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RESEARCH ARTICLE

COVID-19 and socioeconomic development in Africa: The first 6 months (February 2020-August 2020)

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Abstract: The study covers the first 6 months of the coronavirus disease 2019 (COVID-19) epidemics in 56 African countries (February 2020-August 2020). It links epidemiological parameters (incidence, case fatality) with demographic parameters (population density, urbanization, population concentration, fertility, mortality, and age structure), with economic parameters (gross domestic product [GDP] per capita, air transport), and with public health parameters (medical density). Epidemiological data are cases and deaths reported to the World Health Organization, and other variables come from databases of the United Nations agencies. Results show that COVID-19 spread fairly rapidly in Africa, although slower than in the rest of the world: In 3 months, all countries were affected, and in 6 months, approximately 1.1 million people (0.1% of the population) were diagnosed positive for COVID-19. The dynamics of the epidemic were fairly regular between April and July, with a net reproduction rate R_0 = 1.35, but tended to slow down afterward, when R_0 fell below 1.0 at the end of July. Differences in incidence were very large between countries and were correlated primarily with population density and urbanization, and to a lesser extent, with GDP per capita and population age structure. Differences in case fatality were smaller and correlated primarily with mortality level. Overall, Africa appeared very heterogeneous, with some countries severely affected while others very little.

Keywords: COVID-19; Demographic transition; Health transition; Economic development; Africa

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1. Introduction

For most infectious diseases, the relationships between disease prevalence, incidence or mortality, and the level of economic and social development are negative. The more advanced a country is in economic development and in the demographic transition, the more effective it is in controlling infectious diseases, and the less frequent and the less fatal are infectious diseases (Preston, 1976). However, this is not always the case for emerging diseases. The case of HIV/AIDS struck people's minds in the early years of the epidemic: The more advanced countries were often more affected, such as the United States on the American continent or South Africa on the African continent (WHO database, 2020). In addition, at the micro-level (at the individual level), in the first phase of the epidemic, HIV/AIDS was more prevalent among wealthier, more educated, more urban people than among others, whether in Europe, America, or Africa (Fortson, 2008; Mishra, Assche, Greener, *et al*., 2007). The situation changed with the maturation of the epidemic, and in Africa in particular, a reversal

of this relationship was often observed, that is to say, that the underprivileged social strata became more affected because the privileged strata became more aware of danger, practiced prevention more effectively, and benefited earlier from medical treatment (Hajizadeh, Sia, Heymann, *et al*., 2014; Wojcicki, 2005).

The relationship between the coronavirus epidemics and socioeconomic development in Africa has not yet been investigated. This virus, officially called severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), emerged in China at the end of 2019, was quickly identified, and notified to the World Health Organization (2020) (WHO) on January 14, 2020. Since then, it spread across the world, affecting virtually every country in a matter of months. The virus belongs to the β-Coronavirus group; it is new to humans and therefore considered as an emerging disease. The virus is very contagious, it is transmitted in several ways: From person to person by aerosol, especially following the cough it causes in the infected person, and it can be maintained for several hours in a confined atmosphere, as well as by direct or indirect contact (hands, hugs, polluted surfaces, etc.). The disease has various clinical manifestations, ranging from asymptomatic infection, to mild illness, to severe illness requiring hospitalization and may cause death, especially in the elderly or in people with peculiar risk factors (diabetes, obesity, hypertension, etc.) (Velavan and Meyer, 2020). The fact that it often causes asymptomatic infections, especially among young people, makes it difficult to detect the virus in the general population. The diagnosis is usually made by detecting the virus by reverse transcriptase-polymerase chain reaction in a nasal sample, taken among subjects with clinical forms, among contacts traced in contagion studies, or among people wishing to know their infectious status. The more serious the clinical form, the greater the chances of detecting the virus, and in fact, many diagnoses, which are the source of statistics on the epidemic, are done in hospitals and other health structures, as well as in special case/contact surveys or in systematic screening (retirement homes, schools, health centers, travelers, etc.). The statistics available in the general population, therefore, depend on medical diagnostic capacities and, in particular, on hospital infrastructures, health personnel, and their training, as well as on the availability of screening kits. Statistical data are usually collected by specialized institutions (ministry of health, health agency, etc.) and must be transmitted to WHO daily as a notifiable disease.

Scientific output on this emerging disease is outstanding, with thousands of articles published in just 6 months, in one form or another, often in electronic pre-publication form. Most of these publications deal with the Far-East, Europe, America, but few with Africa. A search on Medline database on "coronavirus disease 2019 (COVID-19) epidemiology" on November 07, 2020, gave 687 references for Africa out of 20,373 in the world (3.4%) (Medline, 2020). There are several reasons for this difference: Africa was affected somewhat later than other continents, the medical infrastructure and research are less developed there, and it seems that, at least so far, the virus is less prevalent and less lethal than elsewhere (WHO database 2020).

The purpose of this study is to review the COVID-19 epidemics in Africa 6 months after onset (from mid-February to mid-August 2020) by documenting cases and deaths at country level first, and then linking the observed dynamics to economic development, demographic transition, population patterns, and health infrastructure, all important determinants of the dynamics of infectious diseases in the general population, as well as of the quality of statistics. Africa is indeed a particularly heterogeneous continent, with high-income and low-income countries, more densely and less densely populated countries, countries ahead (as South Africa) or backward (as Niger) in the demographic transition, countries with well-developed health infrastructure, and others with weak infrastructure.

Several determinants of COVID-19 epidemiology were analyzed: demographic characteristics (population density, urbanization, geographic distribution, progress in the demographic transition, and age structure of the population); economic characteristics (gross domestic product [GDP] and air traffic intensity) because the more developed is a country, the more frequent exchanges are, and the greater the risk of contamination; and public health characteristics (screening, intervention, prevention capacities for incidence, and health system performance for case fatality). The study does not deal with the important question of the effectiveness of prevention policies because, on the one hand, necessary data are lacking (the population coverage of preventive measures taken in each country is not available); and, on the other hand, because of reverse causality: The more infected is a country, the more it will tend to implement aggressive policies to fight the disease (as case for example in South Africa). A study of the impact of prevention would require a different methodology than the one proposed here, which is based on the empirical correlations between parameters of the epidemic and parameters of economic and social development.

2. Data and Methods

2.1. Country Databases

Data on the epidemics (reported cases and deaths) are those transmitted to WHO, published in the daily reports (WHO, 2020). The cumulative numbers of cases and deaths were used each week from February 16, 2020, to August 15, 2020,

thus covering the first 6 months of the outbreak. This database covered the 54 African countries (classified in the AFRO zone or in the EMRO zone), as well as two territories located in the Indian Ocean (Reunion and Mayotte). Only one territory did not declare any case by August 2020: The island of Saint Helena, located in the middle of the Atlantic Ocean, one of the rare territories to have escaped the Spanish flu pandemic of 1918-1919 because of its geographic isolation (McSweeny, Colman, Fancourt, *et al*., 2007).

Demographic data for these countries were taken from the United Nations Population Division database: Population in 2020, age structure, mortality, fertility, and urbanization (United Nations, 2014; United Nations, 2019). The data on country area, allowing the calculation of the population density, came from the FAO database (FAO-Stats, 2019). This was added a database on the geographical distribution of the population, but which does not cover the islands (Linard, Gilbert, Snow, *et al*., 2012). The economic data came from the World Bank database (World Bank, 2019), which were supplemented when necessary by the Index Mundi database (Index Mundi, 2020): GDP per capita in purchasing power parity and in constant dollars; air traffic (in passengers per million populations).

2.2. Methods

This study links epidemiological parameters to demographic, economic, and public health parameters. The following indicators were defined:

- Cumulative incidence = Number of cumulative notified cases by August 15, divided by mid-year population (July 01, 2020), expressed in million inhabitants.
- Weekly incidence = Number of cases occurring during the week, from Sunday to Sunday.
- Case fatality = Number of deaths declared/number of cases declared (per 1000 cases).
- The epidemic's net reproduction rate (R_0), also called the "basic reproductive rate" in epidemiology (Anderson and May, 1991), was calculated in two ways:
- Weekly R_0 = 2 × Number of cases of the week/Number of cases of the two previous weeks. This calculation is justified because the contamination mainly occurs during the 2 weeks following the primary infection.
- R_0 smoothed over the period: It is calculated as the growth rate of the number of weekly cases (r), obtained by logarithmic adjustment, and by the average duration between the index and secondary cases (d) = 9 days, according to the classic formula: $R_0 = \exp(r \times d)$. The average interval between index and secondary cases was chosen so that the two measurements were identical over the same period.

The country characteristics were divided into five groups, corresponding to specific thresholds, and classified from least developed to most advance. The categories of demographic transition were developed in the same way based on the criteria of fertility and mortality. These categories with the selected thresholds are displayed in Table 1. A multivariate analysis is presented at the end of the study, which is a linear regression on country characteristics, with an aim trying to explain differences in incidence and case fatality between countries. Main results are presented in graphic form to better show patterns. Charts showing incidence or case fatality are organized according to increasing economic development or demographic transition. A priori, one could have expected a function parallel to the second bisector (more development corresponding to fewer cases and fewer deaths), but in most cases, the diagram was reversed (more development associated with more cases), with a few exceptions. Univariate relationships were confirmed by multivariate analysis, except those that were canceled out by the correlations between variables and one variable which had an inverted relationship: The population age structure.

3. Results

3.1. Diffusion of the COVID-19

First cases of COVID-19 in Africa were notified to WHO in February 2020, by Egypt (February 15), Algeria (February 26), and Nigeria (February 28), practically at the same time as European countries, which were probably the main sources of infection (Mehtar, Preiser, Lakhe, *et al*., 2020). Within 3 months, COVID-19 affected all African countries, the last affected being Comoros (May 01) and Lesotho (May 13). Of the 56 African countries or territories reporting cases, 45 made their first report in March, and 6 in April. The spread of the virus was therefore very rapid, faster even than that of the Spanish flu of 1918-1919 (Martini, Gazzaniga, Bragazzi, *et al*., 2019), and out of all proportion compared with other emerging diseases such as HIV/AIDS which spread in the continent over several years (Buvé, Bishikwabo-Nsarhaza, and Mutangadura, 2002), or Ebola which remained confined in a few countries (Kramer, Pulliam, Alexander, *et al*., 2016). In fact, infectious diseases transmitted by the respiratory tract spread very quickly, and all the more quickly as the communication routes are dense and travels are fast (planes, automobiles, coaches, public transport, etc.).

Table 1. Correlations of COVID-19 parameters with demographic and economic indicators, 56 African countries and territories.

Variable/Category	Threshold value	Number of countries	Mean incidence	Mean case fatality
Population density	**Inhabitants/km²**			
Very low	<40	18	706	29
Low	40-79	15	1730	24
Medium	80-199	11	1074	20
High	200-399	7	1063	16
Very high	400+	5	2477	13
Urbanization	**Percent urban**			
Very low	<20%	6	142	23
Low	20-35%	13	482	27
Medium	35-49%	19	1213	27
High	50-64%	13	2168	15
Very high	>65%	5	2389	16
Income	**GDP per capita ($)**			
Very low	<2000	20	274	26
Low	2000-3999	15	1080	22
Medium	4000-7999	8	1582	25
High	8000-15999	7	3616	23
Very high	>16000	6	1774	13
Age structure	**Mean age**			
Very young	20-21	11	175	36
Young	22-23	22	735	21
Medium	24-25	10	2370	16
Aged	26-29	6	3807	21
More aged	30-39	7	809	19
Fertility	**Children per woman**			
Very high	>5.0	10	163	38
High	4.5-4.9	12	510	18
Medium	4.0-4.4	13	900	26
Low	3.0-3.9	11	2234	19
Very low	<3.0	10	2627	14
Under-five mortality	**Deaths/1000 births**			
Very high	>90	10	577	30
High	70-89	11	496	28
Medium	50-69	11	532	28
Low	30-49	14	2107	22
Very low	<30	10	2372	30
Medical density	**Inhabitants/physician**			
Very low	>10000	21	460	29
Low	>5000	13	580	18
Medium	>2000	8	1723	25
High	>1000	8	4346	16
Very high	<1000	6	758	19

(*Contd...*)

Table 1. (*Continued*).

Variable/Category	Threshold value	Number of countries	Mean incidence	Mean case fatality
Air traffic	**Passengers/million population**			
Very low	<10	10	179	35
Low	<20	12	504	25
Medium	<100	14	624	21
High	<1000	15	2277	19
Very high	>1000	5	3913	12
Population concentration	**Concentration index**			
Very low	<20	8	1944	29
Low	<40	15	676	29
Medium	<50	10	405	20
High	<60	8	967	21
Very high	60+	8	1095	21
Special	Islands	7	3438	13
Date of first cases	**Date**			
Early	<March 15	21	1304	22
Medium	March 15-31	27	1360	25
Late	>April 1	8	776	19
Total		56	1255	23

NB. Thresholds values were designed by the author for this study

3.2. Dynamics of the Epidemic in Africa

While it was very rapid, the spread of the virus within the continent was slower than in Europe or America. Its speed rather corresponds to the dynamics of COVID-19 in the Indian subcontinent (India, Pakistan, and Bangladesh), as shown in Table 2, summarizing the cumulative incidence by August 15. The incidence in Africa was even significantly lower than the world average (31% of the total) and much lower than that found in Europe or America. Likewise, the case fatality in Africa was close to that of the Indian subcontinent, well below the world average (−38%), and much lower than that of Europe or America (Table 2).

3.3. Estimates of the Epidemic's Net Reproduction Rate (R_0)

Two methods were used to estimate the weekly net reproduction rate: a direct method, by weekly incidence, and an indirect method, by the growth rate of the epidemic (see details of calculations in the methodological section). Both methods gave similar results with an average generation time of 9 days. The net reproduction rate was high at the very beginning of the epidemic, as in all countries of the world, then stabilized from mid-April and remained practically constant at an average level of $R_0 = 1.35$ until mid-July, which corresponds to a weekly growth rate of cases $r = 0.213$. After the week ending on July 12, R_0 started to decline steadily, signaling that the first peak of the epidemic was passed, and even crossed the 1.0 bar line, reaching 0.62 in the week of August 15 (Figure 1).

3.4. Regional Differences

The spread of the coronavirus was not homogeneous across the continent. Large differences could be seen already within the six major regions: North Africa, West Africa, Central Africa, East Africa, Southern Africa, and African Islands. The worst affected region was Southern Africa, with an incidence 6.37 times the average, while North Africa and the Islands were close to average, and the other regions much less affected. East Africa was the least affected by August 15, about 3 times less than the average. In contrast, the case fatality was more homogeneous, with relative variations from 0.54 (Africa Islands) to 1.81 (North Africa) compared with the average (Table 3).

The decline in the epidemic's net reproduction rate after July 12 was reflected in the 6 large regions. If the R_0 was high everywhere at the start of the epidemic, as elsewhere in Europe and America, it was quickly restricted to a band between 1

Table 2. Cumulative incidence and case fatality, by major area of the world (as of August 15, 2020).

Continent/World area	Population (millions)	Incidence (cases/million)	Case fatality (deaths/1000 cases)
Americas	1023	11167	36
Europe	561	3672	90
Indian sub-continent	1766	1786	19
Africa	1280	857	22
China	1439	62	52
Other areas	1661	2091	21
World	7731	2755	36

Sources: Population: United Nations Population Division; Cases and deaths: World Health Organization. Americas include both North and South America

Table 3. Incidence and case fatality of COVID-19 in major regions of Africa (as of August 15, 2020).

Region	Absolute value		Relative value	
	Incidence (per million)	Case fatality (per 1000)	Incidence	Case fatality
Northern Africa	803	41	0.97	1.81
Western Africa	362	16	0.44	0.70
Central Africa	289	19	0.35	0.81
Eastern Africa	251	19	0.30	0.83
Southern Africa	5293	20	6.37	0.87
African Islands	708	12	0.85	0.54
Total	830	23	1.00	1.00

Sources: Population: United Nations Population Division; Cases and deaths: World Health Organization. Total is the reference category for relative values

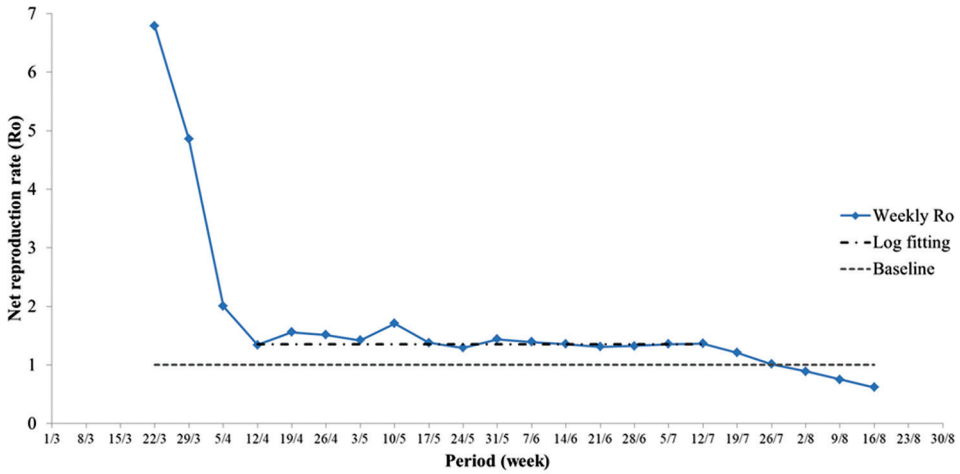

Figure 1. Weekly net reproduction rate (R_0) of COVID-19 in Africa.

and 2, with large local fluctuations. In five of the six large regions, it was decreasing since July and was close to- or <−1.0 by mid-August, with the exception of North Africa, where it seemed to increase again (Figure 2).

3.5. Country Differences

Country differences were considerable, especially with regard to incidence. Incidence expressed in cases per million population ranged from 9 (Tanzania) to 11,433 (Mayotte), which is also the area with the highest population density of all the countries and territories considered (728 inhabitants per km²). The distribution of incidences was fairly uniform, showing a great heterogeneity, without any concentration around the mean.

Countries or territories most affected were certain islands: Mayotte (11,433), Cape Verde (5689), Sao-Tome and Principe (4038), as well as Djibouti (5432) and South Africa (9841), and some oil-exporting countries: Gabon (3695) and Equatorial Guinea (3436). It should be noted that South Africa alone accounted for more than half of all reported cases in Africa (52.4%), while it accounted only for 4.4% of the inhabitants, and that the small islands or small countries that were badly affected accounted for an only small percentage of all cases. The least affected countries were: Some countries in East and Central Africa: Tanzania (9), Uganda (30), Burundi (35), Mozambique (89), Angola (57), and Congo-Kinshasa (108); certain Sahelian countries: Niger (48), Burkina-Faso (59), and Chad (58), as well as a country in the Horn of Africa: Eritrea (80). This list is, therefore, very heterogeneous, in which one could see certain geographical variations, as shown in the map (Figure 3).

Heterogeneity between countries was much less pronounced for case fatality. The case fatality rate varied from <1/1000 (Eritrea, Seychelles) to 80 per 1000 (Chad). The majority of countries and territories (33/56) were at a relatively low level of case fatality (<20/1000) when compared to international data, and the number of countries with higher case-fatality decreased rapidly with the level of case fatality (Figure 4).

Countries with the highest case-fatality rates were Sahelian countries: Chad (80), Sudan (64), Niger (61), Mali (49), Burkina-Faso (46), as well as Egypt (51), and Liberia (64). Countries with the lowest case-fatality rates were countries in East Africa: Eritrea (no deaths reported), Rwanda (2), Burundi (2), Uganda (3), and Mozambique (7); Southern African countries: Botswana (2) and Namibia (5); West African countries: Ghana (5), Guinea (6), and Ivory Coast (6); and Islands: Seychelles (no deaths), Reunion (6), as well as Gabon (7).

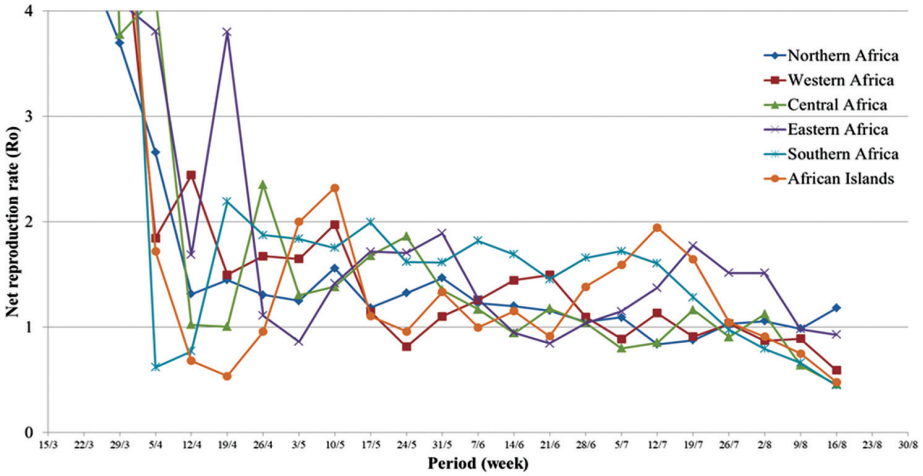

Figure 2. Weekly net reproduction rate (R_0) of COVID-19 in major regions of Africa.

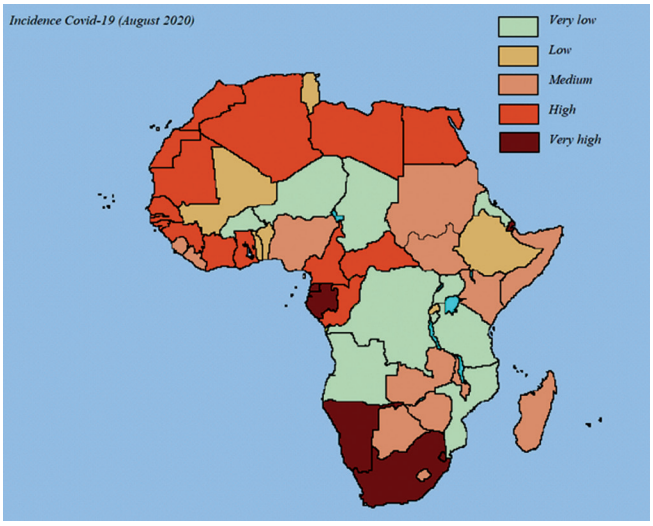

Figure 3. Geographical distribution of cumulative incidence of COVID-19 (as of August 15, 2020).

The geographical distribution of case-fatality levels revealed the particular situation of the Sahelian strip, except Senegal, as well as a strip ranging from Angola to Tanzania, and to a lesser extent, certain countries of North Africa (Algeria, Egypt, Tunisia). Therefore, there was little geographical correspondence between incidence and case fatality, and at the statistical level, the correlation between incidence and case fatality was weakly negative ($P = -0.22$), which implies that countries with high incidence had lower case fatality.

3.6. Correlations with Demographic Factors

This section explores the correlations between demographic parameters and the incidence of COVID-19. In a classic demographic transition framework, one would expect an inverse correlation: The further the country is in the transition, the more developed it is, and therefore the lower the incidence should be. The same goes for economic development. The figure in this section (Figure 5) is presented according to this framework, with the values corresponding to the most advanced situations in terms of development on the right side, that is to say, that one would expect relations parallel to the second bisector, but one finds in fact the opposite relation in most cases.

3.6.1. Population density

The relationship with population density was expected to be complex. On the one hand, economic development implies generally demographic growth, urbanization, densification, and concentration of the population, but a high population

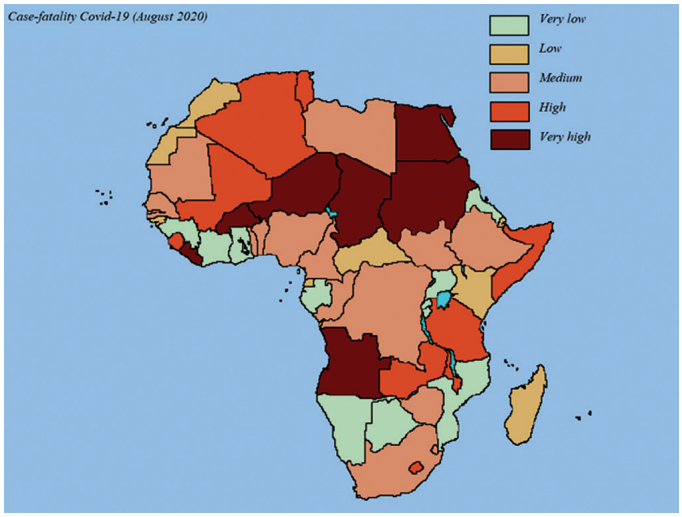

Figure 4. Geographical distribution of case-fatality rate of COVID-19 (as of August 15, 2020).

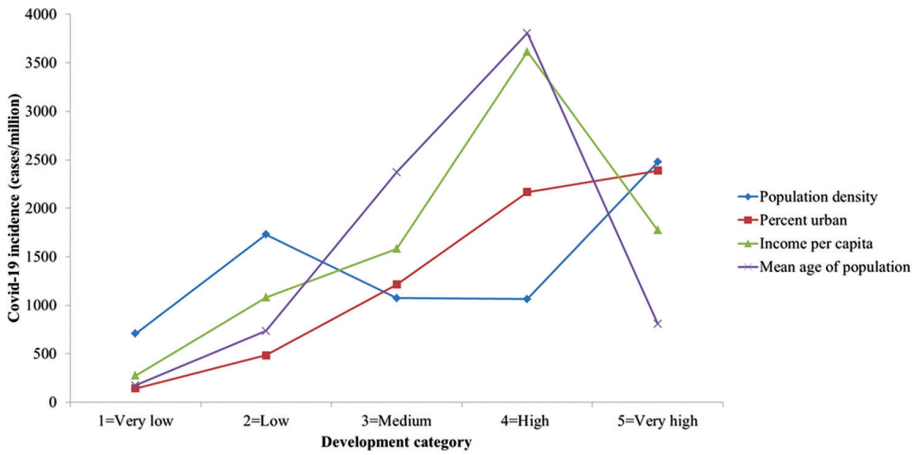

Figure 5. Relationship between COVID-19 incidence and selected demographic and economic development indicators, 56 African countries.

density also favors the spread of infectious diseases transmitted from person to person due to the greater proximity and the greater number of contacts between people. This is indeed what was observed empirically: A positive relationship between incidence and population density, although not totally monotonic. The apparent accident in the second category (density of 40-79 inhabitants per km²) was mainly due to the exceptional case of South Africa; otherwise, the relationship would be monotonously increasing (Table 1 and Figure 5).

3.6.2. Urbanization

The same pattern was found with urbanization, and for the same reasons as for density: The relationship was positive and strong, the most urbanized countries having more viruses, and here the relationship was monotonous with a wide gradient from 1 to 17 (Table 1 and Figure 5).

3.6.3. Population concentration

The relationship with the population concentration index, which measured the geographical distribution of the population in the territory, was U-shaped, which was difficult to explain by purely epidemiological criteria (Table 1).

3.6.4. Fertility level

The relationship between infectious disease and fertility level is often negative, with countries further behind in the fertility transition having more difficulty in controlling infectious diseases. But here the relationship was reversed, with a wide gradient between countries: When the total fertility rate (TFR) was >5 children per woman (10 countries), the incidence was low (108 on average), but much higher (2233) in the opposite case, when TFR was <3 children per woman (10 countries). Hence, the more countries are advanced in the fertility transition, the more COVID-19 they have, and gradients were wide, ranging from 1 to 16 (Table 1).

3.6.5. Mortality level

The same pattern was found for mortality level, here calculated as the under-five death rate per 1000 births. The more advanced in the health transition, the higher COVID-19 incidence. The gradients were weaker and less regular than for fertility, but they remained important, with variations from 577 to 2372 per million, that is, a gradient from 1 to 4 (Table 1).

3.6.6. Age structure of the population

The relationship with the age structure was also complex and not monotonic. The average age of the population and the proportion under age 20 were used, but the second parameter was somewhat less correlated with incidence. Large differences existed between countries, ranging from 175 in very young countries (average mean age 20-21 years, that is, 11 countries) to 3807 in older countries (average mean age 26-29 years, that is, 6 countries), but incidence fell to 809 in the oldest countries (average mean age of 30 years and over, or 7 countries). Here again, the relationship was rather reversed, although not confirmed in the most advanced countries. It should be remembered that the age structure is the result of past fertility and mortality levels, and therefore that one could expect an inverted and strong relationship with the mean age of the population (Table 1 and Figure 5).

3.6.7. Progress of the demographic transition

The five-category demographic transition indicator summarized the relationships with fertility, mortality, and age structure. The incidence gradient, according to this indicator, was close to that noted with the age structure: Monotonic and fairly regular for the first four categories, and different for the highest category (very advanced transition). This category grouped countries with demographic regimes different from others: Islands (Cape Verde, Mauritius, Reunion, and Seychelles) and Maghreb countries (Libya, Morocco, and Tunisia) (Table 1).

3.7. Relationship with Economic Factors

3.7.1. GDP per capita

The relationship with per capita income (GDP in purchasing power parity and in constant dollars) was also inverted and complex: The poorest countries (<$2000, that is, 20 countries) had less COVID-19 (average incidence = 274), middle-income countries ($8000-$15,999, or 7 countries) had more than 10 times as much (average incidence = 3616), but

wealthier countries (>$16,000, or 6 countries) had 2 times less than the previous category (1774). This relationship resembles that of the demographic transition, but the countries in the top category were not the same (Table 1 and Figure 5).

3.7.2. Air transport

Air transport played a fundamental role in the rapid spread of the virus around the world: The first cases in Europe were often traced to contact with travelers from China, and the first cases in Africa to travelers returning from Europe, Italy, and France in particular (Mehtar, Preiser, Lakhe, *et al*., 2020). The relationship between incidence and air traffic was indeed strong and in line with what was expected: The greater the air traffic (in passengers per million population), the greater the incidence, with a gradient of incidence ranging from 179 to 3913, that is, a ratio of 1 to 22 (Table 1).

3.8. Relations with Public Health

3.8.1. Medical density

The relationship with medical density was multifaceted because the more developed the country, the larger the medical density, and the higher the capacity to diagnose cases of COVID-19. The relationship with medical density followed approximately that noted with economic development: Fewer cases (460) when medical density was low (more than 10,000 people per doctor, or 21 countries), more cases when it was high (4346 per 1000-1999 people per doctor, or 8 countries), and again fewer cases when the medical density was very high (<1000 people per doctor, or 6 countries, close to European levels). Therefore, it does not seem that the relationship with medical density could be explained by reporting bias; otherwise, one would have more cases in the last category (Table 1).

3.9. Multivariate Analysis of Incidence Factors

These demographic, economic, and health parameters were, of course, inter-correlated. A multivariate analysis at the level of the 56 countries and territories was therefore carried out. Results appear in Table 4. Two factors stood out clearly and were statistically significant: Population density ($P = 0.018$) and urbanization ($P = 0.030$). These are, in fact, direct epidemiological factors: The higher the density and the greater the proportion living in urban areas, the faster the virus is transmitted, and the higher the cumulative incidence. These two factors remained stable in all multivariate analyzes, regardless of the other variables added. To these, one must add two factors that also seem important but remained at the limit of statistical significance: GDP per capita ($P = 0.050$) and mean age of population ($P = 0.093$). Here, it should be noted that the effect of the mean age was reversed in the multivariate analysis: An older population corresponds to less COVID-19, while the relationship was the other way around in the univariate analysis. These four factors explained 28% of the variance between countries ($P = 0.002$).

These four factors appear to have an impact of the same order of magnitude, measured as the effect of one standard deviation of each variable: +700 for population density; +793 for proportion urban; +812 for Log(GDP); −701 for mean age of population, and all for an average incidence value of 1255 per million. Large variations in these variables could therefore account for the large gradients observed between countries. When added in a stepwise procedure, the other variables played a negligible and non-significant role when the first four factors were taken into account: Date of the first case ($P = 0.945$); medical density ($P = 0.959$); air traffic ($P = 0.887$); under-five mortality ($P = 0.296$); and only fertility remained at borderline statistical significance ($P = 0.068$).

Table 4. Results of multivariate analysis of COVID-19 incidence, 56 African countries and territories.

Variable X_i	Coefficient B_i	Standard error	*t*-test	*P*-value	Significance	Net effect
Constant	−3035.5	2244.0	−1.353	0.182		1255
Population density	+4.373	1.797	2.434	0.018	**	+700
Percent urban	+4249.7	1904.9	2.231	0.030	**	+793
Log(GDP/capita)	+763.3	380.4	2.006	0.050	*	+812
Mean age of population	−173.1	101.3	−1.710	0.093	*	−701

"***": $P<0.01$; "**": $P<0.05$; "*": $P<0.10$; "NS": Not significant. Coefficients are raw beta coefficients. The net effect was calculated for one standard deviation of each independent variable, for constant=mean value. Model: Incidence=Constant + $\sum_i B_i \times X_i$

3.10. Analysis of Case Fatality

The gradients in case fatality did not have a common measure with those of incidence: They were much more concentrated. In particular, there were few regular gradients, and few groups were different from the average. However, most of the extreme categories (the most advanced) had a lower than average case fatality, which corresponds to the relationship observed between incidence and development, or between incidence and demographic transition: Very high population density (13); very high urbanization (16); older age structure (19); very low fertility (14); heavy air traffic (12); population concentration in islands (13); and for an average of 23 deaths per 1000 cases. However, this effect was not verified for the two public health parameters: Very low under-five mortality (30) and very high medical density (19).

A multivariate analysis of case fatality was performed in the same way as that for incidence, using a simple linear regression model. Results revealed only one significant factor: Under-five mortality ($P = 0.003$) and a factor at borderline statistical significance: Geographic concentration of the population ($P = 0.084$) (Table 5). These two factors explained only 16% of the variance between countries. For the first factor, the relationship was straightforward: The higher the level of mortality, the higher case fatality could be expected because of failures or defects in the health system. The effect of the second factor indicates that the more concentrated the population, the lower the case fatality. This could be explained by better access to health care or by a correlation with another factor not taken into account. However, it should be noted that the relationship with the geographical concentration of the population was not linear and that the islands were treated separately. No other factor was significant when introducing under-five mortality into the linear regression equation for case fatality.

4. Discussion

For the continent as a whole, the dynamics of the COVID-19 epidemic appeared slower than in Europe or America and they rather resembled those in the Indian subcontinent. This observation can be related to the levels of economic development: The more developed countries have more transport, trade, and travelers, are more urbanized, and more densely populated, all factors contributing to the rapid spread of the virus. For instance, in Europe, Belgium is one of the most urbanized and densely populated countries and also one of the European countries most affected by COVID-19. Africa and South Asia have closer and lower levels of development, so one could expect similar and slower COVID-19 epidemics.

Variations in incidence by country were very large in Africa. The main factors seem to be demographic (density, urbanization) and economic (GDP, air traffic). The fact that these factors point to the transmission of the disease indicates that data are probably reliable, which indirectly validates the statistics, although they may be questioned in some countries. These variations between countries seem to be greater than in Europe. However, in Europe too, there were large variations in incidence, from 11,363 (Luxembourg) to 475 (Slovakia), that is, a ratio of 24 to 1 among the 48 European countries, excluding the former USSR (WHO database 2020). These large variations in Europe remain poorly explained, and the unexplained part could be due, in addition to population density and economic development, to random phenomena, chaotic dynamics, or quality of surveillance systems.

Variations in case fatality were much smaller, and Africa as a whole appeared fairly homogeneous. These results again point to good data quality, even if it seems surprising that some countries report so few deaths given the number of reported cases (Ghana, Guinea, Cote d'Ivoire in West Africa; Burundi, Rwanda, and Uganda in Central Africa; and Botswana and Namibia in Southern Africa). In Europe, there were also large variations in case fatality between countries, ranging from 16.3 (France) to 0.5 (Iceland) per 1000 reported cases, that is, a ratio of 32 to 1, variations which remain largely unexplained (WHO database 2020). Variations in case fatality in Africa could be explained in part by levels of mortality, by the effectiveness of treatments in the case of severe forms of the disease, by better inclusion of mild cases in the denominator, and perhaps by notification bias, or by other unidentified factors.

The question of the effect of the age structure of African populations remains open. In univariate analysis, more COVID-19 was found in countries with an older population, but in multivariate analysis, the reverse was found after

Table 5. Results of multivariate analysis of COVID-19 case fatality, 56 African countries and territories.

Variable X_i	Coefficient B_i	Standard error	*t*-test	*P*-value	Significance	Net effect
Constant	14.868	5.086	2.923	0.005		23.01
Under-five mortality	+0.261	0.084	3.123	0.003	***	+7.86
Population concentration index	−0.199	0.113	-1.764	0.084	*	−4.44

"***"=$P<0.01$; "**"=$P<0.05$; "*"=$P<0.10$; "NS"=Not significant. Coefficients are raw beta coefficients. The net effect was calculated for one standard deviation of each independent variable, for constant=mean value. Model: Case fatality=Constant+$\sum_i B_i \times X_i$

taking into account population density, urbanization, and GDP per capita. One possible explanation is that young people play an important role in transmission, and therefore in the cumulative incidence for all ages, all other things being equal. But since countries that are more developed are also more advanced in the demographic transition, they have both a higher mean age and more reported cases of COVID-19. The strong correlation with fertility levels could be due to a correlation with economic development, but could also be an indicator of relative isolation of the population: The more isolated is a group, the lower will be access to family planning, the higher the fertility, and the lower the incidence of COVID-19.

The negative correlation between incidence and case fatality could be due to the correlation with development: The most advanced countries having more cases and fewer deaths. However, it could also be due to reporting problems: Countries that work better detect and report more cases, and therefore, the case fatality (calculated as the ratio of deaths to cases) appears lower.

This study did not address the issue of climate and its impact on COVID-19 transmission. Other authors found correlations between climate, in particular temperature, and incidence of COVID-19 in Russia and in cities all over the world (Pramanik, Chowdhury, Rana, *et al*., 2020; Pramanik, Udmale, Bisht, *et al*., 2020). The same type of analysis could be repeated in Africa, contrasting arid with forest areas, high altitude versus low lands, cold versus warm weathers, etc. More could be done when the epidemic would have developed for at least 2 years to assess seasonality.

This study has serious limitations, and the main limitation is the quality of data on incidence and mortality. Even in Europe, COVID-19 cases were not fully reported in the 1st months of the epidemic, and the situation is likely to be worse in Africa because of deficient health systems and lack of tracking systems. If deaths are properly recorded in Europe, they are not in Africa because vital registration systems are deficient in many countries, with the exception of Islands such as Mauritius and continental countries such as South Africa (Joubert, Rao, Bradshaw, *et al*., 2012; Garenne, Collinson, Chodziwadziwa, *et al*., 2016).

The future of the epidemic is uncertain. The first few months of the epidemic were worrisome, as the R_0 remained stable above 1 for weeks and strong enough to eventually lead to a huge epidemic. The fact that it has started to decline since mid-July may lead to less pessimism. The momentum over the next 6 months is likely to be decisive, and it is, of course, too early to make any predictions, even at medium terms. Some authors liked to predict that the COVID-19 epidemic in Africa could be stopped by the end of April or the end of May, depending on the scenario considered, but their predictions have proved far from reality (Zhao, Li, Liu, *et al*., 2020). Recent data, updated in mid-October, are again worrisome, as R_0 increased again in September and over-passed the 1.0 threshold by October 12.

5. Conclusion

The preventive measures taken vary greatly from country to country and will need to be adapted to the local context. However, one could hope that the most advanced countries in economic, social, and health development, which are also the most affected, will find effective solutions to eventually control the epidemic.

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RESEARCH ARTICLE

Influence of the Olympic winter games PyeongChang 2018 on the Korean Wave: Comparison of perceptions between Koreans and Americans

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Abstract: This study was designed to investigate the effects of the Olympic Winter Games PyeongChang 2018 on South Koreans' and Americans' perceptions of the "Korean Wave," or Hallyu. To achieve this purpose, a survey that included questions about the awareness of Hallyu among South Koreans and Americans was conducted before and after the Olympics. The results show that the Olympics positively influenced Hallyu and that the effect was greater for Koreans than for Americans. After watching the Olympics, Koreans had a greater sense of cultural soft power and their perception of Hallyu's influence on the United States than before they watched the Olympics. However, for American participants, enduring involvement with Hallyu was the only factor that reflected a positive influence. This study demonstrates the relationship between international mega-sport events and a host country's perceived cultural values.

Keywords: Korean Wave; Olympics; Culture; Sports

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1. Introduction

The Olympic Games are like a wagon moving on two wheels – sports and culture. The founder of the modern Olympics, Pierre de Coubertin, emphasized culture because promoting mutual understanding among diverse nationalities and cultures was one of his principal goals. The combination of sports and culture in the modern Olympic Games became explicit in 1992 at the Barcelona Olympic Games, which were declared to be "without any conflicts" as the Cold War had recently ended. The cultural aspects aired during the Barcelona Olympic Games highlighted the host city of Barcelona as a tourist destination with beautiful culture and heritage. Since then, culture has been regarded as a primary factor connecting those who participate in, watch, talk about, or think about the Olympics (Nauright, 2004).

Cultural value was deeply rooted in the Olympic Winter Games PyeongChang 2018 from its inception. The strong support of the government and the community was key to South Korea's selection to host the Games after two unsuccessful attempts since 2003 (Kim, Choi, and Kaplanidou, 2015). Specifically, the combination of the local culture of Gangwon Province, the host city for the PyeongChang Olympic Games, and the culture of the host country played a major role in being selected to host the game.

It is impossible to discuss the Winter Olympics without discussing the cultural wave. In the mid and late 1990s, the Korean Wave, or Hallyu, started in Japan and China. Hallyu

refers to the phenomenon of South Korean popular culture, such as TV shows, fashion, cuisine, and music, becoming immensely popular in other countries (Nye, 1967). By 2016, it had grown to generate $6.2 billion, or about 1% of Korea's total exports per year (Korea Creative Contents Agency, 2018). The success of Hallyu can be explained by both direct and indirect factors. First, localization strategies with different approaches for each market were successful. To enter the global market, cultural aspects of Hallyu were adjusted for each country through the efforts of private cultural content companies, such as SM Entertainment and JYP Entertainment (Kim, 2016; Cho, 2017). Indirect factors include governmental policies that emphasize soft power, such as cultural content and Hallyu activities that pursue mutual growth between Korean cultural content and other countries' content (Jang and Paik, 2012).

Scholars have endeavored to understand Hallyu in diverse ways. Some examine the phenomenon in Asian countries, such as Japan and China (Kim, 2013), its effects on the country's image, attracting tourists, and the purchase of products made by Korean companies (Kim, Agrusa, and Lee, 2007). However, few studies have examined the influence of a mega sporting event on Hallyu.

To fill this gap, this study focuses on the effects of the PyeongChang Winter Olympic Games on the perception of Hallyu among people of the host country and the United States; thus, the study included Korea, the host country, to measure the effect of the Olympics on Hallyu in the host country in comparison to another country that shares different cultures and perspectives. The PyeongChang Olympic Games were held 30 years after the 1988 Olympic Games, the first to be held in South Korea. The influence of the 2018 Winter Olympic Games was expected to be significant, as it was a large global event in which 45,000 sports officials and journalists as well as 6500 athletes from more than 90 countries participated directly. With that in mind, the purpose of this study was to measure the influence of the PyeongChang Winter Olympic Games on Koreans and Americans in relation to Korean pop culture, Hallyu. For this purpose, this study assessed the perceptions of Koreans and Americans about Hallyu before and after the PyeongChang Winter Olympics.

1.1. The Impact of Sport Mega-events on the Host Country

Scholars have undertaken to understand the potential consequences of mega-sport events, such as the Olympic Games and the FIFA World Cup, for their host countries (Kaplanidou, 2006). Mega-sport events that people around the world can see are reported in numerous media (Horne and Manzenreiter, 2006). As a global asset, a mega-sport event affects various aspects of the host country, including social, political, and psychological aspects (Parent, 2009). Although the magnitude of the impact of these mega-events is debatable, there is no question that mega-sport events such as the Summer and Winter Games are influential (Toohey and Taylor, 2008).

1.2. The Cultural Impact of Mega-sport Events

Since the Olympic Games were re-established in 1894, an underlying ideology of the Games has been to acknowledge the differences in each culture and to make the world a better place by reducing apprehensions between cultures. While political and economic modernization may change the Olympics at face value, the ideology of the Olympic Games has not changed much from the beginning (Chatziefstathiou, 2005). Media coverage of the Olympic Games showing fairness, friendship beyond borders, and the efforts of athletes is an opportunity to enhance national image by linking such positive aspects with the overall image of the host country. This is also an opportunity to deepen the understanding of a host country's culture among the global audience of the Games.

Mega-sport events can improve the image of the host country in various ways. First, successful events can be transmitted to people around the world through media and affect the awareness and attitudes toward the host country (Lee, Lee and Lee, 2005). Specifically, those who watch the Games are exposed to and learn about the beautiful cities and natural landscapes of the host country, the nation's capability and infrastructure to host mega events, and the cultural and historical heritage of the country (Hede, 2005). Those who attend the events can learn and experience new facts about previously unfamiliar host countries, which can affect behaviors in favor of the host country (Kaplanidou and Vogt, 2007). In particular, because cultural values can affect an individual's emotions, attitudes, and consequences, mega-sport events can have a big impact on the public (Allik and Realo, 2004).

Korea's popular culture, known as Hallyu or the Korean Wave, has developed into a cultural phenomenon that has transcended national boundaries in the past decade (Yoon and Jin, 2016). Hallyu has already had a significant impact on the culture of Southeast Asia and is also the reason many foreign tourists choose to visit Korea (Kim and Ryoo, 2007). Hallyu is the reason Korean popular culture, including popular music, drama, and movies, has become influential and recognized in other countries (Ryoo, 2009). Now the boundaries of Hallyu are expanding to include Korea's lifestyle, cooking, fashion, and so on (Park, 2011).

Cultural cross-border exchanges have been facilitated by globalization and a new world cultural infrastructure (Held *et al.*, 2000). As a potential counterflow of the Western-dominant media stream, Hallyu is considered "a first sign of how a country 'in between' can find a niche and reposition itself as an influential cultural mediator and creator in the midst of global cultural transformation" (Ryoo, 2009). In response to these changes, the Korean government adopted Hallyu as part of its cultural diplomacy programs, strengthening cultural relations with other countries and people (Kwon and Kim, 2014). The government of Korea officially named the 2018 Olympics the "2018 PyeongChang Culture Olympiad" and sought to provide various cultural events to raise awareness of Korean culture in the world. In particular, the opening ceremony of the PyeongChang Olympic Games was praised as a successful showcase of Korean culture and history (Petrusich, 2000).

1.3. Cultural Soft Power

Scholars have investigated the potential soft power capabilities of media messages, as national media messages can be disseminated internationally (Holyk, 2011). Soft power is the ability of a country to "attract and co-opt them (other countries) to want what you want" (Nye, 1990). It is the converse of hard power, which is a country's physical strength – economic and military power. Soft power stimulates sensuality and the rational part of human beings and can be achieved by convincing others through intangible values, such as culture and education. The soft power of a country takes various forms in the media. For instance, soft power can be strengthened by a country's cultural history and heritage, as a tourist destination, or through its popular culture (Holyk, 2011). Scholars have indicated that "popular culture has become a potentially important resource for soft power diplomacy, transcultural collaborations, dialogues, and struggles to win hearts and minds of people" (Nye, Kim, and Kim, 2013). Similarly, another scholar indicated that the appeal of popular culture is a type of cultural soft power along with other types categorized as human capital soft power and political soft power (Holyk, 2011). Studies have found positive associations between the perception of Korean soft power and the benefits it may bring to the nation, such as tourism intention (Ng, Lee, and Soutar, 2007). Many countries are pursuing the development of soft power through their cultural features.

1.3.1. Involvement in Hallyu (situational versus enduring involvement)

Popular media, such as drama, entertainment, and movies, influence the evaluation of the country from which the popular culture originates. Considering the audience from a socio-psychological perspective through involvement can lead to a better understanding of how a mega-sport event influences the perception of global viewers (Havitz and Mannell, 2005). Involvement refers to the degree of importance or concern given to any stimulus in a particular situation (Zaichkowsky, 1985). In addition to interest in objects, arousal is also included in determining involvement levels (Havitz and Dimanche, 1997). Reflecting this, scholars define popular culture involvement as "an individual's interest or arousal toward a certain pop culture" (Whang, Yong, and Ko, 2016). It is important to understand the involvement of individuals in cultural content because individual involvement is often closely related to their supportive behavior (Shao, Baker, and Wagner, 2004).

Involvement can be divided into two categories: Situational involvement and enduring involvement (Richins and Bloch, 1986). Situational involvement refers to involvement caused by a particular situational phenomenon, whereas enduring involvement refers to a sustained involvement with the subject (Havitz and Dimanche, 1997). While situational involvement is a short-term concern for a particular subject in a particular context, enduring involvement is more likely to last longer than situational involvement because it is related to an ongoing interest (Richins and Bloch, 1991). Since there is a tendency for many media to show the culture or arts associated with the host country during the Olympics, audiences are likely to temporarily engage in situational involvement in the culture of the host country. They can be divided into those who participate in enduring involvement with the host country's culture in accordance with their interest and those who do not. Studies have indicated that situational involvement is closely related to enduring involvement, as it leads individuals with a short-term interest in the media content to engage in similar messages or objects (Whang, Yong, and Ko, 2016). This means that it is important to engage the short-term involvement of the audience through interesting and positive media messages to trigger their enduring involvement with a country and its culture. While a handful of studies have discussed the various types of involvement with culture and their consequences, few have examined the association between involvement types and mega-sport events such as the Olympics. To bridge this gap, this study examined the effects of the Olympic Winter Games PyeongChang 2018 on situational and enduring participation.

1.3.2. Likeability of Hallyu

With advances in media technology, popular culture plays an important role in not only its country of origin but also in other countries (Gross and Brown, 2006). Hallyu has become a global phenomenon as interest in Korean culture – Korean

food, brands, and popular culture – has grown (Onishi, 2019). Hallyu has been successful across Asian countries, such as Japan, China, Vietnam, the Philippines, and Thailand, and has recently spread to the Middle East, South America, Africa, and the United States (Shim, 2006). This global success cannot be achieved without public interest and an affinity for Hallyu.

Whether an individual likes a particular object is a reliable indicator of their attitude and future behavior. The audience's favorability toward Korean culture has some expansion effects. In particular, the favorability of Korean culture, such as Korean celebrities and dramas, has led to a better image of Korea as a nation held by consumers in other countries, which in turn has led to a preference for Korean products and travel destinations (Lee, Ham, and Kim, 2015). Hallyu can be indirectly used as a promotion for Korean brands (Hong and Liu, 2009). Sports have been continuously attractive and appreciated by viewers around the world. Especially in the case of mega-sport events such as the Olympic Games, the host nation's traditions and popular culture can be positively shaped through the overall image of the country (Florek, Breitbarth, and Conejo, 2007).

1.3.3. Influence of Hallyu in the US

Popular culture has traditionally flowed from the West to the rest of the world (Schiller, 1971). American media have been especially dominant on the screens of many countries (Hoskins and Mirus, 1988). As a result, it has directly and indirectly influenced other countries' cultures. However, with the development of the internet and other emerging media, the boundaries of culture transferred through media have become blurred (Tunstall, 2008). In that regard, the spread of Hallyu through emerging media has also affected viewers across borders (Jung, 2009). Based on the above discussion, this study proposes the following research question to evaluate the impact of the Olympic Winter Games PyeongChang 2018 on Hallyu.

Research Question 1: Did the 2018 Winter Olympics affect the audience's perception of cultural soft power, involvement, favorability, and influence?

1.4. The Impact of the Olympic Winter Games PyeongChang 2018 on US and Korean Viewers

The image of a country is determined by the way people from other countries view it. A mega-sport event that can show many positive aspects of the host country to audiences around the world is an opportunity to build national identity (Gorokhov, 2015). To measure the effects of large events and the impact on other countries' perception of host countries, researchers have sought to find differences in the effects of large events according to the viewer's nationality. For example, previous studies have described the change in perceptions of China among foreigners, such as Americans and Koreans, following the 2008 Beijing Olympics (Kim, Kang, and Kim, 2014). Another study investigated the impact of the Sydney Olympic Games in four countries and found that the features used to describe Australia had a significant impact on the perceptions of other countries' citizens (Rivenburgh, Louw, and Loo, 2004). For example, the South African press portrayed Australians in a negative way, and as a result, Australia's positive image diminished there after the Games. Based on this point, the second research question is proposed as follows:

Research Question 2: Are there differences in perceptions of Korean cultural content before and after the Olympics among Koreans and Americans?

2. Method

2.1. Data Collection

To answer the research questions and assess the impact of the Olympic Winter Games PyeongChang 2018 on Hallyu, this study conducted two (pre- and post-) online panel surveys among residents of South Korea and the United States. Pre- and post-event impact assessment is a widely accepted research design to test the impact of an event (Ritchie, Shipway, and Cleeve, 2009). Survey invitations were emailed to a nationally representative group maintained by online research companies in Korea and the United States. The first wave of data was collected for a week beginning 2 weeks before the Olympics and ending a week before the opening ceremonies. For the second wave of data collection, the research team repeated the survey immediately after the Olympics ended, and it also ran for a week (February 26, 2018-March 3, 2018). In the first wave, each research panel company distributed the survey links to 2500 people. We received 1057 responses from Korea and 1012 from America. In an effort to secure at least 500 responses among the second wave participants in each country, we aimed to collect double the size of the sample. For the second wave, 798 Koreans and 517 Americans

responded by completing the same questionnaire used in the first wave. Therefore, the retention rates were 75.50% for Korean data and 51.07% for American data.

The participants in the study were residents of South Korea (the host country) and residents of the US who planned to watch (pre-Games) and who had watched (post-Games) the Olympic Games. The surveys targeted adult residents of specifically these two countries for the following reasons. First, a majority of previous Hallyu studies focus on other Asian countries, such as China, Japan, and Taiwan (Kim and Ryoo, 2007), while there has been little research on North America as a Hallyu market, but the recent success and popularity of the song "Gangnam Style" and the pop band BTS in the United States hint at the potential of Hallyu in Western countries. PSY's "Gangnam Style" music video has been viewed over 2 billion times on YouTube, and 12 million copies of the single were sold across the globe, which is a world record (McIntyre, 2020). Second, previous studies on many mega-sport events have explored changes in the perceptions of foreigners about the host country after an event or how such an event affects the host country's economy or community (Kasimati and Dawson, 2009). The current study is important because studies on changes in the overall cultural perception of the host country are limited.

2.2. Measures

The questionnaire was originally created in English. To adapt it for collecting data from Koreans, two native Korean speakers fluent in English translated the questionnaire from English into Korean. To verify its reliability, the Korean version was back-translated into English for comparison.

2.2.1. Screening questions

As the purpose of this study was to assess the impact of the Olympic Winter Games PyeongChang 2018, the intention to watch and having watched was the inclusion criteria applied. Before participating in the survey, potential respondents were asked, "Are you planning to watch the 2018 Winter Olympics?" for the pre-game survey, and only respondents who answered Yes were included in the sample. For the post-game survey, participants who had completed the first survey received a link asking whether they had watched the Games, and an affirmative response was the inclusion criterion for the post-game survey. In the pre- and post-surveys, all questions were the same except the screening question. Participants answered all of the items on a 7-point Likert scale with optional answers ranging from *strongly disagree* (1) to *strongly agree* (7).

2.2.2. Cultural soft power

This variable relates to a country's ability to persuade other countries to want what it wants through cultural exchange. The authors adapted the three items included to fit the purpose of this study (Holyk, 2011). The items were: "South Korea has an appealing popular culture," "South Korea has a rich cultural heritage," and "South Korea is an attractive destination for tourism." The reliability of this variable is 0.88 (K1), 0.92 (A1), 0.88 (K2), and 0.92 (A2). K1 indicates Korean data collected before the Olympics; A1 refers to US data collected before the Olympics. K2 indicates Korean data collected after the Olympic Games, and A2 means US data collected after the Olympic Games.

2.2.3. Situational involvement with Hallyu

This variable refers to the degree of short-term involvement and interest in Hallyu due to the Olympics. The study modified four items developed for previous research (Whang, Yong, and Ko, 2016). The items included: "I recognize Korean pop culture-related products," "I have a favorable impression of Korean pop culture products," "I recognize popular culture-related products influenced by Korean pop culture," and "I think Korean pop culture influences people to travel to Korea." The reliability of situational involvement for Hallyu is 0.82 (K1), 0.96 (A1), 0.81 (K2), and 0.95 (A2).

2.2.4. Enduring involvement with Hallyu (EIH)

This variable is defined as the state of ongoing interest or engagement in the Hallyu content, taking into account the original definition from previous literature (Havitz and Dimanche, 1997). This study adapted the scale established in previous literature and used the following five items to measure enduring involvement for Hallyu (Whang, Yong, and Ko, 2016). The items included: "I am interested in Korean pop culture," "I love and enjoy Korean pop culture," "I am a fan of Korean pop culture," "I am more drawn to Korean pop culture than US pop culture," and "I feel close to Korean pop culture." The reliability of this variable was 0.94 (K1), 0.97 (A1), 0.94 (K2), and 0.97 (A2).

2.2.5. Likeability of Hallyu

The preference for Hallyu was measured with modified items based on previous literature (Lee, Ham, and Kim, 2015). A total of 12 items measuring the likeability of various Hallyu types (e.g., drama, entertainers, music, food, and movies) were used to measure the variable. The reliability of this variable was 0.93 (K1), 0.97 (A1), 0.94 (K2), and 0.97 (A2).

2.2.6. The influence of Hallyu in the United States

This variable measures the respondents' perception of the level of influence Hallyu has in the United States using these items: "Korean films have a positive impact on US popular culture" and "Korean pop culture has a positive effect on American pop culture." The reliability was 0.94 (K1), 0.96 (A1), 0.93 (K2), and 0.96 (A2).

All variables used in this study are above the acceptable level of reliability. Each variable was measured with multiple items. A composite measure was created by summing the items for each variable and was used for further analyses. Independent sample t-tests were conducted to answer the two research questions to determine changes in responses before and after the Games.

2.3. Demographic Profiles

The study included several demographic questions on gender, age, education, and annual household income. As shown in Table 1, the composition of survey participants in the two countries varies. In the first survey, the gender composition of respondents in South Korea and the US was similar (approximately 49% men and 51% women for both Koreans and Americans). In the second survey after the Olympics, men and women participated evenly in the Korean group, but more women (61%) participated in the US group. The average age of Korean respondents was slightly younger than that of US respondents for both pre- and post-surveys (M = 38.54 [K1], M = 40.87 [K2], M = 40.38 [A1], and M = 43.18 [A2]). Respondents with a college degree accounted for the largest portion of both groups, with annual household incomes ranging from $50,000 to $75,000 for both countries across both surveys. American participants were asked about their ethnicity, and a majority of them were White.

Table 1. Demographic profiles.

	Korea Wave 1 (K1) *n*, %	**U.S. Wave 1 (A1) *n*, %**	**Korea Wave 2 (K2) *n*, %**	**U.S. Wave 2 (A2) *n*, %**
Gender				
Male	516, 48.8	500, 49.4	401, 50.3	201, 38.9
Female	541, 51.2	512, 50.6	397, 49.7	316, 61.1
Education level				
(1) High school diploma	164, 15.5	328, 32.4	130, 16.3	173, 33.5
(2) Some college	133, 12.6	175, 17.3	72, 9.0	66, 12.8
(3) College degree	607, 57.4	354, 35.0	493, 61.8	182, 35.2
(4) Graduate degree	121, 11.4	125, 12.4	92, 11.5	73, 14.1
(5) None of the above	32, 3.0	29, 2.9	11, 1.4	23, 4.4
Income				
<$10 k	46, 4.3	75, 7.4	28, 3.5	44, 8.5
$10 k-<$20 k	77, 7.3	101, 10.0	56, 7.0	41, 7.9
$20 k-<$30 k	139, 13.1	104, 10.3	90, 11.3	51, 9.9
$30 k-<$40 k	163, 15.4	111, 11.0	126, 15.8	50, 9.7
$40 k-<$50 k	176, 16.7	91, 9.0	139, 17.4	45, 8.7
$50 k-<$75 k	264, 25.0	181, 17.9	206, 25.8	107, 20.7
$75 k-<$100 k	139, 13.1	128, 12.6	106, 13.3	60, 11.6
$100-<$150 k	44, 4.2	120, 11.8	38, 4.8	55, 10.6
$150 or more	9, 0.9	60, 5.9	9, 1.1	38, 7.4
Prefer not to answer	--	41, 4.1	---	26, 5.0
Ethnicity				
White		767, 75.8		408, 78.9
Black or African American		126, 12.5		56, 10.8
Asian or Pacific Islander		59, 5.8		28, 5.4
Mixed race		25, 2.5		8, 1.5
Native American		3, 0.3		2, 0.4
Others		32, 3.2		15, 2.9
Age	M=38.54 (19-58)	M=40.87 (18-79)	M=40.38 (20-59)	M=43.18 (19-62)

3. Results

3.1. The Impact of Olympic Winter Games PyeongChang 2018 on Hallyu

The first research question addressed changes in the soft power of Hallyu, situational and enduring Hallyu involvement, likeability of Hallyu, and the influence of Hallyu in the United States as perceived by Koreans and Americans before and after the 2018 Winter Olympics. Testing homogeneity of variance showed that 10 of 48 analyses returned significant results. To control the influence of demographic variables, a series of one-way ANCOVA tests was conducted to determine a statistically significant difference between pre- and post-Olympics on the dependent variables, controlling for demographic variables (i.e., gender, age, income, and educational level). Table 2 shows the influence of PyeongChang Olympics on Hallyu.

All the mean post-Games scores were higher than pre-Games scores across both countries' samples, but not all differences were statistically significant. The effects of the Games on Hallyu were higher in the Korean sample than in the US. Variables that revealed significant differences before and after the Olympics among the Korean participants included "cultural soft power" (M = 4.93 [pre-Olympics], M = 5.02 [post-Olympics] [F = 14.652 (1, 1853), $P < 0.05$]), and "the influence of Hallyu in the US" (M = 4.37 [pre-Olympics], M = 4.47 [post-Olympics] [F = 3.670 (1, 1853), $P < 0.01$]). For respondents in the United States, a statistically significant change was observed for "EIH" (M = 2.90 [before the Olympics], M = 3.00 [after the Olympics] [F = 5.489 (1, 1497), $P < 0.05$]).

3.2. Perceptual Differences between Koreans and Americans

The second research question sought to address whether Koreans and Americans differ in terms of the variables tested in this study. Table 3 shows the results of independent sample t-tests conducted to compare the responses of Koreans and Americans collected before and after the Olympics. The mean scores of all variables for Americans and Koreans showed significant differences. The mean scores of Koreans were significantly higher than those of Americans for all variables measured. More specifically, "EIH" showed the greatest differences (M = 4.83 for Koreans and M = 2.90 for Americans [F = 349.940 (2048), $P < 0.05$]) while "the influence of Hallyu" demonstrated the smallest differences between the groups

Table 2. Influence of PyeongChang Olympics on Hallyu.

Variable name	Korea		ANCOVA	US		ANCOVA
	Pre-Olympics (*n*=1057) M (SD)	Post-Olympics (*n*=798) M (SD)	F (df1, df2), *p*	Pre-Olympics (*n*=1012) M (SD)	Post-Olympics (*n*=517)	F (df), *P*
Cultural soft power	4.93 (1.15)	5.02 (1.02)	14.652 (1, 1853), <0.05	4.15 (1.69)	4.27 (1.72)	n.s.
Situational involvement	4.68 (1.01)	4.84 (.93)	n.s	3.26 (1.83)	3.30 (1.91)	n.s.
Enduring involvement	4.83 (1.12)	4.95 (1.07)	n.s.	2.90 (1.86)	3.00 (1.97)	5.489 (1, 1497), <0.05
Likeability of Hallyu	4.85 (0.99)	4.87 (0.94)	n.s.	3.67 (1.65)	3.72 (1.73)	n.s.
Influence of Hallyu on U.S.	4.37 (1.06)	4.47 (0.98)	3.670 (1, 1853), <.01	3.83 (1.68)	3.95 (1.68)	n.s.

Table 3. Perceptual differences between Koreans and Americans.

Variable name	Pre-Olympics		*t*-test	Post-Olympics		t-test
	Korea (*n*=1057) M (SD)	US (*n*=1012) M (SD)	F (df), p	Korea (*n*=798)	US (*n*=7517)	F (df), *P*
Cultural soft power	4.93 (1.15)	4.15 (1.69)	147.119 (2066), <0.05	5.02 (1.02)	4.27 (1.72)	179.707 (1313), <0.05
Situational involvement	4.68 (1.00)	3.26 (1.83)	849.624 (2066), <0.05	4.85 (0.93)	3.30 (1.91)	458.770 (1313), <0.05
Enduring involvement	4.83 (1.12)	2.90 (1.86)	349.940 (2048), <0.05	4.95 (1.07)	3.00 (1.97)	387.540 (1305), <0.05
Likeability of Hallyu	4.85 (0.99)	3.67 (1.65)	266.355 (2029), <0.05	4.874 (0.936)	3.72 (1.73)	255.458 (1293), <0.05
Influence of Hallyu on U.S.	4.37 (1.06)	3.83 (1.68)	203.669 (2056), <0.05	4.469 (0.983)	3.95 (1.68)	138.102 (1308), <0.05

(M = 4.37 for Koreans and M = 3.83 for Americans [F = 203.669 (2056), $P < 0.05$]). The post-Games data displayed the same pattern. In other words, Koreans rated all measured variables much higher than Americans, and these differences were statistically significant. These results suggest that Koreans perceived the influence of Hallyu from the PyeongChang Winter Olympics more positively than Americans.

4. Discussion

This study was designed to achieve two purposes: (1) To understand the impact of the PyeongChang Winter Olympic Games on Hallyu and (2) to examine perceptual differences between Koreans and Americans in terms of Hallyu. These goals were fulfilled by conducting two surveys, one before and one after watching the Olympics, in the two countries, South Korea and the United States. In short, Koreans perceived Hallyu more positively than Americans as a result of the Olympic Games. This study has several meaningful findings as follows.

First, the PyeongChang Winter Olympic Games brought synergy to Hallyu. When comparing viewers' perceptual differences before and after the Olympics, all items – cultural soft power, situational involvement, enduring involvement, likeability of Hallyu, and the influence of Hallyu in the United States – were enhanced after the Games. Although three of the five items in the Korean survey and four of the five items in the US survey were not statistically significant, the cultural recognition of Hallyu after the Olympics was higher than the pre-Olympics level. This indicates that the Games had a synergy effect on Hallyu. This finding expands the literature on the influence of mega-sport events in regard to host countries' cultural features and supports previous findings suggesting that the Olympic Games offer an opportunity to build and maintain national identity among global citizens (Havitz and Dimanche, 1997). The statistical analysis indicated that the Olympics significantly impacted Koreans between pre- and post-Olympics, in terms of cultural soft power and their perceived influence of Hallyu in the United States; it is worth noting that the margin of difference was not large. One of the explanations for this phenomenon may be the design of the study. This study did not consider participants' previous attitudes or perceptions toward the Olympics. Studies have indicated that the citizens of countries who benefit from hosting the Games, either directly through tourism or indirectly, have a tendency to view positively the impact of mega sporting events (Fredline, 2004). Future studies should control pre-existing individual factors that may influence the results to gain more robust results.

Second, the effects on the host country of the Olympic Games were reflected in Hallyu. The statistically significant change in levels of cultural soft power and influence of Hallyu on Americans that was perceived by Koreans from the PyeongChang Winter Olympic Games may represent how Koreans feel about Hallyu. It is possible that Koreans are proud of Hallyu and their culture, and as a result, the perceived influence of Hallyu was higher among Koreans than among Americans. In particular, positive results in the perceived influence of Hallyu in the United States can be interpreted as the confidence Koreans have in Hallyu being circulated successfully in the US market as a result of the PyeongChang Winter Olympic Games. Reflecting the effects of hosting the PyeongChang Winter Olympic Games on Hallyu, it can be said that policy related to Hallyu can be managed based on the cycle of creation-growth-peak-decline.

Third, EIH showed a statistically significant change before and after the PyeongChang Winter Olympics among Americans. Enduring involvement is a long-term interest in Korean pop culture, rather than short-term enjoyment (Havitz and Dimanche, 1997). The 2018 Olympic Games were held not only in the pure sports context but also under the shadow of the threat of North Korea's nuclear development and missile launches, which could have produced a fear factor for Americans. The theme of the PyeongChang Olympic Games was the global harmony of communication and peace through the history and culture of Korea. For Americans who were able to see peaceful cultural messages throughout the Olympics, including the unified Korean ice hockey team, the long-term relevance of Korea's popular culture may have played a role beyond a short-term awareness of Korean culture. In other words, rather than directly associating the mega-sport event of the PyeongChang Winter Olympics with Hallyu, Americans may associate it with complex political, diplomatic, and military issues and consider fundamental aspects of the peaceful culture of Korea.

Fourth, this study expanded the horizons of Hallyu research using an approach that has not been used in previous research – asking Korean and American viewers about their perceptual changes before and after a mega-sport event. The results of this study suggest that the current trends of Hallyu can penetrate countries of the Organization for Economic Co-operation and Development beyond the Asian countries (Japan, China, and the Middle East) and Africa that have been previously studied.

Last, this study provided a research topic – cultural aspects of the host country – on international mega-sport events such as the PyeongChang Winter Olympic Games. In this study, the specific effect regarding the cultural aspects of a hosting country was examined by comparing changes in the perceptions of viewers in target countries before and after the

Games. This can contribute meaningfully to the literature and suggests a comprehensive view that mega-sports events are a good opportunity to enhance the national image.

4.1. Limitations

Certain shortcomings should be noted in this study. First, although the participants' evaluations of all variables were more positive after the Olympics than before, the changes in some variables were statistically insignificant. The short time difference between surveys (before and after the Games) could be a reason. While the first survey was completed before the Olympics, at the time of the first survey, media coverage about Korea in light of the upcoming Olympics was being widely disseminated. Future scholars might consider completing the first data collection at least 100 days before the Olympics to limit the potential influence of news coverage related to the Olympics and the host city. This could improve data accuracy regarding changes in perception. Second, this study did not measure the perceptions of the participants who did not watch the Games. To evaluate more accurately the effect of the Olympics, researchers should consider evaluating the differences between changes in a control group who did not watch the Games and in a study group who did.

5. Conclusions

This study examined the effects of the Olympic Winter Games PyeongChang 2018 on the perceptions of the host country's citizens and of Americans with regard to the "Korean Wave" or Hallyu. The findings support the fact that the Olympics not only played a role as a cultural Olympic Games but also played a major role in the ripple effect of Hallyu throughout the United States and Korea. The authors hope that this study opens doors to evaluating the diverse effects of the Olympics in the hosting country and other countries.

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Conflicts of Interest

No conflicts of interest were reported by the authors.

Authors' Contributions

Introduction draft: Chan Souk Kim. Literature Review draft: Jeyoung Oh. Method, data analysis, results, discussion, and conclusion: Eyun-Jung Ki. Revised the manuscript: Eyun-Jung Ki, Jeyoung, and Chan Souk Kim. Contributed to tools/materials/data collection: Eyun-Jung Ki, Jeyoung, and Chan Souk Kim.

Ethical Approval

Overall study design, questionnaires, and consent processes were reviewed and approved by the IRB of the University of Alabama.

Availability of Supporting Data

None.

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RESEARCH ARTICLE

Correlates of internet use among African American older adults: Gender and age differences

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Abstract: This study aimed to compare internet use among African American older adults by gender and age group and investigate correlates of internet use by gender and age group. A total of 1117 African American older adults aged over 50 from the 2016 Wave of the Health Retirement Study were included in the study. Sequential ordinal logistic regressions were conducted to investigate correlates of internet use among older African Americans by gender and age group. Significant gender and age differences were identified in internet use frequency. Gender differences on correlates were revealed: being old-old and limitations on activities of daily living were only associated with decreased odds of more frequent internet use among women. In addition, higher depression was only associated with reduced odds of more frequent internet use among men. Age differences on correlates indicated that education and cognition were the only two significant factors pertinent to internet use among the old-old. By contrast, for young-old adults, retirement, poverty, education, cognition, and depression were also predictive. Practitioners should consider these gender and age differences when promoting internet use among older African Americans. The results presented in this study might also inform the design of future gender- and age-tailored interventions.

Keywords: Internet use; African American older adults; Gender; Old-old

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1. Introduction

The advent and fast development of information and communication technology (ICT) brings more potential for successful aging of older adults. Overcoming the limitations of distance and space, the use of ICT can expand older adults' social networks, provide healthcare treatments to people at home, offer easier access to more resources, and increase living standards (Berde, 2019; Harper, Wellman, and Quan-Haase, 2020). Recent studies have indicated the positive effects of the Internet among older populations (Cotten, Anderson, and McCullough, 2013; Yu, Wu, and Chi, 2020). Internet use among older adults has increased their social interactions, reduced social isolation and loneliness, helped to manage chronic diseases, assisted with activities of daily living (ADL) in older adults, and increased their quality of life (Harper, Wellman, and Quan-Haase, 2020; Kim, Lee, Christensen, *et al*., 2017; Yu, Wu, and Chi, 2020). Furthermore, through the Internet, many traditional interventions for older adults could be delivered online. Evaluation studies have confirmed the effectiveness of computerized interventions on reducing older adults' loneliness and depression, promoting healthy lifestyles, and increasing cognitive functioning (Choi, Kong, and Jung, 2012; Sriramatr, Berry, and Spence, 2014). Thus, use of the Internet is playing an increasingly important role in older adults' wellbeing. However, compared to young and middle-aged adults, internet use among older adults is still low. A recent Pew Research Center survey found that about two thirds older adults aged over 65 used the Internet, while the average number of all adults in the United States (U.S.) was 90% (Anderson and Perrin, 2017). Therefore, it is necessary to investigate correlates of internet use among older adults and promote their adoption and use of the Internet.

1.1. Internet Use among Older African Americans

In the past two decades, internet use among older adults in the U.S. has increased by 55% (Anderson and Perrin, 2017). Despite the fast-growing number of older adults going online, African American older adults are lagging behind in the adoption and use of the Internet when compared with Whites (Choi and DiNitto, 2013; Elliot, Mooney, Douthit, *et al*., 2014; Yoon, Jang, Vaughan, *et al*., 2018). Choi and DiNitto (2013) analyzed a nationally representative sample of the U.S. Medicare beneficiaries aged over 65 from the 2011 National Health and Aging Trends Study and found that, compared to non-Hispanic Whites, African American older adults were 0.41 times less likely to use the Internet. A similar finding was reported in another large survey study using a sample of 17,704 older adults in the California Health Interview Survey, indicating that African American older adults were 0.54 times less likely to use the Internet for health information than their White peers (Yoon, Jang, Vaughan, *et al*., 2018).

Previous studies have indicated that the low internet adoption and use rates within the African American older adult population might be explained by the lower level of education, higher prevalence of poverty, and more health and mental health-related diseases (Carpenter and Buday, 2007; Berde, 2019; Kim, Lee, Christensen, *et al*., 2017; Mitchell, Chebli, Ruggiero, *et al*., 2019). Considering the benefits of the Internet on increasing health, mental health, and quality of life among older adults, the low adoption and use of internet resources among African American older adults may further enlarge existing health and mental health gaps. Thus, it is of great importance to increase internet adoption and use among this population.

Numerous studies have examined ICT use among older adults and investigated racial and ethnic differences. Most of these studies have included race or ethnicity as a categorical variable and compared African American older adults with other racial or ethnicity groups (Choi and DiNitto, 2013; Mitchell, Chebli, Ruggiero, *et al*., 2019; Yoon, Jang, Vaughan, *et al*., 2018). However, few studies have explored other aspects of racial or ethnic differences on ICT use, such as correlates. Studies on correlates of internet use may help researchers to identify target factors and further explore causal associations. It may also help practitioners identify problematic factors, design interventions to fix these problems or alleviate their influence, and promote the use of the Internet. African American older adults have different life experiences from older adults of other racial and ethnic groups in many ways, such as their social support networks, experience of depressive symptoms, and experience of systemic discrimination (Ayalon and Young, 2003; Peek and O'Neill, 2001; Sarkisian and Gerstel, 2004), so correlates of internet use among African American older adults may be different from other races or ethnicities. For example, a White older adult who experiences ageism may feel uncomfortable going outside and prefer to instead spend more time online. Different from their White counterparts, African American older adults may have experienced discrimination since their childhood or young adulthood, and they may consequently be more resilient. Thus, the effect of discrimination on internet use may be different between White and African American older adults. In addition, even though African Americans account for a large amount of racial or ethnic minorities, compared to the Whites, African Americans' population is small. Thus, results may be misleading for African Americans when exploring correlates without differentiating race or ethnic groups. Interventions based on these correlates to increase older African American's internet use may not be able to target and fix their real problems. Therefore, this study will focus on older African American adults and investigate correlates of internet use among this population.

1.2. Gender Differences among Older Adults

Gender differences in internet use among older adults are inconsistent. Some empirical evidence indicates that, compared with older women, older men are more likely to access and use the Internet (Kim, Lee, Christensen, *et al*., 2017; Marston, Kroll, Fink, *et al*., 2016). Attempts to explain such differences have included suggestions that older men may be higher in self-confidence, hold more positive attitudes toward the Internet, or simply be more adept in computer use (Chu, 2010; Hunsaker and Hargittai, 2018). However, several recent studies have failed to detect differences in internet use between men and women (Friemel, 2014; König, Seifert, and Doh, 2018) or have found that internet use was higher among older women as opposed to men (Yu, Ellison, McCammon, *et al*., 2016). These inconsistent findings related to gender differences in internet use indicate the necessity of further exploration involving correlates of internet use among older adults. Given the likelihood that multiple factors play a role in determining internet use prevalence among older adults, investigating correlates may provide more insight to gender differences in internet use among older African American adults.

In addition, older women experience aging differently from older men (Xie, 2003). For example, menopause and widowhood are social aging markers specific to the experience of older women (Osorio-Parraguez, 2013). Women who are in menopause may increase their use of the Internet to look for menopause consultation and other helpful information online. Considering the widely accepted longer life expectancy, relative to men, among older women and women's roles

of caregivers, the negative effects of widowhood/widowerhood on daily life may affect widowers more than widows. A widower living alone at his home may need to spend more time to do housework and take care of himself than he did before his bereavement, which may reduce his time spent online. By contrast, a widow may need to spend more time online to gain more social interaction and support. Thus, the effects of correlates may be different between older men and women. In analyzing internet withdrawal reasons among older adults in Taiwan, Chiu and Liu (2017) found that older women were more likely to be affected by health factors than older men. Therefore, it is valuable to examine correlates of internet use among older adults by gender. Furthermore, considering that women live longer than men and, typically, there are more older women than men in study samples, results may be misleading for older men if they are not separated in analysis. Thus, in this study, we will investigate correlates among older African American men and women separately.

1.3. Age Differences among Older Adults

Age differences in internet use among older adults have been well confirmed by many previous studies (Anderson and Perrin, 2017; Chang, McAllister, and McCaslin, 2015). Compared with young-old adults, old-old adults were less likely to use the Internet. Meanwhile, they had higher risks of experiencing loneliness, cognitive decline, and increased functional limitations than their young-old counterparts (Cohen-Mansfield, Shmotkin, Blumstein, *et al*., 2013; Koo, Kõlves, and De Leo, 2017). Numerous studies have indicated the potential of internet use in reducing loneliness, depression, stimulating cognitive functioning, and promoting psychological well-being among older adults, especially old-old adults (Sims, Reed, and Carr, 2017; Fang, Chau, Wong, *et al*., 2018). Thus, increasing the adoption and use of the Internet among old-old adults is of great value. However, considering differences between young-old adults and old-old adults, especially those involving health and mental health conditions, correlates of internet use may be different. Internet use is complex and requires high cognitive functioning. Thus, different from young-old adults who have better cognitive functioning, developing the skills necessary to use the Internet may be more challenging for old-old adults. Therefore, it is important to investigate correlates of internet use by age groups to assist the design and implementation of age-tailored interventions to increase African American older adults' internet use.

1.4. Current Study

An overview of the literature has showed several research gaps in the literature involving African American older adults' internet adoption and utilization. First, most racial or ethnic disparity studies included race or ethnicity as a categorical variable and compared groups. However, very few studies focused on the African older adult group to explore correlates of the internet use among this specific population. Second, gender and age differences in internet use among older adults indicate the necessity of more studies to investigate correlates of different subgroups and conduct more tailored interventions to increase internet adoption and use. Thus, focusing on African American older adults, the present study will (1) compare internet use prevalence among older African American by gender and age group and (2) investigate correlates of internet use among African American older adults by gender and age groups.

2. Method

2.1. Study Sample

Data were drawn from the 2016 Wave of the Health and Retirement Study (HRS), the most recent available data from the pertinent archive. The HRS is a nationally representative longitudinal panel survey of U.S. individuals aged over 50 and their spouses. Questions about participants' health, family structure, retirement, subjective well-being, and lifestyles have been collected. HRS is funded by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The Institutional Review Board at the University of Michigan and the National Institution on Aging provided ethical approval for the HRS.

Two separate data files – 2016 HRS Core (Final) and RAND HRS Longitudinal File 2016 – were merged based on key values in the current study. internet use and perceived daily discrimination were obtained from the Left-Behind Questionnaire from the HRS core data. All other demographic, socioeconomic, health, and mental health variables were drawn from the RAND HRS data files. In the 2016 Wave, 20,912 adults participated in the survey. First, since the Left-Behind Questionnaire was assigned to a rotating (random) 50% of participants who completed the enhanced face-to-face interview, 10,674 participants who were ineligible for the Left-Behind Questionnaire were removed from this study. Second, among the total eligible sample, 3882 participants who did not return or complete the questionnaire and 32 questionnaires completed by those who were not the assigned respondents were excluded from this study. Third, after

removing participants who were not older than 50 or did not report their age, a subsample of 1117 African American older adults was included as the final analytic sample.

2.2. Measures

2.2.1. Internet use

The dependent variable, internet use, was measured by a single-item question, "How often do you use a computer for e-mail, Internet or other tasks?" Responses to this question were reversely coded as 1 = never/not relevant, 2 = not in the last month, 3 = once a month, 4 = several times a month, 5 = once a week, 6 = several times a week, and 7 = daily.

2.2.2. Health-related factors

Previous studies have indicated that health-related factors, such as self-rated health, number of diseases, ADL, and instrumental ADL (IADL) are correlates of internet use among older adults (Ang, Lim, and Malhotra, 2020; Choi and DiNitto, 2013). Self-rated health was measured by a 5-point Likert Scale (1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent). Number of chronic illnesses was the sum of doctor diagnosed illnesses, including high blood pressure, diabetes, cancer, lung disease, heart condition, stroke, and arthritis, ranging from 0 to 7. Difficulties in ADL and IADL were measured by the total number of limited activities, including ADL, such as bathing, dressing, eating, getting in/out of bed, and walking across a room, and IADL, such as using a phone, using money, taking medications, shopping for groceries, and preparing for hot meals. Both difficulties in ADL and IADL ranged from 0 to 5.

2.2.3. Mental health-related factors

Based on previous studies, depression, discrimination, and cognitive functioning were included as mental health-related factors in this study (Ang, Lim, and Malhotra, 2020; Choi and DiNitto, 2013; Choi, Kim, Chipalo, *et al*., 2020; Elliot, Mooney, Douthit, *et al*., 2014). Depression was measured by the Center for Epidemiological Studies Depression (CESD) scale (Radloff, 1977). Participants were asked to indicate whether they "felt depressed," "felt activities were efforts," "slept restless," "was happy," "felt lonely," "enjoyed life," "felt sad, and "could not get going" in much of the time during the past week (0 = no, 1 = yes). The items, "was happy" and "enjoyed life," were reversely recoded in this study (0 = yes, 1 = no). Depression was assessed by the unweighted sum of the 8 binary items, ranging from 0 to 8, with higher score indicating higher levels of depression. Perceived everyday discrimination was measured by a six-item scale. Participants were asked to indicate how often they experienced the following things, "You are treated with less courtesy or respect than other people," "You receive poorer service than other people at restaurants or stores," "People act as if they think you are not smart," "People as if they are afraid of you," "You are threatened or harassed," and "You receive poorer service or treatment than other people from doctors or hospitals." Responses to these items were reversely recoded (1 = never, 2 = less than once a year, 3 = a few times a year, 4 = a few times a month, 5 = at least once a week, and 6 = almost every day). Perceived everyday discrimination was assessed by the average of six items, ranging from 1 to 6, with higher scores indicating higher levels of discrimination. Cognitive functioning was measured by a reduced version of the Telephone Interview for Cognitive Status (TIC) scale (Brandt, Spencer, and Folstein, 1988). Cognitive functioning is a composite score of immediate (0-10) and delayed word recall (0-10), serial 7s (0-5), backwards counting (0-2), date naming (month, day, year, day of week; 0-4), object naming (scissors and cactus; 0-2), naming the President (0-1), and Vice President of the United States (0-1). Cognitive functioning ranged from 0 to 35 with higher scores indicating higher cognitive functioning.

2.2.4. Socioeconomic factors

Education, marital status, retirement status, and poverty were included as socioeconomic factors for internet use in this study (Ang, Lim, and Malhotra, 2020; Chang, McAllister, and McCaslin, 2015; Choi and DiNitto, 2013). Education was a continuous variable and measured as years of education. Marital status (0 = divorced, widowed, never married, or others, 1 = married or partnered), retirement status (0 = not retired or partially retired, 1 = completely retired), and living in poverty (0 = no, 1 = yes) were measured dichotomously.

2.2.5. Demographic factors

Previous studies have found that age, gender, and living arrangements were important correlates of internet use among older adults (Ang, Lim, and Malhotra, 2020; Chang, McAllister, and McCaslin, 2015; Choi and DiNitto, 2013; Choi, Kim, Chipalo, *et al*., 2020; Elliot, Mooney, Douthit, *et al*., 2014). The Pew Research Center Survey indicated that internet use among older adults dropped dramatically around 75 years of age (Anderson and Perrin, 2017). Consequently, in this study, age was categorized into a binary variable (0 <75 years, young-old; 1 = 75 years or older, old-old). Gender (0 = men, 1 = women) and living arrangements (0 = living alone, 1 = living with others) were dichotomous variables.

2.3. Analytic Strategies

First, descriptive statistics were used to better understand the characteristics of the African American older adults in this study and their internet use status. Next, bivariate analysis of internet use was conducted to investigate gender and age differences in internet use. Third, considering that the dependent variable, internet use, was measured as an ordinal variable, ordinal logistic regressions were performed in this study. Two sets of sequential ordinal logistic regressions were conducted separately by gender and age. Four models were performed for both sets: in Model 1, only demographic factors were added; in Model 2, both demographic and socioeconomic factors were included; in Model 3, demographic, socioeconomic, and health-related factors were assessed; in Model 4, demographic, socioeconomic, health-related, and mental health-related factors were analyzed. All analyses were performed using Stata 14.2.

3. Results

3.1. Sample Characteristics

Table 1 shows descriptive characteristics of the African American older adults in the study sample. About 18% of the sample was aged 75 years or older, 63% were women and about 29% were living alone. The participants had about 13 years of education on average (SD = 2.73), or just above high school completion. Less than half of the participants were married/partnered (45%) or retired (46%), and about 22% were living in poverty. As for their health, the mean self-rated health was 3 (SD = 0.99), and on average participants had 2 chronic illness (SD = 1.39). Participants had very low difficulties in ADL (M = 0.41, SD = 0.98) and IADL (M = 0.27, SD = 0.77). Regarding mental health-related factors, African American older adults had relatively low levels of depression (M = 1.68, SD = 2.00) and perceived

Table 1. Sample characteristics of African American Older adults (*n*=1117).

	Mean	SD	*n*	%
Demographic				
Old-old			200	17.9
Women			707	63.3
Living alone			327	29.3
Socioeconomic				
Years of education (0-17)	12.84	2.728		
Married or partnered			506	45.3
Retired			509	45.6
Living in poverty			242	21.7
Health-related				
Self-rated health (1-5)	2.94	0.994		
Number of chronic illness (0-7)	2.19	1.390		
Difficulties in activities of daily living (0-5)	0.41	0.981		
Difficulties in instrumental activities of daily living (0-5)	0.27	0.767		
Mental health-related				
Depression (0-8)	1.68	2.003		
Discrimination (1-6)	1.75	0.838		
Cognitive functioning (0-35)	20.28	4.613		

daily discrimination (M = 1.75, SD = 0.83). Cognitive functioning scores among participants was about 20 (SD = 4.61), indicating no cognitive impairment.

3.2. Internet Use Differences by Gender and Age Group

Descriptive and bivariate analyses of internet use are presented in Table 2. About 56% of older African American adults in the study sample used the Internet at least once a week, whereas about 31% never used the Internet or reported "not relevant." Chi-square tests showed significant gender differences in internet use ($\chi^2 = 13.05$, $P < 0.05$). About 42% of sampled older women used the Internet daily, and 28% never used the Internet or reported "not relevant." By contrast, about 38% of older men used the Internet daily, and 37% never used the Internet or reported "not relevant." Significant age differences were also found ($\chi^2 = 94.82$, $P < 0.001$). Among sampled old-old adults, about 16% used the Internet daily, and 59% never used the Internet or reported "not relevant." However, among young-old adults, about 45% used the Internet daily, and 25% never used the Internet or reported "not relevant."

3.3. Sequential Ordinal Logistic Regression on Internet Use

Findings from the sequential ordinal logistic regressions by gender are summarized in Table 3. In Model 1, being old-old was associated with decreased odds of more frequent use of the Internet for both men and women, while living alone was only associated with decreased odds of more frequent internet use among older men. In Model 2, more years of education was associated with increased odds of more frequent internet use for both older men and women, whereas being retired and living in poverty were associated with decreased odds of more frequent internet use for both older men and women. Age and living alone were not significant covariates among older men, while age was still significant among older women. In Model 3, more difficulties in ADL were associated with decreased odds of more frequent internet use among older women. None of the health-related factors were significant among older men. Other significant demographic and socioeconomic variables retained the same directions as in the prior model. In Model 4, better cognitive functioning was associated with increased odds of more frequent internet use both among older men and women. Depression was a significant predictor only among older men. To be more specific, for one-unit increase in the level of depression, the odds of having more frequent internet use would decrease by 23%. All other significant variables in Model 3 remained significant or marginally significant

Ordinal logistic regression results by age groups were presented in Table 4. In Model 1, only among young-old adults, being women were associated with higher odds of more frequent internet use, and living alone was associated with lower odds. In Model 2, more years of education were associated with increased odds of more frequent internet use among both young-old and old-old adults. Being retired and living in poverty were associated with decreased odds and being women were associated with increased odds among young-old adults. In Model 3, no health-related factors were significant both among young-old and old-old adults. Significant variables in Model 2 remained the same direction in Model 3. In Model 4, better cognitive functioning was associated with increased odds of more frequent use of the Internet for both young- and old-old adults. Among young-old adults, depression was also a significant predictor. For a one-unit increase in the level of depression, the odds of more frequent use of the Internet would decrease by 13%. All other significant variables remained the same directions as in Model 3.

Table 2. Descriptive and bivariate analysis of the internet use by gender and age group.

Internet use	Total		Men	Women	Young-old	Old-old
	N	%	%	%	%	%
			χ^2= 13.05*		χ^2= 94.82***	
Never/not relevant	341	30.94	35.89	28.08	25.00	58.76
Not in the last month	55	4.99	2.97	6.16	4.85	5.67
Once a month	38	3.45	2.97	3.72	3.63	2.58
Several times a month	56	5.08	4.21	5.59	5.51	3.09
Once a week	38	3.45	3.47	3.44	3.52	3.09
Several times a week	132	11.98	12.87	11.46	12.33	10.31
Daily	442	40.11	37.62	41.55	45.15	16.49

*p<0.05; ***p<0.001.

Table 3. Ordinal logistic regression on internet use by gender.

	Model 1		Model 2		Model 3		Model 4	
	Men	Women	Men	Women	Men	Women	Men	Women
Demographic								
Old-old (ref=young-old)	0.33***	0.20***	0.58	0.28***	0.54	0.28***	0.69	0.35***
Living alone (ref= yes)	0.57*	0.87	1.21	0.99	1.18	0.97	0.38	1.15
Socioeconomic								
Years of education			1.32***	1.42***	1.32***	1.41***	1.18**	1.28***
Married/partnered (ref= yes)			1.52	0.99	1.61	0.99	0.76	1.32
Retired (ref= yes)			0.42***	0.39***	0.44**	0.50***	0.39**	0.39***
Living in poverty (ref= yes)			0.26***	0.39***	0.27***	0.42***	0.12***	0.57^{+}
Health-related								
Self-rated health					1.14	1.19	1.12	1.15
Number of diseases					1.07	0.98	1.05	1.07
Difficulties in activities of daily living					1.19	0.75*	0.86	0.72*
Difficulties in instrumental activities of daily living					0.62	0.93	0.97	1.18
Mental health-related								
Depression							0.77*	0.91
Discrimination							1.13	1.18
Cognitive functioning							1.17***	1.12***
R square	0.022	0.034	0.115	0.141	0.125	0.151	0.212	0.168
-Log Likelihood	575.95***	1038.79***	500.78***	892.61***	472.57***	841.84***	238.65***	476.83***

Effect sizes stand for odds ratio. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001.

3.4. Sensitivity Analysis

Sensitivity analyses were conducted and presented in Appendix Tables A1-A3. First, the outcome variable, the internet use, was analyzed as a continuous variable, and multilinear regressions were conducted (Appendix Table A1). Second, the ordinal internet use variable (1-7) was recoded into two categories: internet nonuser (1) and user (2-7), and binary logistic regressions were performed and reported in Appendix Table A2. Third, the ordinal internet use variable (1-7) was categorized into a binary variable: active internet user (5-7) versus non-active user (1-4), and its binary logistic regressions were conducted and summarized in Appendix Table A3. Results from all the three analyses remained largely the same.

4. Discussion

The purpose of this study was to examine internet use among African American older adults and investigate gender and age differences on correlates of internet use. Internet users among older African American adults in this study were <70%, and the active users, those who used the Internet at least once a week, was only about 55%. Gender and age differences in internet use were identified in this study: older women and young-old adults had higher percentages of active internet users and lower percentages of non-users than older men and old-old adults, respectively. Gender and age differences on the correlates of internet use among older African Americans were revealed: being old-old and difficulties in ADL were significant factors only for older women, whereas depression was predictive only for older men. Education and cognition were the only two significant predictors for old-old adults. By contrast, for young-old adults, besides education and cognition, being retired, living in poverty, and depression all affected their internet use.

Findings in this study indicated that membership within the old-old category was associated with decreased odds of more frequent use of the Internet only among older African American women but not men. This difference may be explained by gender differences on internalized ageist stereotypes. Compared to older men, older women are more susceptible to internalized ageist stereotypes and are more likely to feel helpless, dependent, and weak and have reduced self-esteem and self-efficacy because of their older age (Chrisler, Barney, and Palatino, 2016; Choi, Kim, Chipalo, *et al*., 2020). Due to the negative effects of internalized ageist stereotypes, older women may have lower self-confidence and believe that they are not capable of using the Internet when they become older, especially when they have functional

Table 4. Ordinal logistic regression on internet use by age group.

	Model 1		Model 2		Model 3		Model 4	
	Young-old	**Old-old**	**Young-old**	**Old-old**	**Young-old**	**Old-old**	**Young-old**	**Old-old**
Demographic								
Women	1.38*	0.94	1.47**	0.92	1.50**	1.14	2.19**	1.05
Living alone	0.73*	0.90	0.98	1.11	0.99	0.98	0.91	0.91
Socioeconomic								
Years of education			1.38***	1.35***	1.37***	1.38***	1.22***	1.26**
Married or partnered			1.03	1.76	1.02	2.18	1.15	1.71
Retired			0.38***	0.48	0.46***	0.61	0.37***	0.45
Living in poverty			0.32***	0.51	0.32***	0.66	0.27***	0.75
Health-related								
Self-rated health					1.15	1.18	1.11	1.21
Number of diseases					1.00	1.21	1.03	1.32
Difficulties in activities of daily living					0.89	0.78	0.77	0.76
Difficulties in instrumental activities of daily living					0.81	0.86	1.15	1.05
Mental health-related								
Depression							0.87*	0.90
Discrimination							1.19	1.02
Cognitive functioning							1.15***	1.14**
R square	0.004	0.000	0.111	0.081	0.118	0.097	0.156	0.124
-Log likelihood	1364.58***	255.20***	1165.23***	233.20***	1102.75***	217.71***	526.80***	194.56***

Effect sizes stand for odds ratio. *p<0.05; **p<0.01; ***p<0.001.

difficulties. They may be more likely to interpret their limitations in ADL as results of older age, internalize ageist stereotypes and believe that they are too old, and act out those stereotypes in the form of a self-fulfilling prophecy (Chrisler, Barney, and Palatino, 2016). Consequently, they might reduce the use of the Internet, which is consistent with a recent study (Choi, Kim, Chipalo, *et al*., 2020). Choi *et al*. (2020) also used the 2016 Wave of the HRS data and found that negative self-perception of aging was associated with reduced internet use only among older women but not older men, despite using a different analytical method.

Previous studies have indicated that older adults with depressive symptoms were more likely to have less social resources, such as living alone, lacking or having lost close relationships, and having low levels of social support, so they might be more likely to use the Internet and look for social interactions with others online (Bessiere, Kiesler, Kraut, *et al*., 2008; Choi and DiNitto, 2013). However, in this study, depression was found to be associated with decreased odds of more frequent use of the Internet among older African American men and not significant among women. This may be explained by different influences of depression on older men and women and their different coping strategies. The negative effects of depression on daily functioning such as decreased primary activity, mobility, and the ability to conduct household chores are more severe for men than for women (Forlani, Morri, Ferrari, *et al*., 2014). Older men who are affected by depression may not have time or be competent to use the Internet. Older women's internet use may also be affected by depression, but they may have been more likely to use the Internet to seek social support compared to men (Girgus, Yang, and Ferri, 2017). For example, older women experiencing depression might be more likely to chat with their families and friends online, post their experiences and feelings in their social media accounts, or look for more coping strategies online.

Age difference on correlates of internet use was also revealed in this study. Among old-old adults, those who aged 75 or older, more years of education and better cognitive functioning were the only two significant correlates of more frequent use of the Internet. However, among young-old adults, being retired, living in poverty, and depression were also predictive of internet use frequency besides education and cognition. Different from retirement, poverty, and depression, education and cognition are relevant to one's capacity to use the Internet. It seemed that compared to young-old adults, the capacity to use the Internet may be more essential for internet use among old-old adults. This could be explained by the complexity of the Internet and the required technology knowledge and skills to use it. Older adults with higher education

may have previous training, use experience, or have more self-confidence and capacity to use the Internet (Carpenter and Buday, 2007; Choi and DiNitto, 2013; Elliot, Mooney, Douthit, *et al*., 2014; Hung, Lyons, and Wu, 2020). Cognitive function decreases with age, so compared to young-old adults, old-old adults may have lower cognitive functioning or even cognitive impairment, which may be the biggest challenge for them to use the Internet (Choi and DiNitto, 2013; Elliot, Mooney, Douthit, *et al*., 2014; Hunsaker and Hargittai, 2018).

4.1. Limitations

This study has several limitations. First, the cross-sectional design of this study does not allow for the estimation of causal associations. Future longitudinal studies are needed to further examine the causal predictors of technology use among older African Americans. Second, due to the limitation of the archival questionnaires, in this study, internet use was measured as use frequency by a single question. Future studies may include more computer/internet use information, such as types of activities, time spent online, and internet use efficiency (Berde, 2019). Third, this study revealed gender and age differences of internet use correlates among older African Americans. However, the mechanisms of these differences were still unclear. Future research should further investigate why some correlates were different between gender and age groups. Finally, the non-response rate of the 2016 Wave of HRS was high, nearly 40% for the entire sample and 47% for African Americans. As the non-response pattern among African Americans was related to men, living alone, and better ADL and IADL functioning, there may exist possible biases for the present findings. More research is clearly warranted to quantify such biases.

4.2. Implications

Despite the limitations, the current study contributes to the field of older African American' technology use in the following ways. First, this study is among the few studies focusing specifically on correlates of the technology use among older African Americans, and as such it provides more insights about this population and expands the currently limited literature. Second, this study provides valuable insights for future practice. Future interventions to promote computer/internet use among older African Americans need to target those with low socioeconomic status. Providing more computers in senior centers and more free training programs may be good ways to increase computer/internet use in this population. Furthermore, gender differences on correlates of internet use indicate that future interventions for promoting technology use among African American older adults need to be gender-tailored. For example, interventions for older African American women may need to target those at older ages and with difficulties in ADL, change their internalized negative ageist stereotypes, and empower them, whereas interventions for older men need to target those having depressive symptoms. Considering the age differences on the correlates and that the use of the Internet itself is a cognitive stimulation activity, more innovative computer training programs need to be designed to assist in the cognitive stimulation of older African Americans with and without mild cognitive impairment.

5. Conclusions

Literature on the use of technology by older adults is vast, but studies focusing specifically on African American older adults are very sparse and discrepant in their results. Findings in this study indicated that internet use among older African Americans is low. Interventions that integrate the use of technology would go a long way in benefiting African American older adults. Results showed similarities and gender and age differences among older African American adults. As such, practitioners should consider these gender and age differences when promoting computer/internet use among older African Americans, as well as in the design and implementation of more gender-specific interventions.

Conflicts of Interest

No conflicts of interest were reported by all others.

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Authors' Contributions

KW conceived the research question, conducted the analysis, drafted the introduction, methods, results, and discussions of the manuscript, and reviewed the manuscript. KK advised on the research question, drafter the introduction, and reviewed the manuscript.

Ethics Statement

The HRS data used in this study are publicly available and are waived from the oversee of the authors' Institutional Review Board.

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Appendix

Table A1. Multilinear regression coefficients of internet use.

	Gender		Age	
	Men	**Women**	**Old-old**	**Young-old**
Demographic				
Women			1.01**	0.29
Old-old	−0.25	−1.15***		
Living alone	−0.80	0.11	−0.48	−0.06
Socioeconomic				
Years of education	0.15**	0.23***	0.26***	0.26**
Married or partnered	−0.05	0.20	0.10	0.51
Retired	−1.18**	−0.78**	−1.00**	−0.43
Living in poverty	−1.95***	−0.68*	−1.10**	−0.52
Health-related				
Self-rated health	0.12	0.14	0.17	0.11
Number of diseases	0.11	0.05	0.12	0.31
Difficulties in activities of daily living	−0.31	−0.29*	−0.19	−0.34
Difficulties in instrumental activities of daily living	0.14	0.19	0.03	0.16
Mental health-related				
Depression	−0.21*	−0.09	−0.13	−0.09
Discrimination	0.18	0.11	0.19	0.35
Cognitive functioning	0.16***	0.12***	0.17***	0.14**

Effect sizes stand for unstandardized coefficients. *p<0.05; **p<0.01; ***p<0.001.

Table A2. Logistic regression odds ratios of internet use.

	Gender		Age Group	
	Men	**Women**	**Old-old**	**Young-old**
Demographic				
Women			2.75**	1.34
Old-old	0.53	0.31***		
Living alone	0.37	1.03	0.62	0.94
Socioeconomic				
Years of education	1.25**	1.39***	1.30***	1.30**
Married or partnered	1.27	1.17	1.11	1.67
Retired	0.32*	0.43*	0.37**	0.65
Living in poverty	0.15**	0.66	0.33**	0.60
Health-related				
Self-rated health	1.22	1.12	1.19	1.12
Number of diseases	1.17	1.12	1.13	1.36^{+}
Difficulties in activities of daily living	0.94	0.71^{+}	0.82	0.71
Difficulties in instrumental activities of daily living	1.28	1.03	1.03	1.17
Mental health-related				
Depression	0.70**	0.96	0.88	0.91
Discrimination	1.29	1.27	1.20	1.42
Cognitive functioning	1.22***	1.13**	1.19***	1.15***

Effect sizes stand for odds ratio. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001.

Table A3. Logistic regression odds ratios of active internet use.

	Gender		Age group	
	Men	**Women**	**Old-old**	**Young-old**
Demographic				
Women			1.93*	0.93
Old-old	0.94	0.41**		
Living alone	0.48	1.12	1.09	0.70
Socioeconomic				
Years of education	1.17*	1.24***	1.18**	1.20*
Married or partnered	0.92	1.54	1.51	1.32
Retired	0.16***	0.59^{+}	0.34***	0.76
Living in poverty	0.04***	0.47*	0.19***	0.61
Health-related				
Self-rated health	1.20	1.11	1.09	1.22
Number of diseases	1.26	0.92	1.03	1.23
Difficulties in activities of daily living	0.75	0.67*	0.68*	0.69
Difficulties in instrumental activities of daily living	0.99	1.28	1.32	0.99
Mental Health-related				
Depression	0.77^{+}	0.91	0.86*	0.82
Discrimination	1.51^{+}	1.06	1.31	0.83
Cognitive functioning	1.17**	1.12**	1.16***	1.12*

The active Internet use was defined as use of the Internet at least several times per month. Effect sizes stand for odds ratio. $^{+}$p< 0.10; *p<0.05; **p<0.01; ***p<0.001.

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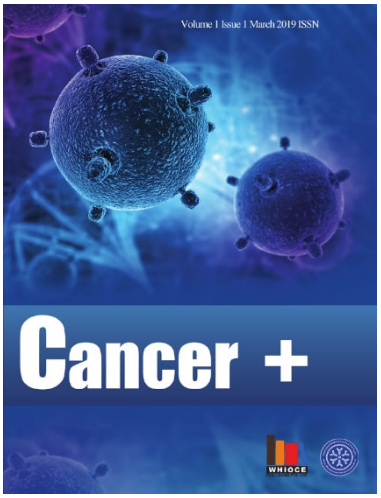

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