & Mom, 2018). Service providers currently measure call drops based on the failure codes received from either the phone or the network.

Ghana has a total of four (4) mobile network providers. These four wireless cellular networks served a total wireless cellular network user base of 26,469,963 in 2020, according to the National Communication Authority's (NCA) Telecom Subscription Survey (NCA, 2020). Ghana's mobile phone business is unquestionably one of the most competitive in the world. As of January 2020, Scancom (MTN) had 55.95 percent of the market share, followed by Vodafone Mobile, which controlled 21.93 percent, AirtelTigo, which controlled 20.37 percent, and Glo, which controlled 1.75 percent (NCA, 2020). Despite the remarkable growth of customers and market penetration, users of wireless mobile networks in Ghana continue to complain about the poor services being rendered by these networks, especially in the area of call-drops (Akanbasiam & Ngala, 2017).

According to the Chronicle (2021), the problem of call-drop in Ghana appears to be due to the over-subscription of the wireless cellular networks, thus making it impossible to render quality services. The call-drop rate among wireless cellular networks has increased recently, creating inconveniences not only for individual users but also for the business communities in Ghana, affecting the smooth running of businesses in the country (Chronicle, 2021). For instance, the issue of call-drop is gradually creeping into the mobile money transfer sector, making it very difficult to transfer and receive money from clients, family members, and friends. The problem is so alarming that if not properly addressed, it will bring chaos to all Ghanaians.

Many research works have been carried out on call-drop. For instance, Aalo and Efthymoglou (2010) examined call-drop probability for a heterogeneous wireless network with uniformly distributed handoff failure rates. Boggia et al. (2007), from data analysis to modeling, evaluated call-drop probability in established cellular networks. Erunkulu et al.

(2019), using an artificial neural network, predicted call drops in the GSM network. Tarkaa and Mom (2018) made a comparative analysis of call-drop probability due to handover and other factors. Iraqi and Boutaba 2005) conducted a study on the handoff and call-dropping probabilities in wireless cellular networks. Li and Chao (2004) studied handover and call dropping considering a cellular mobile communication network with multiple cells and different classes of calls. Nasser (2006) examined drop-call probability considering a multimedia wireless network. However, despite the many studies that have been carried out on call-drop, none of them have so far investigated the factors influencing call-drop among wireless cellular network users. Therefore, this paper is to investigate the factors influencing call-drop among wireless cellular network users in Ghana. The paper is to:

- Specifically, identify the causes of call-drops among wireless mobile network users in Ghana,
- Find out the latent factors influencing call-drop among wireless cellular network users in Ghana, and
- Examine the differences in the call-drop variables in terms of wireless cellular network, geographical location, and phone type

The rest of the paper is organized as follows:

- Section 2 presents the methodology of the paper
- Section 3 presents the results of the study
- Section 4 presents the discussions of the study
- Section 5 presents the conclusion and recommendations of the study

2. Literature Review

2.1. Call-Drop in Mobile Cellular Network

Call drop occurs when a call is terminated before the speaking parties have ended their conversational tone and one of them has hung up. The percentage of total calls is a common way to describe this (Tarkaa & Mom, 2018; Erunkulu et al., 2019). A telephone conversation may be cancelled before the parties who initiated the call choose to do so because of a technical issue. Such calls are referred to as "dropped calls" (Boggia et al., 2007). This explanation of call-drop has to be augmented in many real-world settings, according to Iraqi and Boutaba (2005), by additional specifics such as which calls are deemed dropped and at what stage of the call setup process a conversation is classified as connected (Pattaramalai et al., 2007). Several methods define when a call is considered correctly connected in modern telecommunications systems, such as cellular networks, complicating the process of calculating the dropped-call rate (Tarkaa et al., 2011; Shrivastava & Sinha, 2016). The call-drop rate (CDR) is, therefore, used as one of the essential figures of merit to measure the quality of service in mobile wireless networks (Kumar, 2015).

Having a phone call dropped impacts the level of service quality that may be anticipated to be provided by a mobile communications network (Li & Chao, 2004). A call drop is more concerning than a blocked call since a call drop means that the caller is no longer in the queue to re-establish the connection (Kumar, 2015; Khare & Sudhakar, 2019). In fixed-line networks, call drops are quite infrequent. Since the mobile wireless network is an extension of the fixed-line network, most consumers anticipate the same performance in mobile networks as they do in fixed-line networks, according to the study (Kumar, 2015; Pattaramalai et al., 2007; Khare & Sudhakar, 2019). Since services provided by mobile wireless networks will become more important in people's lives in the future, there will be an even greater need for enhanced service quality in the near future (Kumar, 2015).

In addition to the annoyance that the user will experience, the call drops will result in the user incurring extra costs as a result of the user's repeated attempts to call in order to continue the communication (Kumar, 2015; Pattaramalai et al., 2007; Khare & Sudhakar, 2019). As a result, dropped calls result in an unwarranted financial burden for the user. Consumers are required to pay even if they maintain a connection for one or more seconds until the call is disconnected. As a result, the user is the one who suffers(Kumar, 2015; Khare & Sudhakar, 2019). Not only do call drops result in monetary losses for the user, but it also wastes the user's time since the user will spend more time on the follow-up call to make up for the time lost due to the interruption in the original discussion. This has a negative impact on production and efficiency (Kumar, 2015). This underscores the need for an investigation into the factors influencing call-drops and coming out with a recommendation for improvement and solution to the problem.

It is usually possible to eliminate call drops if service providers take certain precautions, such as optimizing traffic distribution across the multiple frequency layers, limiting interference and congestion, and expanding the service area (Khare & Sudhakar, 2019). As a result, the only way to improve the quality of service in mobile networks within the constraints of the available spectrum is to improve the network infrastructure and implement technological solutions that reduce call drops (Kumar, 2015; Shrivastava & Sinha, 2016).

2.2. Causes of Call-Drop in Mobile Cellular Network

A wide variety of call-drop reasons may be found in cellular networks, with the majority of them happening in the Um interfaces. This is primarily due to a shortage of radio resources caused by electromagnetic causes, user mobility, and user movement. Another key factor in the drop call rate is the traffic load, in which the call arrival rate and holding time both play significant roles in determining the rate of drops (Tarkaa et al., 2011). Mishra (2004) describes call drop as an issue resulting from various technical issues, including:

- Insufficient coverage,
- Signal quality issues,
- Interfering signals,

- Network congestion, and
- Network failure

Shrivastava Sinha (2016), in a study on reducing call drops due to cell failure, mentioned that call drops result from overloaded cell towers, cityscape changes, switching between towers, and technical failures. Kaushik (2015) reported that call drops occur due to a lack of cell towers, low spectrum availability, lack of punitive action for poor service, and a mobile network unwilling to make an investment. Levin (2020) indicated that calls are dropped due to physical obstructions, mother nature, phone memory, battery power, cell tower locations, user overload, power outages, and cell phone case and antenna.

Jeff (2017) reported that there are a number of reasons why a cell phone call might drop, which can be categorized as problems with the carrier, problems in the local environment, and problems with the phone. According to the author, calls are dropped due to tower handoff problems, distance from cell towers, bad reception due to the type of construction materials used in home or office, and damaged cell phone antenna. Jones (2020) also reported that calls are dropped due to distance from the nearest cell tower, natural obstacles that block cell signals, and man-made obstructions to mobile reception.

According to Dhanya and Sankar (2016), call drop is caused by a shortage of accessible radio channels, which, in turn, may be caused by propagation variables such as multipath fading path loss and distance losses. Radio connection failures and signal handovers are additional variables that affect the capacity of a given channel, which may affect the amount of data that can be sent. In this case, the Rayleigh effect or path loss may be to blame. When there is no direct line of sight between the sending and receiving antennas, the Rayleigh effect occurs because of the rapid change in the received signal level, both in terms of amplitude and phase.

Chandler (2020) reported that there are numerous reasons why a call may be dropped, including:

- Hardware failure,
- Transmission problems,
- Version upgrade issues,
- Parameter setting issues,
- Interference from other networks,
- Overshooting from neighboring BTS,
- Imbalances between uplink and downlink,
- Repeater problem,
- Coverage problem as blind spots,
- Antenna system problem,
- High bit error rate

Sudhindra and Sridhar (2011) identified three forms of call drops:

- Radio link failure call drop,
- handover failure call drop, and
- Link Access Protocol on D-Channel (LAPD)

Existence of weak coverage area and weak radio signal, intra-network interference, unreasonable radio parameter settings, equipment hardware faults such as low output power of the power amplifier, large differences among different carrier transmission, power, carrier transmitter fault, combiner fault, and splitter fault, faults in antenna feeder system, and weak battery power, are all reported as causes of radio link failure call drop existence of interference such as intra-network interference due to unreasonable frequency planning and other external interference, equipment hardware fault, such as clock fault in destination cell or in source cell, low output power of the power amplifier, large difference among different transmitter's transmission power, transmitter fault, combiner fault, and divider fault, and unreasonable radio parameter settings, are the causes of handover failure call drop according to Sudhindra and Sridhar (2011).

According to the authors, LAPD call drops may be caused by:

- Site transmission problems, such as transmission interruption or unstable transmission,
- Site-side hardware faults, such as unreliable cable, control, and maintenance module fault, and backplane connection fault,
- BSC-side hardware faults, such as LAPD processing board faults

As already stated, the causes of call drop present a major challenge to customers because they influence the quality of service of mobile telecommunication networks. Although many research works have been carried out to solve this problem, none of these works has considered the latent or underlying factors responsible for the call-drops. The significant contribution of this research is that in an attempt to provide a solution to the problem, the present study examines the underlying latent factors influencing call drops among mobile networks. The research methods used in examining the factors influencing call drops among mobile wireless cellular networks are presented in the next section.

3. Methodology

3.1. Study Population and Sample

The target population of the study comprised mobile wireless network users all over Ghana. A sample size of 1109 mobile wireless network users who experience call-drops was estimated for the study. The sample size was calculated based on a 3.0% call-drop rate (NCA, 2020). The Cochran's formula $n = \frac{z^2 pq}{E^2}$, where z = 95% confidence interval, p = prob. of call-drop, q = prob. call-success, and E = margin of error, was used to calculate the sample size. Based on Cochran's formula, the sample size was computed as:

$$n = \frac{1.96^2(0.03)(0.97)}{0.01^2} = 1118$$

Where:

- z = 1.96,
- p = 0.03(3.0%),
- q = 0.97(97%), and
- E = 0.01(1%)

We reached 1109 adults out of the 1118 estimated sample size representing a high response rate of 99.2%. The high rate of response could be a result of the interest of the participants in the solution of the problem of call drops in the country.

3.2. Instrument

The study was carried out through the use of a questionnaire. The questionnaire consisted of three sections. The first section focused on the demographics of the participants - age, sex, geographical location, working status, educational level, and type of phone. The second section of the questionnaire elicited information on the call-drops experienced by wireless mobile network users. The response format was predominantly based on a five-point scale: 1= never, 2 = less often, 3= few times/week, 4 = once/day, 5 = several times/day. The third section of the questionnaire measured the call-drop causes among wireless cellular networks. The response format was based on a five-point scale: 1=strongly disagree, 2 = disagree, 3= neither agree nor disagree, 4 = agree, 5 = strongly agree.

3.3. Instrument Reliability

The internal consistency of the research instrument's reliability was analyzed using Cronbach's alpha coefficient. Test-retest reliability was analyzed by using Spearman's rank correlation coefficient. Cronbach's alpha coefficient of 0.892 was obtained for the factors influencing call-drop. Spearman's rank correlation coefficients, which were used to assess correlations between test-retest results, ranged from 0.672 to 0.879. In general, Cronbach's alpha coefficients of at least 0.6 are thought to be indicative of good reliability (Lee, Yim & Kim, 2018). Hence, the questionnaire for the study was confirmed to exhibit internal consistency for all the items.

3.4. Procedure

A cross-sectional survey was conducted within a period of one month, that is, between April and May 2021. All the participants were adults who had used a particular wireless cellular network for at least one year. Informed consent was sought from each of the participants of the study. The data collection was done online. With colleagues' help, the researchers distributed the questionnaire to the participants.

3.5. Data Analysis

Data analysis was performed using IBM SPSS Statistics version 20.0 (IBM, Armonk, NY) and LISREL for Windows Version 10, with an alpha level of 5%. First, general descriptive statistics of frequency and percentage were used to report the demographic characteristics of the participants. Second, descriptive statistics of mean and standard deviation were used to identify the causes of call-drops among wireless mobile network users in Ghana. Third, the factors influencing call-drop among wireless cellular network users in Ghana were explored using factor analysis – exploratory and confirmatory. Finally, the differences in the call-drop factors in terms of network type, geographical location, and phone type were examined using an independent sample t-test and one-way variance analysis (ANOVA).

3.5.1. Exploratory Factor Analysis (EFA)

Exploratory factor analysis was first of all carried out. The exploratory factor analysis was used to find out the latent factors and the items under each of the latent factors. The EFA was conducted using the principal component analysis and varimax rotation methods. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was used to measure the factorability of the analysis. Furthermore, the items that did not have factor loadings of at least 0.5 were deleted from the analysis.

3.5.2. Confirmatory Factor Analysis (CFA)

The results of the EFA were used to conduct the confirmatory factor analysis. The confirmatory factor analysis was used to verify the *factor* structure of the set of observed variables. *In other words, the researchers used the* CFA to test the hypothesis that a relationship between the observed variables and the underlying latent constructs exists. The confirmatory factor analysis was carried out using LISREL for Windows Version 10. The maximum likelihood estimation method was applied to the analysis. Meanwhile, a single-factor model was used for the confirmatory factor analysis.

4. Results

4.1. Demographic Characteristics of Participants

Table 1 shows the demographic characteristics of the study participants of the study. Among the sample of 1109 who participated in the study, more than half (52.2%) were male, while 47.8% were female. The participants were 18 years and above, with:

- 22.1% (n=245) between the ages of 18-25 years,
- 19.4% (n=215) between the ages of 26-30 years,
- 16.1% (n=178) between the ages of 31-35 years,
- 15.6% (n=173) between the ages of 36-40 years,
- 11.4% (n=126) between the ages of 41-45 years,
- 8.0% (n=89) between the ages of 46-50 years, and
- 7.5% (n=83) above 50 years

The trend in the age analysis indicates that the older the user, the less they become users of wireless cellular networks. In terms of the educational background of the participants:

- 16.4% (n=182) had secondary education or below,
- 17.7 %(n=196) had high school or vocational school education,
- 22.8% (n=253) had three-year diploma education,
- 22.1% (n=245) had bachelor's degrees, and
- 21.0 % (n=233) had postgraduate degrees.

	Frequency (N)	**Percent (%)**
Gender		
Male	579	52.2
Female	530	47.8
Age		
18-25 years	245	22.1
26-30 years	215	19.4
31-35 years	178	16.1
36-40 years	173	15.6
41-45 years	126	11.4
46-50 years	89	8.0
More than 50 years	83	7.5
Educational level		
Secondary School or Below	182	16.4
High School or Vocational School	196	17.7
Three Year Diploma	253	22.8
Bachelor's Degree	245	22.1
Postgraduate Degree	233	21.0
Marital Status		
Single	484	43.6
Married	407	36.7
Others (Divorced, Widowed, etc.)	218	19.7
Geographical location		
Rural	409	36.9
Urban	700	63.1
Job Status		
Working full-time	550	49.6
Working part-time	275	24.8
Unemployed	284	25.6
Phone type		
Smart Phone	777	70.1
Other non-Smart Phones	332	29.9
Wireless cellular network		
MTN	685	61.8
Vodafone	276	24.9
AirtelTigo	94	8.5
Glo	54	4.9
Frequency of call-drop		
Few times/week	34	3.1
Once/day	65	5.9
Several times/day	1010	91.1

Table 1: Demographic Characteristics of the Participants (N=1109)

The distribution of the marital status of the participants of the study revealed that:

- The majority of the respondents (43.6%, n=484) were single,
- 36.7% (n=407) were married, and
- 19.7% (n=218) had either divorced or were widowed

The geographical location of the participants of the study indicates that about two-thirds (63.1%, n=700) lived in urban areas, while a little over one-third (36.9%, n=409) lived in rural areas. About half (49.6%, n=550) of the participants declared themselves working full-time, 24.8% (n=275) of the respondents reported working part-time, while 25.6% of the participants declared themselves unemployed. More than 70 percent of the participants owned smartphones, while less than 30 percent had non-smartphones. With respect to the network, the majority of the respondents (61.8%, n=685) were users of MTN, 24.9% (n = 276) were users of Vodafone, 8.5% (n=94) were users of Airtel-Tigo, and 4.9% (n=54) were users of Glo. Meanwhile, the distribution of call-drops experienced by the participants of the study, as shown in the table, indicates that 91.1% (n=1010) of the participants or cell phone owners experienced call-drops several times a day, while 5.9% (n=65) experienced call-drops once per day. Meanwhile, only 3.1% (n=34) of the cell phone owners who participated in the study reported experiencing call-drops a few times a week.

4.2. Call-Drops Causes among Wireless Mobile Network Users in Ghana

Table 2 shows the causes of call-drops among wireless cellular network users in Ghana. As shown in the table, the findings of the study indicated that cell users experience call-drops when they are within a room or building (M=3.6, SD=1.35), in a car (M=4.1, SD=0.90), in the village or wooded area (M=4.2, SD=0.63), and when they are in a hilly or a mountainous area (M=4.1, SD=0.83). The participants of the study also reported that they experience call-drops when there are poor or cold weather conditions (M=4.3, SD=0.53), when there is lightning after heavy rain (M=4.1, SD=0.79), when there is a heavy downpour (M=4.3, SD=0.60), and when there is fog and cloudy weather (M=4.1, SD=1.02). The participants of the study reported that they experience call-drops when they have low phone memory (M=4.2, SD=0.66), when they have phone malfunction (M=4.0, SD=0.81), when they have damaged internal phone antenna (M=4.2, SD=0.61), and when their phone's roaming software is not updated (M=4.0, SD=0.81). They also indicated that they have call-drops when they have low battery power (M=4.2, SD=0.60) and there is bad signal strength (M=4.6, SD=0.61). The issue of cell towers was found to be a highly contributory factor to call-drops among the cell phone users who participated in the study.

	Mean	SD.	Min.	Max.
I am in my room or in a building	3.6	1.35	1.0	5.0
I am in my car or a parking garage	4.1	0.90	1.0	5.0
I am in my village	4.2	0.63	1.0	5.0
I am in a hilly or mountainous area	4.1	0.83	1.0	5.0
There are poor or cold weather conditions	4.3	0.53	1.0	5.0
There is lightning after a heavy-downpour	4.1	0.79	1.0	5.0
There is a heavy downpour	4.3	0.60	1.0	5.0
There is fog and also clouds in my area	4.1	1.02	1.0	5.0
My phone memory is low	4.2	0.66	1.0	5.0
My phone goes off because of a malfunction	4.0	0.81	1.0	5.0
My cell phone has a damaged antenna	4.2	0.61	1.0	5.0
My phone's roaming software has not been updated	4.0	0.81	1.0	5.0
I have low battery power	4.2	0.60	1.0	5.0
There is a bad signal strength	4.6	0.61	1.0	5.0
My Bluetooth is on	2.9	1.86	1.0	5.0
My cell phone screen is bright or has a lot of apps running	2.5	1.89	1.0	5.0
Lack of cell tower in the vicinity	4.6	0.56	1.0	5.0
I am far away from the cell-tower	4.5	0.50	1.0	5.0
I am walking faster or running	4.5	0.50	1.0	5.0
There are very few inhabitants or travelers	4.2	1.01	1.0	5.0
There is a power outage	4.5	0.50	1.0	5.0
There are power fluctuations	4.5	0.50	1.0	5.0
There is a low-power voltage	4.5	0.50	1.0	5.0
There is a limited power supply to maintain a stable connection	4.5	0.50	1.0	5.0
There is a large crowd in an area	4.2	0.87	1.0	5.0
There is a rush hour/peak period	4.5	0.50	1.0	5.0
I am moving from one area to another area (Tower handoff)	4.4	0.50	1.0	5.0
There is a large traffic jam	4.2	0.81	1.0	5.0
I use a phone with limited connectivity access	3.3	1.60	1.0	5.0
When I hold my cell in a certain position	2.0	1.32	1.0	5.0
My phone does not have a 3G network	3.1	1.27	1.0	5.0
I do not use a smartphone.	3.2	1.57	1.0	5.0

Table 2: Descriptive Statistics of Mean and Standard Deviation Showing the Causes of Call-Drops among Wireless Mobile Network Users in Ghana (N=1109)

As shown in the table, the participants of the study indicated that they experience call-drops as a result of:

- A lack of cell-towers in their vicinity (M=4.6, SD=0.56),
- When they are far away from the cell tower (M=4.5, SD=0.50),
- When they are walking faster or running (M=4.5, SD=0.50), and
- When there are very few inhabitants in the area (M=4.2, SD=1.01)

The cell phone owners who participated in the study reported that they experience call-drops when there is a power outage (M=4.5, SD=0.50), power fluctuations (M=4.5, SD=0.50), low power voltage (M=4.5, SD=0.50), and limited power supply to maintain a stable connection (M=4.5, SD=0.50). The participants of the study also reported that they experience call-drops:

- When there is a large crowd in an area (M=4.2, SD=0.87),
- When there is a rush hour/peak period (M=4.5, SD=0.50),
- When moving from one area to another area (M=4.4, SD=0.50), and
- When there is a traffic jam (M=4.2, SD=0.81)

4.3. Factors Influencing Call-Drop among Wireless Cellular Network Users in Ghana

Table 3 shows the results of the EFA used to identify the latent factors influencing call-drop among wireless cellular network users in Ghana. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was 0.964, indicating that the sample was adequate. Tabachnick and Fidell (2001) suggest that a computed KMO value greater than or equal to .60 is indicative of factorability - that is, if KMO is at least 0.60, there is sufficient evidence that there exists at least one common factor underlying the observed variables. On the other hand, Bartlett's Test of Sphericity gave a p-value of <0.001, indicating that the EFA best fits the data. The results of the EFA suggested an eight-factor construct based on the estimated eigenvalues of 1, which explained more than 90.0% of the total variance in the model. Figure 1 shows a Scree plot of eigenvalues constructed to indicate the number of factors to be extracted. The Scree plot, as indicated in the figure, was also found to be firmly in favor of the eight-factor structure.

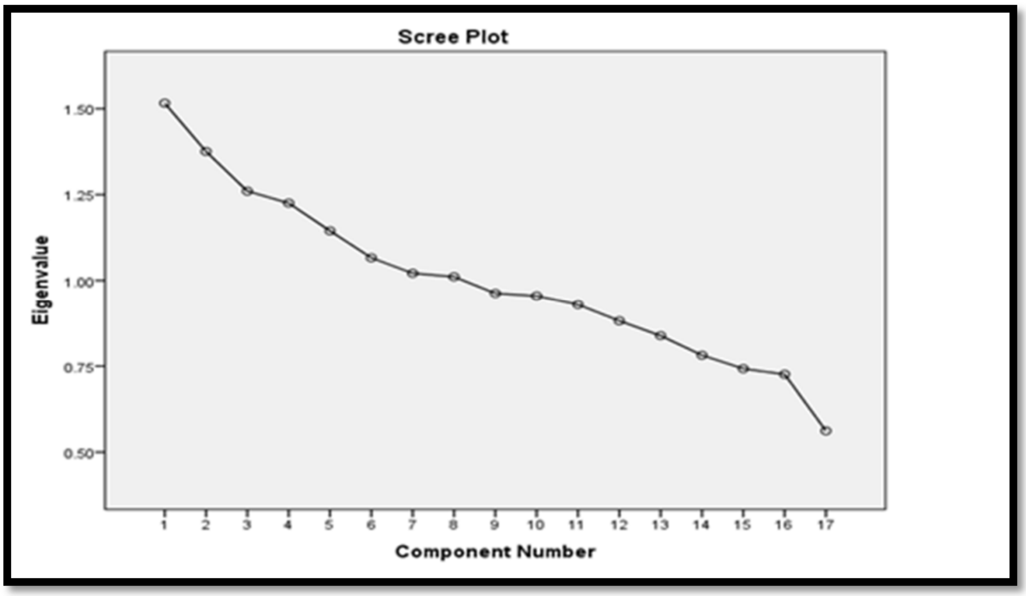

Figure 1: Scree-Plot Showing the Number of Latent Factors Influencing Call-Drop among Wireless Cellular Network Users in Ghana

Hence the results of the EFA, as indicated in table 3, revealed that eight factors influence call-drops among wireless cellular network users in Ghana. They include:

- Physical obstructions, contributing 7.9% of the total variance explained,
- Natural obstructions, contributing 8.9% of the total variance explained,
- Phone malfunctions, contributing 6.9% of the total variance explained,
- Battery power, contributing 10.8% of the total variance explained,
- Limited cell towers, contributing 20.9% of the total variance explained,
- General power problems, contributing 16.4% of the total variance explained,
- Cell tower overload, contributing 19.9% of the total variance explained, and
- Limited phone functionalities, contributing 6.0% of the total variance explained

Factors	CV	FL	KMO	TVE
Physical obstructions			0.964	7.891
I am in my room or a building	.601	.676		
I am in my car or a parking garage	.656	.772		
I am in my village or hilly or mountainous area	.672	.543		
I am in a hilly or mountainous area	.663	.681		
Natural obstructions				8.901
There are poor or cold weather conditions	.698	.584		
There is lightning after a heavy-downpour	.623	.552		
There is a heavy downpour	.645	.653		
There is fog and also clouds in my area	.783	.691		
Phone malfunctions				6.947
My phone memory is low	.682	.558		
My phone goes off because of a malfunction	.634	.491		
My cell phone has a damaged antenna	.578	.586		
My phone's roaming software has not been updated	.612	.652		
Battery power				10.77
I have low battery power	.687	.782		
There is a bad signal strength	.567	.756		
My Bluetooth is on	.756	.761		
My cell phone screen is bright or has a lot of apps running	.767	.785		
Limited cell towers				20.892
Lack of cell tower in the vicinity	.893	.892		
I am far away from the cell-tower	.853	.781		
I am walking faster or running	.883	.762		
There are very few inhabitants or travelers	.891	.863		
General power problems				16.402
There is a power outage	.784	.673		
There are power fluctuations	.793	.781		
There is a low power voltage	.896	.783		
There is a limited power supply to maintain a stable connection	.763	.761		
Cell tower overload				19.946
There is a large crowd in an area	.834	.862		
There is a rush hour/peak period	.868	.781		
I am moving from one area to another area	.891	.783		
There is a large traffic jam	.881	.871		
Limited phone functionalities				6.043
I use a phone with limited connectivity access	.585	.468		
When I hold my cell in a certain position	.532	.501		
My phone does not have a 3G network	.503	.491		
I do not use a smartphone.	.589	.411		

Table 3: Exploratory Factor Analysis Results Showing the Latent Factors Influencing Call-Drop among Wireless Cellular Network Users in Ghana

Notes: CV: Communality Value; FL – Factor Loading; KMO – Kaiser–Meyer–Olkin Test; TVE – Total Variance Explained

4.3.1. Confirmatory Factor Analysis

Table 4 shows the results of the CFA used to confirm the latent factors influencing call-drop among wireless cellular network users in Ghana. Several statistics were used to investigate the models' goodness of fit:

- Overall χ^2 (Hooper et al., 2008),
- Root mean square error of approximation (RMSEA) (Steiger, 1990; Hooper et al., 2008),
- Comparative fit index (CFI),
- Tucker Lewi index (TLI) (Bentler, 1990), and
- The standardized root mean square residual (SRMSR) (Hooper et al., 2008)

Hooper et al. (2008) indicated that a good confirmatory factor analysis should have:

- The p-value of the model chi-square > .05,
- A TLI $\geq$ 0.95,
- A CFI $\geq$ 0.90,
- RMSEA < .08, and
- SRMR < .08

All these fit indices criteria, as shown in table 4, were met by all the eight latent factors influencing call-drop among wireless cellular network users in Ghana. Therefore, the CFA results support eight factors influencing call-drop among wireless cellular network users – physical obstructions, natural obstructions, phone malfunctions, battery power, limited cell towers, general power problems, cell tower overload, and limited phone features.

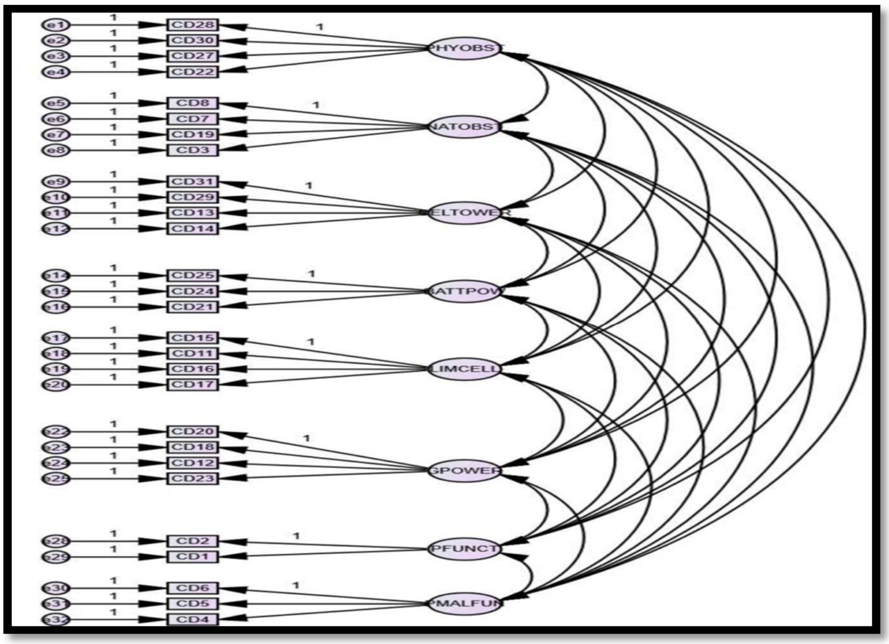

Figure 2: Confirmatory Factor Analysis Model of Factors Influencing Call-Drop among Wireless Cellular Network Users in Ghana

4.4. Differences in Call-Drop Factors in Terms of Wireless Cellular Network, Geographical Local, and Phone Type

Table 4 shows the results of the one-way analysis of variance (One-way ANOVA) of the differences in the call-drops concerning the wireless cellular networks. The results of the one-way analysis of variance revealed that except for cell tower problems (F=14.266, df = [3; 1105], p<.05) and limited phone features, which are found to be statistically significant (F=154.366, df = [3; 1105], p<.05), no significant differences exist among the wireless cellular networks when it comes to the other factors influencing call-drops among wireless cellular network users in Ghana.

Factors	F-value	p-value
Physical obstructions	1.580	.193
Natural obstructions	1.788	.148
Phone malfunctions	.726	.536
Battery Power	1.070	.361
Limited cell towers	2.388	.067
General power problems	1.105	.346
Cell tower problems	14.266	.000
Limited phone features	154.366	.000

Table 4: One-Way ANOVA Showing Differences in the Call-Drop Factors in Terms of Wireless Cellular Network

Table 5 shows the results of the independent t-test of the differences in the call-drop factors in terms of the geographical location of the user. The results of the independent t-test indicate that there are significant differences in some of the call-drop factors when it comes to the geographical location of the user. The results revealed that geographical differences exist when it comes to natural obstructions (t=1.142, df = 1107, p<.05) and limited cell towers (t = 2.093, df = 1107, p<.05).

Factors	T-value	df	p-value
Physical obstructions	1.142	1107	.254
Natural obstructions	3.841	1107	.000
Phone malfunctions	-1.254	1107	.210
Battery Power	-.710	1107	.478
Limited cell towers	2.093	1107	.037
General power problems	.774	1107	.439
Cell tower problems	.348	1107	.728
Limited phone features	.818	1107	.414

Table 5: Independent T-Test Showing Differences in the Call-Drop Factors in Terms of the Geographical Location of the User

Table 6 shows the results of the independent t-test of the differences in the call-drop factors in terms of the phone type of the user. The results revealed that Smartphone owners reported higher incidence levels of these problems compared with other cell phone owners. The results revealed that phone type differences exist when it comes to physical obstructions ($t = -2.933$, $df = 1107$, $p<.05$), phone malfunctions ($t = 5.113$, $df = 1107$, $p<.05$), cell tower problems ($t = 3.152$, $df = 1107$, $p<.05$), and limited phone features ($t = 5.167$, $df = 1107$, $p<.05$).

Factors	T-value	df	p-value
Physical obstructions	-2.933	1107	.003
Natural obstructions	-.044	1107	.965
Phone malfunctions	5.113	1107	.000
Battery Power	-1.446	1107	.148
Limited cell towers	1.099	1107	.272
General power problems	-1.735	1107	.083
Cell tower problems	3.152	1107	.002
Limited phone feature	5.167	1107	.000

Table 6: Independent T-Test Showing Differences in the Call-Drop Factors in Terms of Phone Type

5. Discussions

This study first found that there are several reasons for call-drops among wireless cellular network users in Ghana. Call-drops in Ghana could be a result of:

- Problems in the surrounding area, such as obstructions from both physical and natural sources,
- Issues with the network, such as limited connectivity as a result of limited cell towers, lack of cell tower in the vicinity of the cell phone user, cell tower overload, power outages, and limited power supply to maintain a stable connection as a result of power outage which affects cell towers and cell sites,
- Problems with the user, such as low call-credit, walking faster or running, and
- Problem with the phone itself, such as low battery power, phone malfunctioning, and limited phone capabilities

This result is consistent with the literature. According to Jeff (2017), calls may be dropped due to network, user, or phone difficulties. According to Boggia et al. (2007), electromagnetic interference causes most call dropouts. The authors also claim that typical user behavior causes a high percentage of lost calls. According to Arokiamary (2009), lack of radio coverage, radio interference between subscribers, network flaws, and congestion of network components are the most frequent reasons for call-drops.

The EFA results suggested that eight main factors influence call-drops among wireless cellular networks in Ghana. Based on the characteristics of the variables, the eight latent factors were found to be:

- Physical obstructions,
- Natural obstructions,
- Phone malfunctions,
- Battery power,
- Limited cell towers,
- General power problems,
- Cell tower overload, and
- Limited phone functionalities

Confirmatory factor analysis (CFA) conducted confirmed these eight latent factors.

A review of literature on call-drop factors found similar results. Levin (2020) attributed call-drop to seven main factors – physical obstacles, Mother Nature, phone memory, battery power, cell tower positions, user overload, and power interruptions, as well as the phone case and antenna. Jones (2020) stated that call-drops occur due to distance from the closest cell tower and natural and physical obstructions. Telecommunication tower handover issues, distance from towers, building materials, and damaged equipment were also mentioned by Jeff (2017).

According to Levin (2020), concurred by Jeff (2017), thick materials used in buildings, bridges, tunnels, and parking garages may disrupt connection signals. The author reported that calls may drop when in a home or office due to the building materials utilized for the structure. Jones (2020) said that natural obstacles, such as lightning, may disrupt cell transmissions. According to Levin (2020) and Jeff (2017), heavy rain is the worst. However, a hot and humid day may also be problematic.

The findings of this research indicate that battery issues are one of the major causes of call drops among Ghanaian wireless cellular network users. It accounted for about 10% of the overall variation in the variables affecting call-drops among wireless cellular network users in Ghana. Lack of battery power has been mentioned as one of the major mobile phone user issues affecting call-dropping (Levin, 2020; Jones, 2020). Levin (2020) found that low battery power reduces phone signal strength to the cell tower, which results in call drops. Jones (2020) advises customers to switch off Bluetooth, adjust the screen brightness, and remove unused applications to prevent call-drops.

The study has revealed that phone issues are minor factors when it comes to the factors influencing call-drops among wireless cellular networks in Ghana. It accounted for not more than 6% of the overall variation in the factors affecting call-drops among Ghanaian wireless cellular network users. Jeff (2021) indicated that calls may drop due to limited phone memory, phone failure, antenna damage, and lack of software upgrades. However, the author opined that phone issues, such as call-drops, rarely occur because users are usually aware of their phone problems and would not want to communicate with such phones.

The study has revealed that limited cell towers are the highest major factor influencing call-drops in Ghana. Limited cell towers account for more than 20 percent of the total variation in the factors influencing call-drops among wireless cellular network users in Ghana. Limited cell towers have been cited as one of the main factors influencing call drops (Levin, 2020; Kaushik, 2015). Kaushik (2015) reported that call-drop in a wireless mobile network can happen due to many factors, including non-availability of sites due to acquisition problems and sealing of sites by local authorities due to fear of electromagnetic fields from mobile radiations.

Call drops may also be due to general power issues. This research has found that general power issues account for about 16% of the variation in the variables affecting call-drops among Ghanaian wireless cellular network users. General power issues are found to be the third leading cause of call drops among Ghanaian mobile phone users. This result is not surprising as Ghana's power is not quite stable. Jeff (2017) states that mobile phone towers need high-quality electricity to sustain a steady connection. In any event, where there are power fluctuations, cell towers may experience breaks in the transmission of signals leading to weak signal strength and call-drops.

Cell tower overload is one of the main contributory factors of call-drops. Cell tower overload is found to be the second main contributor to the factors influencing call-drops among wireless cellular network users in Ghana. It accounted for over 19 percent of the total variance in the factors influencing call-drops among wireless cellular network users in Ghana. According to Levin (2020), a cell tower's capacity is limited. Thus, if a huge number of users reach for their phones, an overcrowded tower may refuse incoming calls and drop current ones. Chandler (2020) found that unexpected spikes in network traffic cause lost calls and data signals during high-traffic events like concerts and football games. Call-drops also occur when there is a heavy traffic jam (Jeff, 2017).

Limited phone functionality has been found in this study to be one of the minor factors influencing call drops among wireless cellular networks in Ghana. It accounted for not more than 6% of the total variation in the variables affecting call-drops among Ghanaian wireless cellular network users. Though minor, call-drops have been linked to limited phone functionality. Levin (2020) claims that a stylish and sleek phone metal cover may block call signals, causing call dropouts. The author claims that the metal cover interferes with Wi-Fi, Bluetooth, and LTE.

The study has revealed that geographical differences exist in the factors influencing call-drops among wireless cellular network users in Ghana. The results have indicated that wireless network users in rural areas in Ghana experience more call drops than those in urban areas. This result could be explained by the fact that most rural areas in Ghana are deprived of many infrastructures, such as electricity and cell towers. According to Jeff (2017), because of the very few inhabitants or travelers, wireless cellular network towers are limited, or there is no coverage at all.

The study has revealed that there are significant differences in the call-drop factors when it comes to Smart and Non-Smart phone users. Jan and Lee (2012) found that Smartphone owners report a higher incidence of call-drops than other cell owners. According to Jan and Lee (2012), the many functionalities of smartphones lead to issues such as frequent low batteries and more running apps leading to frequent low battery power, affecting successful call completion.

6. Conclusion and Recommendations

6.1. Conclusion

In wireless cellular networks, there are several factors influencing call-drops. The present study discusses the factors influencing call-drop among wireless cellular network users in Ghana. The study used subscribers of the four major mobile telecommunication operators in Ghana, namely:

- Mobile Telecommunication Network (MTN),
- Vodafone,
- AirtelTigo, and
- Globacom (GLO)

The present study specifically sought to:

- Identify the causes of call-drops among wireless mobile network users in Ghana,
- Find out the latent factors influencing call-drop among wireless cellular network users in Ghana, and
- Examine the differences in the call-drop variables in terms of wireless cellular network, geographical location, and phone type

The result of this study has revealed that the main factors influencing call-drops among wireless cellular network users in Ghana are physical and natural obstructions, phone malfunctioning, battery power, limited cell towers, general power problems, cell tower overload, and limited phone functionalities. Among these factors, limited cell towers, cell tower overload, and general power problems, respectively, are the highest contributory factors influencing call-drops among wireless cellular network users in Ghana. These three factors combined account for more than 50 percent of the total variance in the factors influencing call-drops among wireless cellular network users in Ghana. All these three factors are network-related**,** indicating that most of the call-drops that occur in Ghana can be attributed to the operations of the wireless cellular networks. Network operators are encouraged to improve their network infrastructure, acquiring and using up-to-date mobile telecommunication network equipment for their operations. This will help solve some network problems, such as excessive call-drops being experienced by mobile network subscribers.

The results of this study have revealed that when it comes to call-drops among wireless cellular network users in Ghana, users in rural communities experience more call-drop factors than those in urban communities. This result underscores the need for the government to pay attention to the infrastructure need of the rural areas in Ghana to enhance development in the rural areas. Meanwhile, mobile network operators should extend more of their network infrastructure to the rural areas of the country to enhance mobile communication to and from the rural areas. On the other hand, smartphone users are found to experience more call-drop factors than non-smartphone users. However, in terms of users' networks, the study has revealed that there is no significant difference in call-drops. This suggests that in Ghana, the factors influencing call-drops are the same irrespective of the user's network.

6.2. Recommendations

The results of the study on the factors of call-drops among wireless cellular network users in Ghana have revealed areas where policymakers, regulators, wireless networks, and academicians need to pay serious attention. First, the results of the study have revealed that wireless cellular networks are the key contributors to call-drops in Ghana. This result implies that wireless cellular networks in Ghana are unwilling to make investments that can support the rising voice traffic. The government, through its regulatory body, that is, NCA, should, as a matter of urgency, stop all telecommunication companies in Ghana from enrolling new subscribers in their existing network platforms until they improve their system.

The second implication of this result is that there is a lack of punitive measures for poor service, resulting in the continual experience of call-drops among wireless cellular network users in Ghana. It is high time policymakers in Ghana devised penalty guidelines to ensure quality service to the Ghanaian populace. Thirdly, wireless cellular networks should invest in new and emerging technologies to provide excellent network services to Ghanaians.

To academicians, the results of this study have opened a wide door of research to be carried out on call-drops in Ghana. To assist network operators in improving their services, an experimental study is, therefore, recommended to simulate the number of cell sites and cell towers that should be put in place in a particular area to improve call quality and reduce call drops.

6.2.1. Potential Future Work

Although the present study critically examined the factors influencing call-drops among wireless cellular network users in Ghana, the authors believe that the study results are inconclusive since this is the first time such a study has been conducted in Ghana. Further research is, therefore, recommended on the topic to disentangle all the factors influencing call-drop among wireless cellular network users in Ghana to come to the final conclusion on the issue in Ghana.

The present study examines the factors influencing call-drop among wireless cellular network users in Ghana. The study failed to examine the call-drop factors in each wireless cellular network. It is recommended that factors influencing call-drop among each wireless cellular network user in Ghana be carried out to bring forth the issue of each network to assist each network know where they need improvement to better serve their customers.

Furthermore, to address the issue of call-drop in Ghana, the authors recommend that nationwide research be carried out to thoroughly examine the network parameters of the mobile networks. This will help determine whether the mobile network operators are working within the recommended parameters. Although, from time to time, NCA analyzes the network parameters of the mobile network operators, the authors are of the view that the coverage of the analysis is very limited. Therefore, the coverage needs to be extended, and other essential network parameters, such as call-drop, should be added and given optimum attention.

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