Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol. 5 No. 9 (2024): September 2024 Issue
https://doi.org/10.51168/sjhrafrica.v5i9.1304
Original Article

A CROSS-SECTIONAL INFOVEILLANCE STUDY ON WIKIPEDIA WAS USED FOR ACCESSING MAMMOGRAM INFORMATION.

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ABSTRACT

Background

Wikipedia has emerged as a source of health information for patients and the public. The study aimed to identify trends in the use of Wikipedia to access information on mammograms and to assess the quality of this information.

Methods

This was a trend analysis of cross-sectional data, namely Wikipedia page views for mammogram-related searches between 2016 and 2022. Data was analyzed with descriptive statistics. Overall trends in page views were analyzed by year and month. Pairwise comparisons were assessed with Analysis of Variance (ANOVA) testing. The quality of mammogram-related information on Wikipedia was evaluated using Couto and Lope's four quality assessment features (Completeness, authority, informativeness, and consistency).

Results

The total number of page views for mammography-related terms during 2016-2022 was 1 180 947. The data fluctuated across years and months. When analyzed by year, mean page views peaked during 2018 (mean = 20 600.6) and were lowest during 2021 (mean = 10 267.9). When analyzed by month, mean page views peaked during March and October (means = 15 845.7 and 15 608.6, respectively). Overall, there were strong trends in page views across years (R2=0.99) and months (R2=0.73). The pairwise comparisons revealed numerous statistically significant differences in mean page views across years and months, which manifested as the observed polynomial trends. The quality assessment scores were as follows: Completeness (Medium), authority (Medium), informativeness (Low), and consistency (Medium).

Conclusions

Wikipedia is a potentially important source of mammogram information for patients and the public. This platform could be improved (diversity of page content and image presentation) and used to support public health awareness campaigns in combating breast cancer worldwide.

Recommendation

Efforts should be made to encourage the sustained use of Wikipedia by patients and the public as a source of mammogram information.

Keywords: *Wikipedia, Mammogram, Mammography, Infoveillance.*
Submitted*: 2024-07-24* ***Accepted:*** *2024-08-08*

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INTRODUCTION

Breast cancer is one of the most commonly diagnosed cancers among women and one of the leading causes of cancer-related mortality worldwide.1 In 2020, there were an estimated 2.2 million new breast cancer cases and 685,000 associated deaths worldwide.2 Globally, breast cancer incidence rates are highest in North America and Oceania, with Age-Standardised Incidence Rates (ASIR) of 89.4 and 87.8 per 100 000 women, respectively.1 Although Africa has a lower breast cancer ASIR of 40.7 per 100 000 women, it records the highest Age-Standardised Mortality Rate (ASMR) for breast cancer at 19.4 per 100 000 women.1 Mortality is high in developing countries due to a lack of early detection programs and inadequate healthcare systems.2 The majority of published guidelines for breast cancer screening advocate for annual/biennial mammograms for women aged 40-74 years in average-risk populations and annual breast cancer screening starting at younger age groups in higher-risk populations.3

The introduction of breast cancer screening programs such as breast self-examination, lifestyle modification, and most importantly, the use of mammograms, has facilitated earlier detection, treatment, and an improved prognosis of breast cancer. This has in turn reduced breast cancer deaths by about 20% to

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30%.2Mammography screening encompasses two common types: digital mammograms, utilizing advanced imaging technology, and film mammograms, which use traditional X-ray film to examine breast tissue.4 Older film-based mammography is more likely to be used in low-resource settings, while digital mammography is being adopted in high-income settings.5 The sensitivity of mammography for breast cancer varies between 71-87%, with higher sensitivity values noted for women older than 60.6On the other hand, mammography has an 88.6% specificity in women aged 40 to 49, 90.3% in women aged 50 to 59 and 93.1% in women 60 years and above.6

The benefits of breast cancer screening are well established. The BreastScreen Australia Program reduced breast cancer mortality from 74 per 100,000 women to 50 deaths per 100,000 women.2 There was also an estimated 30% decrease in breast cancer mortality among women aged 50 to 74 years in Europe due to effective breast cancer screening programs.7 However, mammography compliance is less than desirable; for instance, about 60 to 70% of American women over 40 are willing to take mammogram screenings in the United States. 8 It is thought that a lack of knowledge/awareness of the mammogram procedure might contribute to low compliance.9 Knowledge and awareness of a disease (or its diagnosis and treatment) are cues to action (i.e. health-seeking behavior) according to the Health Beliefs Model. 10 For this reason, the source of information accessed by women on mammograms and the quality of this information is of the utmost importance if mammogram compliance rates are to be improved.

About six million people search for health-related information daily online.11 This number exceeds in-and-out patient-physician daily visits (2.24 million) in the United States,11 highlighting the significance of the Internet as a source of healthcare information for patients and the general public. Usually, patients resort to Google or Wikipedia searches as that becomes more straightforward compared to the complex task of searching for peer-reviewed articles or published books.12 Wikipedia is amongst the first search results that are returned for health information when a Google search is done.12 As a source of information, Wikipedia has over 10 million articles in 253 languages.13 The dynamic nature of Wikipedia makes edits and updates to information possible.14 An individual's knowledge and awareness of a disease condition and or the screening/ diagnostic test is a key component of the well-established Health Beliefs Model and is one of the cues to behavioral actions, including healthcare-seeking behavior.10This study sought to identify trends in the use of Wikipedia to access information on mammograms and to assess the quality of this information.

METHODS

Study design, data source, and data extraction

This was a trend analysis of publicly available, cross-sectional data from Wikipedia. This research utilized the Wikipedia Page Views tool (https://pageviews.toolforge.org), an open-source tool that collates page view data from Wikipedia articles, as the data source for this research. This research focused on Wikipedia searches related to mammography and mammograms (hereafter referred to as "mammogram-related terms"), collecting page view counts from 1 January 2016 to 31 December 2022. The Wikipedia page view tool had accurate data from 2016-2022, hence this timeframe was selected. The page view data were extracted from the Wikipedia Page Views tool as a Microsoft Excel file.

Data analysis

Descriptive statistical analyses were conducted to report the total number of page views for mammogram-related terms by year and month, as well as the mean number of page views (with standard deviation, SD) for these time points. The mean percentage change (increase or decrease) in page views for mammograms by year and by month was also computed. Trends in page views (by year and month) were assessed using polynomial trendline analyses. The results of the polynomial trendline analyses are presented as graphs, with the mean number of page views plotted on the y-axis and the period plotted on the x-axis, along with an R2 value (the square of the Pearson correlation coefficient r). An R2 value of >0.70 was considered to be representative of a strong trend in mean page views over the periods being investigated. A one-way Analysis of Variance (ANOVA) test with Bonferroni post hoc testing was also performed to compare mean page views across years and months. A p-value of <0.05 was considered statistically significant. The data was analyzed using Microsoft Excel and GraphPad Prism statistical software (version 8.0).

Quality assessment of mammogram-related information on Wikipedia

This research study adopted Couto and Lopes's proposed criteria (Authority, completeness, informativeness, and consistency) to establish the quality of Wikipedia information on mammograms.15 This tool was developed for Wikipedia quality assessment and thus it was selected for this study. Wikipedia was searched using the terms "mammogram" and "mammography". The quality of the Wikipedia pages for the mammogram-related terms was performed independently by two reviewers. Where there was a disagreement with the quality assessment, a third reviewer was consulted. A more detailed explanation of the scoring criteria used in the assessment tool is provided in Table 1. Each criterion

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is allocated a graded score, with higher overall scores indicative of a higher quality.

Ethical approval

This research was approved by the Human Research Ethics Committee of Stellenbosch University, Cape Town, South Africa (Project ID: 28207).

Table 1: Criteria used in this research study for assessing the quality of mammogram-related information on Wikipedia

Criteria	Score	Description
Authority	0	There is a lack of unique editors, no connectivity on editing, and numerous anonymous editors.
	1	There is a lack of unique editors, little connectivity on editing, and fewer anonymous editors.
	2	Unique editors, less connectivity on editing, fewer anonymous editors.
	3	Unique editors, high connectivity on editing, no anonymous editors.
Completeness	0	Articles lack a thorough discussion of mammography.
	1	Major omissions in mammography
	2	Minor omissions, not fully discussed, some content missing.
	3	A complete discussion of mammography, proper article length, recommended content, appropriate references
Informativeness	0	No diversity, it lacks proper images and presentation, and it is less readable.
	1	Little diversity, limited image presentation
	2	Diversity in content, some image illustration, reasonably readable.
	3	Clear content diversity, proper image illustration, well-presented content, and adequately readable.
Consistency	0	No content format, structure, or precision.
	1	Some structure or format with limited precision.
	2	Structure and format with moderate precision.
	3	Articles follow a specific structure, format, and high precision.

RESULTS

An overall description of total Wikipedia page views for mammogram-related terms is shown in Figure 1. From 2016 to 2022, the total number of mammogram-related page views on Wikipedia was 1 180 947, of which the majority were directed to the webpage on mammography (95.6%).

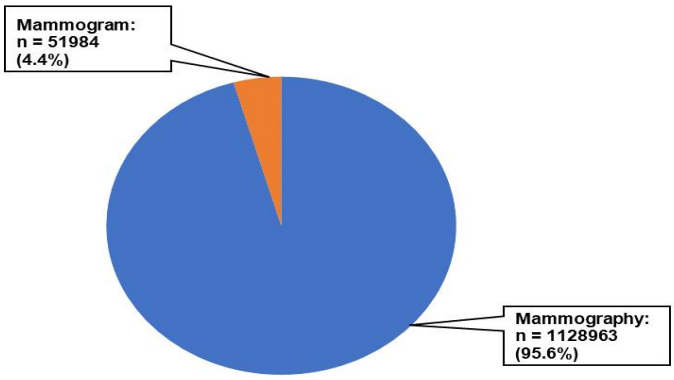

Figure 1: Breakdown of Wikipedia page views by search term used during 2016-2022 (Total page views for mammogram-related terms: n = 1 180 947)

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The page views for mammogram-related terms, stratified by year, are shown in Figure 2. The highest number of page views during the study period was recorded during 2018 (n=247 207; 21.0%), while the lowest number of page views was recorded during 2021 (n=123 215; 10.4%).

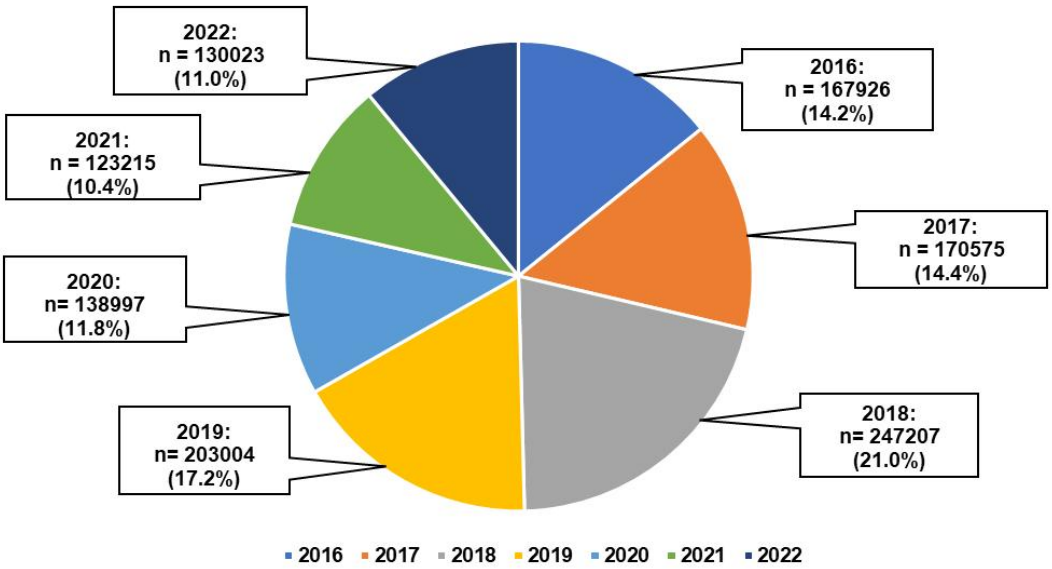

Figure 2: Breakdown of Wikipedia page views for mammogram-related terms by year

The yearly trend in the mean number of Wikipedia page views for mammogram-related terms during the study period is shown in Figure 3. Page views peaked during 2018 (mean = 20 600.6, SD:1 508.1), and were lowest during 2021 (mean = 10 267.9, SD: 1 157.4). A polynomial trend was observed, suggesting fluctuations in the mean number of page views across years. Overall, page views increased between 2016 and 2018, experienced a decrease between 2018 and 2021, and saw a slight increase between 2021 and 2022. The biggest % increase in page views was between 2017 and 2018 (44.9% increase), while the biggest % decrease in page views was between 2019 and 2020 (31.5% decrease). The R^2 value of 0.99 suggests a strong trend in mammogram information searches across years.

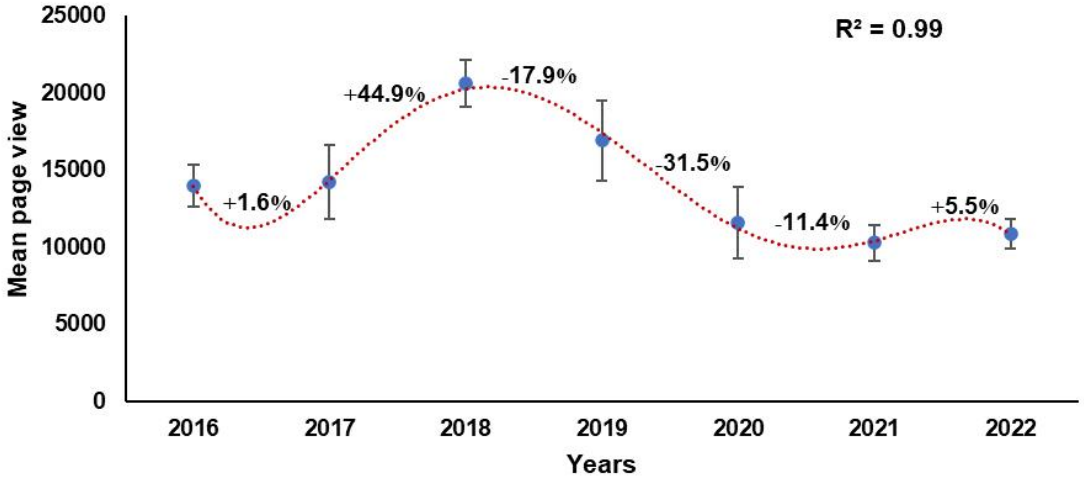

Figure 3: Yearly trend in Wikipedia page views for mammogram-related terms (mean and SD, with % change between data points) for 2016-2022

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The monthly trend in the mean number of Wikipedia page views for mammogram-related terms during the study period is shown in Figure 4. Once again, the data was observed to follow a polynomial trend. Notably, page views peaked during two months - March (mean = 15 845.7, SD:4 481.6) and October (mean = 15 608.6, SD: 4 127.9). The highest % increase in mean page views was between September and October (20.7% increase), while the highest % decrease was between March and April (12.8% decrease). The R^2 value of 0.73 suggests a strong trend in mammogram information searches across years.

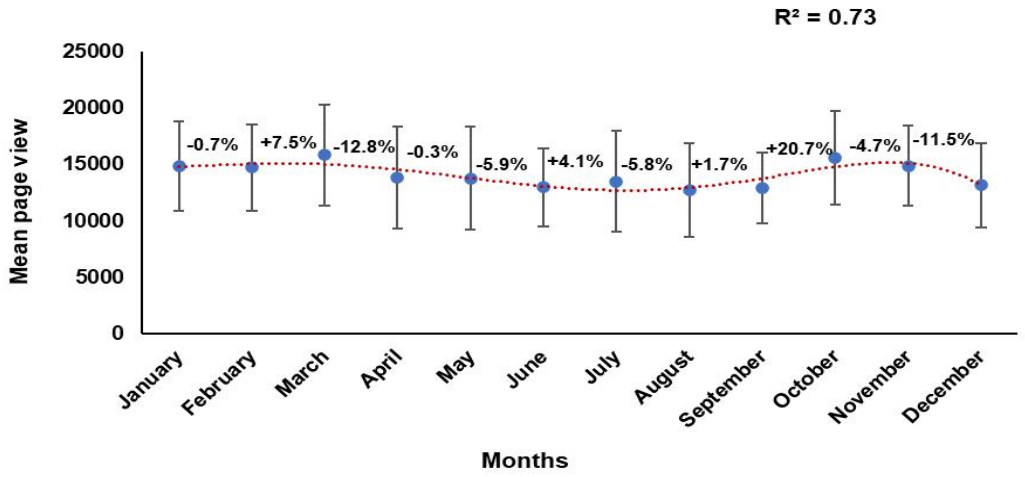

Figure 4: Monthly trend in Wikipedia page views for mammogram-related terms (mean and SD, with % change between data points)

Comparisons of mean Wikipedia page views for mammogram-related terms are shown in Table 2. There were statistically significant differences in mean page views noted for the following: 2016 vs. 2018 (Mean difference [i.e. the difference between the mean page views between two years which are being compared]: -6 606.8), 2017 vs. 2018 (Mean difference: -6 386.0), 2018 vs. 2020-2022 (Mean difference range: +9 017.5 to +1 0332.7), and 2019 vs. 2021 (Mean difference: +6 649.1). No other statistically significant results were noted for the other pairwise comparisons investigated.

Table 2: Pairwise statistical comparison of differences in mean Wikipedia page views for mammogram-related terms by year

Year	2016	2017	2018	2019	2020	2021	2022
2016	N/A	-220.8	-6606.8*	-2923.2	+2410.8	+3725.9	+3158.6
2017	+220.8	N/A	-6386.0*	-2702.4	+2631.5	+3946.7	+3379.3
2018	+6606.8	+6386.0	N/A	+3683.6	+9017.5*	+10332.7*	+9765.3*
2019	+2923.2	+2702.4	-3683.6	N/A	+5333.9	+6649.1*	+6081.6
2020	-2410.6	-2631.5	-9017.5	-5333.9	N/A	+1315.2	+747.8
2021	-3725.9	-394.7	+10332.7	-6649.1	-1315.2	N/A	-567.3
2022	-3158.6	-3379.3	+9765.3	-6081.6	-747.8	+567.3	N/A

p<0.05, N/A: Not Applicable.

The results from the comparative analyses of mean Wikipedia page views across months are shown in Table 3. The mean differences in monthly page views (i.e. the difference between the mean page views between two months which are being compared) were statistically significant between January and the following months: June (Mean difference: +1 873.3), August (Mean difference: +2 133.1), September (Mean difference: +1 918.4), and December (Mean difference: +1 689.1). The mean differences in page views were statistically significant between February and the following months: June (Mean difference: +1 769.4), August (Mean difference: +2 029.3), September (Mean difference: +1 814.6), October (Mean difference: -8 63.7), November (Mean difference: -130.4), December (Mean difference range: +1 585.3).

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The mean differences in page views were statistically significant between February and the following months: April (Mean difference: +2 020.9), May (Mean difference: +2 056.1), June (Mean difference: +2 870.3), July (Mean difference: +2 342.9), August (Mean difference: +3 130.1), September (+ 2 915.4), and December (Mean difference: +2 686.1). Mean page views in April were significantly lower than page views in October (Mean difference: -1 783.7). A similar result was observed for May vs. October (Mean difference: -1 819) and July vs. October (Mean difference: -2 105.7). Mean page views during October were higher than those observed in December (Mean difference: +2 449.0). Mean page views in June were statistically different from the following months: October (Mean difference: -2 633.1) and November (Mean difference: -1 899.9).

Mean page views in August were statistically different from the following months: October (Mean difference: +2 832.0) and November (Mean difference: -2 159.7). Mean page views in September were statistically different from the following months: October (Mean difference: -2 678.3) and November (Mean difference: -1 945.0). No other statistically significant results were noted for the other pairwise comparisons investigated.

Table 3: Pairwise statistical comparison of differences in mean Wikipedia page views for mammogram-related terms by month

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Jan	N/A	-103.9	+997	-1023.9	-1059.1	-1873.3	-1345.9	-2133.1	-1918.4	+759.9	+26.6	-1689.1
Feb	+103.9	N/A	+1100.86	-920.0	-955.3	-1769.4	-1242.0	-2029.3	-1814.6	+863.7	+130.4	-1585.3
Mar	-997	-1100.9	N/A	-2020.9	-2056.1	-2870.3	-2342.9	-3130.1	-2915.4	-237.1	-970.4	-2686.1
Apr	+1023.9	+920.0	+2020.9*	N/A	-35.3	-849.4	-322.0	-1109.3	-894.6	+1783.7	+1050.4	-665.3
May	+1059.1	+955.3	+2056.1*	+35.3	N/A	-814.1	-286.7	-1074.0	-859.3	+1819.0	+1085.7	-630.0
Jun	+1873.3*	+1769.4*	+2870.3*	+849.4	+814.1	N/A	+527.4	-259.9	-45.1	+2633.1	+1899.9	184.1
Jul	+1345.9	+1242.0*	+2342.9*	+322.0	+286.7	-527.4	N/A	-787.3	-572.6	+2105.7	+1372.4	-343.3
Aug	+2133.1*	+2029.3*	+3130.1*	+1109.3	+1074.0	+259.9	+787.3	N/A	+214.7	-2893.0	+2159.7	+444.0
Sept	+1918.4*	+1814.6*	+2915.4*	+894.6	+859.3	+45.1	+572.6	-214.7	N/A	+2678.3	+1945.0	+229.3
Oct	-759.9	-863.7*	+237.1	-1783.7*	-1819*	-2633.1*	-2105.7*	+2893.0*	-2678.3*	N/A	-733.3	-2449.0
Nov	-26.6	-130.4*	+970.4	-1050.4	-1085.7	-1899.9*	-1372.4	-2159.7*	-1945.0*	+733.3	N/A	-1715.7
Dec	+1689.1*	+1585.3*	+2686.1*	+665.3	+630.0	-184.1	+343.3	-444.0	-229.3	+2449.0*	+1715.7	N/A

p<0.05, N/A: Not applicable.

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An assessment of the quality of Wikipedia information on mammograms is shown in Table 4. The quality of information was scored as "Medium" in three of the four quality domains (Authority, completeness, and consistency). However, the information on mammograms scored very low on informativeness (i.e., little diversity in page content and limited image presentation). Also, there were fewer unique and anonymous editors with some content omissions.

Table 4: Quality of mammogram-related information on Wikipedia

Criteria	Score	Description
Authority	2	Fewer Unique editors, less connectivity on editing, and fewer anonymous editors.
Completeness	2	Minor omissions, not fully discussed, some content missing.
Informativeness	1	Little diversity, limited image presentation
Consistency	2	Structure and format with moderate precision.

DISCUSSION

There were three key findings from this research - There were nearly 1.2 million Wikipedia page views for mammography-related terms during the study period; the data fluctuated across years and months, with strong polynomial trends in page views observed across years and months; and the overall quality of mammogram information was acceptable, but there was little diversity in the page content and limited image presentation.

The overall finding around the high volume of Wikipedia page views for mammogram-related terms during the study period highlights the importance of Wikipedia as a healthcare information tool for women. The high overall volume of Wikipedia page views for mammogram-related terms is unsurprising, considering that internet access and mobile phone ownership have increased rapidly worldwide.16,17 The high overall volume of Wikipedia page views during the study period might also be explained by the general public's "normalization" of using internet sources as an opportunity to access healthcare information or "self-diagnosis" to complement in-person engagements with healthcare professionals.18 It is also possible that the high overall volume of Wikipedia page views might be a consequence of the nearly worldwide accessibility of the Wikipedia website,19 and this emphasizes the platform's global reach. This might have important future applications in global health campaigns for breast cancer, and thus public health specialists should investigate exactly how Wikipedia or similar platforms can be efficiently integrated into these health campaigns.

A fluctuating annual trend in Wikipedia use for mammogram information was observed in this study. Ideally, a trend line with either an increasing gradient (suggesting increased utilization of Wikipedia) or a horizontal trend line (suggesting consistent utilization of Wikipedia) would have been desirable. The encouraging increase in Wikipedia utilization between 2016 and 2018 follows the increasing trends in mammogram procedures observed throughout the world between 2010 and 2019 that have been reported in the published literature. Two potential explanations regarding the increase in Wikipedia page views during 2016-2018 can be offered. Firstly, there were numerous breast cancer guidelines published between 2010 and 2019, which placed a greater focus on early mammogram screening. 3 These guidelines could have then provided the basis for aggressive public health campaigns involving breast cancer screening, which may have garnered public interest and encouraged women to seek additional information on the procedure. Secondly, the increased interest in mammograms during the 2016-2018 period could also be due to the implementation of policies in some countries that contributed to reduced out-of-pocket costs for women interested in breast cancer screening.20 The reduced out-of-pocket costs associated with the procedure might have encouraged women who were keen to undergo the procedure to seek more information about the procedure itself. The usage of Wikipedia for mammogram information within these periods confirms the internet's potential role in influencing increased online health-seeking behavior among individuals.15 Moreover, in the context of the widely used Health Beliefs Model, it can be inferred that the utilization of Wikipedia for mammogram information will have a positive uptake of mammograms.10

This analysis found that interest in mammogram-related information was highest during October, which has also been reported in similar studies of accessing breast cancer information involving Google and Twitter/Instagram.21,22 The increased interest in the Wikipedia page on mammograms during October is likely due to public health campaigns implemented as part of Breast Cancer Awareness Month.23 A similar peak in page views was observed during March, and this could also be due to the general public health awareness campaigns targeting cancer, which were implemented in observance of World Cancer Day in the preceding month.

A decline in Wikipedia page views was observed after 2019. This decline is probably due to the emergence of the COVID-19 pandemic around the same time. During 2019-2020, the public's focus was fixed on the COVID-19 pandemic.24 Most public health specialists prioritized health campaigns around COVID-19 control and treatment during this period, and health systems suspended non-essential health services, including the

provision of mammograms.24 It is encouraging, however, that a slight increase in Wikipedia page views for 2021-2022 was observed, suggesting that the public's focus has now shifted toward other diseases since the COVID-19 pandemic has largely been brought under control.

The overall information presented on Wikipedia for mammograms was satisfactory. However, the inclusion of additional illustrative materials might be beneficial in strengthening the health information being conveyed through the Wikipedia page. Linking pictures to text, rather than conveying health information via text alone, is more effective at gaining the interest of the target population for a public health campaign.25 The use of pictures in healthcare information also improves recall of the information, improves comprehension of more difficult ideas, and invokes an emotional response that can improve adherence to healthcare instructions.25 The role of short videos online is growing in significance for cancer health education. In a recent study, breast cancer literacy was shown to improve using online videos.26 This approach could also be considered to improve the presentation of healthcare information around mammograms on Wikipedia. A major difference between Wikipedia and some of the other internet-based platforms through which breast cancer information is disseminated is that Wikipedia information is subject to review and editing for factual accuracy.19 It is therefore important that qualified experts in breast cancer be involved in the regular review, editing, and updating of mammogram information on Wikipedia. Another important difference between Wikipedia and some of the other more commonly used online platforms to disseminate breast cancer information is that tools exist to gauge the quality of the information presented on Wikipedia, which might be lacking for the other online avenues.19 On the other hand, platforms such as Pinterest do not have such quality assessment tools. Thus, misinformation on Pinterest can undermine the work of bona fide breast cancer campaigns and healthcare practitioners.27 This further highlights the need for public health specialists to integrate Wikipedia into breast cancer campaigns and promote the use of this platform, to reduce the number of women who seek additional information on breast cancer from less trustworthy platforms.

Strength of study

A major strength of this research was that it involved an analysis of raw data on Wikipedia page views related to mammogram/mammography over a long period of seven years.

Limitations of study

A limitation of this study was that data from other online platforms was not analyzed. Another limitation of this research was that only a selected number of variables were made publicly available for Wikipedia page analytics. For example, the countries in which the Wikipedia pages were viewed are not provided, and this could not be analyzed in the current study. The demographic characteristics of those accessing the Wikipedia pages and multiple page views for the same individual could also not be established since Wikipedia pages can be viewed without the need for a user login. Also, the researcher could not directly link Wikipedia use with mammogram utilization since the data available from Wikipedia does not allow for this. Further research is needed to address the current study's limitations.

Recommendation

This study highlights the potential importance of Wikipedia as a tool to disseminate information about breast cancer screening to women across the world. Efforts should be made to encourage the sustained use of Wikipedia by patients and the public as a source of mammogram information.

CONCLUSION

This infoveillance study has identified Wikipedia as a potentially important source of mammogram information for patients and the general public. The quality of mammogram information on Wikipedia was satisfactory but could be further improved. Additional research is required to establish the best way to encourage the utilization of this platform as part of a breast cancer public health campaign.

Data Availability

The data used in this study are publicly available from Wikipedia.

List of abbreviations

ANOVA: Analysis of Variance.
ASIR: Age-Standardised Incidence Rate
ASMR: Age-Standardised Mortality Rate
SD: Standard deviation

Source of funding

No grants were involved in supporting this work.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

ISA conducted the data collection, and analysis, and wrote the first draft of the manuscript.
HS conducted a critical review of the draft manuscript and was ISA's research supervisor.
YM conducted the analysis, conducted a critical review of the draft manuscript, and was ISA's research supervisor.

Acknowledgements

This research was a component of the first author's postgraduate studies.

Author Biography

ISA is a postgraduate student at Stellenbosch University, South Africa. HS is an associate research scientist at the African Population Health Research Centre, Nairobi, Kenya. YM is an associate professor and cancer epidemiologist at Stellenbosch University, South Africa, and a research associate at the Central University of Technology, South Africa.

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