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Real-Time Inferential Analytics Based on Online Databases of Trends: A Breakthrough within the Discipline of Digital Epidemiology in Dentistry and Dental Anatomy

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ABSTRACT

BACKGROUND

Epidemiological sciences have been evolving at an exponential rate paralleled only by the comparable growth within the discipline of data science. Digital epidemiological studies are playing a vital role in medical science analytics for the past few decades. To date, there are no published attempts at deploying the use of real-time analytics in connection with the disciplines of Dentistry or Medicine.

AIMS AND OBJECTIVES

We deployed a real-time statistical analysis in connection with topics in Dental Anatomy and Dental Pathology represented by the maxillary sinus, posterior maxillary teeth, related oral pathology. The purpose is to infer the digital epidemiology based on a continuous stream of raw data retrieved from Google Trends database.

MATERIALS AND METHODS

Statistical analysis was carried out via Microsoft Excel 2016 and SPSS version 24. Google Trends database was used to retrieve data for digital epidemiology. Real-time analytics and the statistical inference were based on encoding a programming script using Python high-level programming language. A systematic review of the literature was carried out via PubMed-NCBI, the Cochrane Library, and Elsevier databases.

RESULTS

The comprehensive review of databases of the literature, based on specific keywords search, yielded 491813 published studies. These were distributed as 488884 (PubMed-NCBI), 1611 (the Cochrane Library), and 1318 (Elsevier). However, there was no single study attempting real-time analytics. Nevertheless, we succeeded in achieving an automated real-time stream of data accompanied by a statistical inference based on data extrapolated from Google Trends.

CONCLUSION

Real-time analytics are of considerable impact when implemented in biological and life sciences as they will tremendously reduce the required resources for research. Predictive analytics, based on artificial neural networks and machine learning algorithms, can be the next step to be deployed in continuation of the real-time systems to prognosticate changes in the temporal trends and the digital epidemiology of phenomena of interest.

KEYWORDS

Evidence-Based Dentistry; Public Health Dentistry; Google Trends; Real-time Analytics; Predictive Analytics.

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1. INTRODUCTION

Digital epidemiology is an emerging discipline of public health and epidemiological sciences, and it has been evolving rapidly over the past few decades. [1, 2] It can be implemented based on data from online resources of the surface web including trends databases, online drug fora and blogs, and social communication media. [3, 4] Google Trends database perfectly fits this purpose as it contains an up-to-date collection of raw data based on queries of users of the web from all over the world, including millions if not billions of users. [2, 5] Epidemiologist never attempted to carry out real-time or predictive analytics within the context of digital epidemiology and in connection with the discipline of dentistry or medicine. [6-8] In this study, we will explore this concept via the integrative use of Python programme language, statistical packages, and spreadsheet templates in an aim to demonstrate a prototype for real-time analytic of data retrieved from Google Trends.

The paranasal sinuses are of prime importance for the region of the head. [9, 10] Leonardo da Vinci (1452-1519) made the very first schematic illustration, via sectional anatomical sketches, of the paranasal sinuses with particular attention to the maxillary sinus which holds great importance from an evolutionary perspective. [11, 12] Da Vinci's anatomical drawings were the principal motivation towards the primary objective of this study in creating a successful prototype of inferential real-time analytics in connection with topics that are related to the maxillary sinus. These topics are mainly limited to the Schneiderian membrane, posterior maxillary teeth, and related oral pathologies including periapical abscess formation, periodontal pathologies, and complicated dental implants. Real-time analytics can be of considerable impact when implemented in biological and life sciences as they will tremendously reduce the required resources for research. On the other hand, Predictive analytics based on artificial neural networks and machine learning algorithms, can be the next step to be deployed in continuation of the real-time systems to prognosticate changes in the temporal trends and the digital epidemiology of phenomena of interest in medicine, dentistry, as well as other subdisciplines of biological and life sciences.

Following a maxillary molar tooth extraction, the treatment modalities routinely involve dental prostheses. However, the central fossa of the candidate implant site may require bone grafting techniques to achieve a satisfactory surgery outcome at the prospective implantation site. [13] Oberli and workmates analysed a series of one hundred thirteen periapical radiographs of maxillary premolars and molars with periapical radiolucency indicating chronic apical periodontitis. The cohort was evaluated for the occurrence of maxillary sinus perforations and postoperative complications. Perforation of the Schneiderian membrane occurred in 9.6% of the cases, while membrane exposure without rupture existed

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in 12%. The distance between the apex of the periapical lesion and the sinus floor did not serve as a predictor of a potential sinus membrane rupture. [14] In 2013, Dagassan-Berndt and fellow workers measured the thickness of the Schneiderian membrane via dental Cone-Beam Computed Tomography (CBCT). It was significantly higher in the dentate group compared to the edentulous group in connection with the position of the first and second molar. Further, in the dentate group, clinical signs of periodontal destruction were not associated with Schneiderian membrane thickness. [15]

2. MATERIALS AND METHODS

2.1 ETHICAL APPROVAL

This study has been ethically permitted by the Institute Review Board (IRB) of the College of Medicine at the University of Baghdad and in compliance with the authority of the IRB meeting number seven that took place on the 20th of December in 2016 (Project Identification Code: IRB7-202016).

2.2 REVIEW OF LITERATURE

An analysis of the existing body of literature was conducted systematically from the 1st to the 15th of August 2018 via medical and paramedical databases including NCBI-PubMed, the Cochrane Library, and Elsevier. The unpublished grey literature was also consulted for data of interest. The concept of real-time and predictive analytics was never explored medical and paramedical literature (Table 1A). Further, keywords of different themes were utilised in the process of examining the databases of published research in connection with the anatomy of the maxillary and related pathologies (Table 1B). Themes included five different topics including "Premolars and Molars", "Maxillary Sinus", "Pathologies", "Surgical Procedures", and "Radiology". We applied different combinations of themes, via the implementation of Boolean Operators (AND, OR, NOT). [16] Bibliographic materials of interest were assessed and appraised for validity via critical appraisal tools. [17, 18] Duplicate publications were eliminated, and studies that successfully passed the critical appraisal were deemed as satisfactory reference materials. Those studies were conducted on humans as well as non-human species, and written exclusively in the English language. Priority was given to the published literature from the past 5-10 years.

2.3 EXPLORATION OF GOOGLE TRENDS

Data were extracted from Google Trends database for the past five years from the 18th of August 2013 to the 18th of August 2018. [19] We used five keywords to retrieve raw numerical week-by-week particulars on the temporal trends, geographic mapping, and related queries by web users. Keywords included "Schneiderian membrane", "Maxillary Sinus", "Sinus lift", "Endodontics", and "Periodontal disease". Our

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study is a hybrid of an internet snapshot as well as real-time analytics of the trends. Hence, the level-of-evidence for this study cannot be categorised in correspondence with the Oxford Centre for Evidence-Based Medicine (CEMB). [20] Real-time analysis was attempted via the integration of Python high-level language (HLL) and Microsoft Excel 2016. This concept was never tried as confirmed the complete absence of publications within existing literature (Table 1B). Statistical analyses and hypotheses testing were carried out via Microsoft Excel 2016 and the Statistical Package for Social Sciences (SPSS v.24). The implemented statistical tests included the *Analysis of Variance and Covariance* (ANOVA), *Student's t-test*, and *Linear Regression*. An alpha value (α) of 0.05 and a confidence interval of 95% are considered as the cut-off margin for statistical inference.

2.4 A PROTOTYPE OF REAL-TIME ANALYSIS OF GOOGLE TRENDS

To achieve real-time analytics based on data already available on Google Trends (Figure 1), we wrote a script, a programming code, via Python high-level programming language version 3.6.6 (32-bit) using Linux Deepin 15.6 (64-bit) and Windows 10 Pro (64-bit) operating systems. [21] We applied Thonny version 2.1.21 interpreter, a Python Integrated Development Environment (IDE). The interpreter is a computer program that directly executes the programming script. [22, 23] Two libraries (modules) were imported, Pytrends and OpenPyXl. Those modules are a collection of precompiled routines that a program can use. [24, 25]

3. RESULTS

3.1 DATABASES OF LITERATURE

The systematic inspection of databases of interest of the published literature yielded a total of 491813 hits distributed as 488884 (PubMed-NCBI), 1611 (the Cochrane Library), and 1318 (Elsevier). The most successful keywords to retrieve data addressing the research questions included two combinations of keywords seen in bold fonts (Table 1) generating 441 and 30 hits respectively.

3.2 GOOGLE TRENDS

Exploration of Google Trends database gave data on related queries from users of the surface web. Those queries were not limited to "Maxillary sinus cyst", "Maxillary sinus infection", "Maxillary sinus pain", "Maxillary sinusitis", "Maxillary sinus retention cyst", "Sinus lift surgery", "Sinus graft", "Sinus augmentation", "Dental implants", "Gum disease", "Periodontitis", "Gingivitis", "Gum disease treatment", and "Periodontal treatment" (Table 2). Google Trends also led to accurate data about the geographic mapping (geo-mapping) of the web users queries towards topics of interest in connection with

the maxillary sinus, the posterior maxillary teeth, and related oral pathologies. Geo-mapping was limited to forty-seven countries including Japan, Taiwan, Chile, Germany, Ecuador, United Kingdom, Bulgaria, Ireland, Peru, Italy, Spain, Austria, Venezuela, Brazil, Mexico, Colombia, Greece, United States, Australia, Norway, New Zealand, South Korea, Sweden, Switzerland, Portugal, Ukraine, Singapore, Russia, France, Canada, Romania, Belgium, the Netherlands, Philippines, Argentina, South Africa, Egypt, Malaysia, United Arab Emirates, Kingdom of Saudi Arabia, Poland, India, Pakistan, Thailand, Indonesia, Iran, and Turkey. Countries from the Middle East accounted for 10.64% while countries that represented statistical outliers has contributed to 6.38% of the global map (Figure 2). Those outliers were related to the keyword "Sinus lift" and included Austria, Romania, and Turkey. Concerning geo-mapping, the "Schneiderian Membrane" generated no hits at all while other keywords averaged 2.81 +/- 0.63 (Maxillary sinus), 1.47 +/- 0.39 (Sinus lift), 27.43 +/- 2.76 (Endodontics), and 68.30 +/- 3.14 (Periodontal Disease) (Table 3). Based on Student's t-test statistics, there was a statistically significant difference between all keywords with an exception for "Maxillary sinus" versus "Sinus lift" (*p-value*=0.091) (Table 4). The surface web users were most interested in periodontal diseases and endodontics.

The temporal trends were variable for the past five years (2013-2018) (Figure 3), and they averaged 0.02 +/- 0.01 (Schneiderian Membrane), 2.64 +/- 0.04 (Maxillary sinus), 1.27 +/- 0.03 (Sinus lift), 25.59 +/- 0.17 (Endodontics), and 54.38 +/- 0.38 (Periodontal Disease) (Table 3). Statistical outliers co-existed for only two keywords, "Endodontics" and "Periodontal disease", during December of each year as well as lately during September and October in 2017. Scattered correlation and regression analysis confirmed a strong positive correlation between the two keywords "Endodontics" and "Periodontal disease" (*R score*=0.669, *p-value*<0.001) (Table 5, Figure 4). Besides, other keywords also had a significant moderate-to-strong positive linear correlation including "Schneiderian Membrane" and "Sinus Lift" (R=0.166), "Maxillary Sinus" and "Sinus Lift" (0.226), "Maxillary Sinus" and "Endodontics" (0.516), "Maxillary Sinus" and "Periodontal Disease" (0.495), "Sinus Lift" and "Endodontics" (0.330), and "Sinus Lift" and "Periodontal Disease" (0.218). Besides, Student's t-test calculations confirmed the existence of statistically significant differences (*p-value*<0.001) among all keywords (Table 5). Hence, the summative statistical inference validates that the web users are most interested in endodontics and periodontal diseases.

3.3 REAL-TIME ANALYSIS OF GOOGLE TRENDS

The programming script, via Python, enables an unmanned retrieval of data from Google Trends based on keywords of interest (up to five). The retrieval process is fully-automated and in real-time, and can be set at any regular interval (weekly, bi-weekly, monthly, etc.) that can be customised according to the specific

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requirements of the researchers. The data were self-regulated to be transferred to an Excel spreadsheet template (Microsoft Excel 2016, 64-bits) that had built-in formulas for inferential statistical analysis based on multiple hypothesis testing and in real-time. The complimentary statistical analysis was carried out via SPSS. Eventually, the process was successful in generating a real-time stream of inferential analytics.

4. DISCUSSION

4.1 THE CONCEPT OF REAL-TIME ANALYSIS

The concept of real-time analysis was never explored before not only within the field of dental anatomy and dental pathology but also in connection with the entire discipline of Medicine and Dentistry. [26, 27] We used keywords that are specific to the proposed research questions on the maxillary sinus, maxillary teeth and related oral abnormal conditions (Table 1B). The total number of hits, representing published papers was 346146, most of which (342841) were indexed via PubMed-NCBI, and much less (3305) were found on the Cochrane Library, while none existed on Elsevier database. However, there was no single study attempting real-time analytic. Hence, there is a full deficit within the existing body of literature about the objectives of this study. Our study is the first of its kind according to which an automated real-time stream of data accompanied by a statistical inference was applicable based on raw data extrapolated from Google Trends.

4.2 LIMITATIONS OF THE REAL-TIME ANALYSIS

The digital epidemiological analysis can be applied via online databases of trends. Geographic mapping of the top contributing countries originated mainly from the developed world, as well as few countries from the Middle East, some Latin countries, and others from Eastern Europe. This study may have some limitations due to the sole reliance on Google Trends as a representative of the databases of trends existing on the surface web. Besides, the retrospective analytic part of the study was limited to a restricted period (2013-2017). Data collected from Google Trends might be occasionally faulty or misleading as some web users might be deploying the use of a disguised mode of web browsing or dedicated incognito web browsers including Tor Browser, and virtual private networks as well as internet protocol masking. Subsequent studies should incorporate more than one trends database for cross-validation. Additionally, ventures into the deep web and the darknet should be attempted to recover any relevant data including those on the geographic mapping and temporal trends whenever feasible.

4.3 LITERATURE REVIEW OF RELEVANCE TO MAXILLARY SINUS AND POSTERIOR MAXILLARY TEETH

Lozano-Carrascal (2014) and Bornstein (2016) confirmed that CBCT is an invaluable tool for evaluating variations of the maxillary sinus anatomical parameters. [28, 29] In 2015, Goller-Bulut and teammates found that mucosal thickening (MT) of the sinus was common in patients with the periodontal bone loss (PBL), and it was significantly associated with apical lesions and PBL. [30] On the other hand, Bayrak and colleagues (2018) found no statistically significant relationship between Schneiderian membrane thickening (SMT) and nasal septum deviation (NSD). [31] Earlier in 2017, Khorramdel and fellows published similar data confirming that periapical lesions and periodontal infections were associated with SMT particularly in the posterior maxilla. [32] Acharya and co-workers proved that the incidence of advanced periodontal disease was common among Hong Kong Chinese and Asian Indian subjects who sought tooth replacement. [33] Lu and colleagues (2012) validated that the prevalence and extent severity of SMT is positively correlated with the severity of apical periodontitis especially among patients in their 7th decade of life. [34] Further, Bornstein and co-authors confirmed that the thickness of the apical bone and the Schneiderian membrane were generally higher in patients with periapical pathoses. [35]

4.4 FUTURE RESEARCH

Real-time analytics are of vital importance for research ventures in biological and life sciences as they will tremendously reduce the required research resources. Predictive analytics, based on pattern recognition and machine learning algorithms, should be the upcoming milestone in continuation of our efforts with real-time analytics in an aim to anticipate changes in the digital epidemiology of phenomena of interest.

AVAILABILITY OF DATA

All data are available upon request from the corresponding author.

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CONFLICTS OF INTEREST

The authors have nothing to be declared.

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CONTRIBUTION OF AUTHORS

AHMED AL-IMAM: Study concept and design, reviewing the literature, conducting the statistical analysis and hypothesis testing, writing the first draft of the manuscript, proofreading, and editing of the manuscript. USAMA KHALID: Developing the study concept, writing the code using Python programming language and Microsoft Excel 2016. NAWFAL AL-HADITHI: Reviewing the first draft of the manuscript. DAWOUDE KAOUCHE: Review of Literature.

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Table 1A. Investigation of Databases of Literature: The Topic of "Real-time" Analysis.

		Number of Hits per Database			
Theme of Keywords	Keywords	PubMed-NCBI	The Cochrane Library	Elsevier	Total
Real-time and Predictive Analytics	real-time analysis OR real-time analytics OR real-time anal* OR predictive analysis OR predictive analytics OR predictive anal*	333835	2403	0	336238
Real-time Analytics and Digital Epidemiology	(real-time analysis OR real-time analytics OR real-time anal* OR predictive analysis OR predictive analytics OR predictive anal*) AND (epidem* OR digital epidem*)	8570	896	0	9466
Maxillary Sinus and Maxillary Teeth	("Molar Teeth" OR "Premolar Teeth" OR "Tooth Extraction" OR "Exodontia") AND ("Maxillary Sinus" OR "Sinus Anatomy" OR "Schneiderian Membrane")	436	5	0	441
Combination of Themes	((real-time analysis OR real-time analytics OR real-time anal* OR predictive analysis OR predictive analytics OR predictive anal*) AND (epidem* OR digital epidem*)) AND (("Molar Teeth" OR "Premolar Teeth" OR "Tooth Extraction" OR "Exodontia") AND ("Maxillary Sinus" OR "Sinus Anatomy" OR "Schneiderian Membrane") AND ("Sinus Abnormalities" OR "Periapical Abscess" OR "Periodontitis"))	0	1 †	0	1
Total Number of Hits		342841	3305	0	346146

† Hits were irrelevant to the research questions.

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Table 1B. Investigation of Databases of Literature: The Maxillary Sinus.

		Number of Hits			
Theme of Keywords	Keywords	PubMed-NCBI	The Cochrane Library	Elsevier	Total
Premolars and Molars	Molar Teeth	35591	92	23	35706
	Premolar Teeth	14043	40	9	14092
	Tooth Extraction	23824	306	36	24166
	Exodontia	23903	1	9	23913
Maxillary Sinus	Maxillary Sinus	16536	35	52	16623
	Sinus Anatomy	41450	17	185	41652
	Schneiderian Membrane	30189	18	0	30207
Pathologies	Sinus Abnormalities	16032	176	83	16291
	Periapical Abscess	2005	7	7	2019
	Periodontitis	36335	101	269	36705
Surgical Procedures	Candidate Site	9355	247	120	9722
	Endodontics	37412	50	108	37570
	Implant Dentistry	15440	60	101	15601
	Dental Implant	42325	64	230	42619
	Dental Implant Complications	4866	51	35	4952
	Sinus Floor Elevation	832	8	1	841
Radiology	Dental X-Ray	30688	44	43	30775
	OPG	312	3	6	321
	Orthopantomogram	312	14	1	327
Combination of Keywords within Theme	“Molar Teeth“ OR “Premolar Teeth“ OR “Tooth Extraction“ OR “Exodontia“	24057	74	0	24131
	“Maxillary Sinus“ OR “Sinus Anatomy“ OR “Schneiderian Membrane“	14878	26	0	14904
	“Sinus Abnormalities“ OR “Periapical Abscess“ OR “Periodontitis“	32757	102	0	32859
	“Candidate Site“ OR “Endodontics“ OR “Implant Dentistry“ OR “Dental Implant“ OR “Dental Implant Complications“ OR “Sinus Floor Elevation“	28894	63	0	28957
	“Dental X-Ray“ OR “OPG“ OR “Orthopantomogram“	6386	3	0	6389
Combination of Themes	**(“Molar Teeth“ OR “Premolar Teeth“ OR “Tooth Extraction“ OR “Exodontia“) AND (“Maxillary Sinus“ OR “Sinus Anatomy“ OR “Schneiderian Membrane“)**	436	5	0	441
	(“Molar Teeth“ OR “Premolar Teeth“ OR “Tooth Extraction“ OR “Exodontia“) AND (“Maxillary Sinus“ OR “Sinus Anatomy“ OR “Schneiderian Membrane“) AND (“Sinus Abnormalities“ OR “Periapical Abscess“ OR “Periodontitis“)	26	4	0	30
	(“Molar Teeth“ OR “Premolar Teeth“ OR “Tooth Extraction“ OR “Exodontia“)	0	0	0	0

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	AND (“Maxillary Sinus“ OR “Sinus Anatomy“ OR “Schneiderian Membrane“) AND (“Sinus Abnormalities“ OR “Periapical Abscess“ OR “Periodontitis“) AND (“Candidate Site“ OR “Endodontics“ OR “Implant Dentistry“ OR “Dental Implant“ OR “Dental Implant Complications“ OR “Sinus Floor Elevation“) AND (“Dental X-Ray“ OR “OPG“ OR “Orthopantomogram“)				
	Total Number of Hits	488884	1611	1318	491813

Table 2. Google Trends: Top Related Queries on the Maxillary Sinus.

	Related Queries
1.	Maxillary sinus cyst
2.	Maxillary sinus infection
3.	Left maxillary sinus
4.	Right maxillary sinus
5.	Maxillary sinus pain
6.	Maxillary sinusitis
7.	Maxillary sinus retention cyst
8.	Sinus lift surgery
9.	Sinus graft
10.	Sinus augmentation
11.	Sinus lift procedure
12.	Sinus lift cost
13.	Sinus lifting
14.	Dental implants
15.	Sinus lift recovery
16.	Endodontic treatment
17.	Devitalisation
18.	Gum disease
19.	Periodontitis
20.	Gingivitis
21.	Gum disease treatment
22.	Periodontal treatment

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Table 3. Descriptive Statistics: Geo-mapping (top) and Temporal Trends (bottom).

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Schneiderian Membrane	47	0	0	0	.00	.000	.000	.000
Maxillary Sinus	47	14	0	14	2.81	.627	4.297	18.463
Sinus Lift	47	15	0	15	1.47	.399	2.733	7.472
Endodontics	47	75	1	76	27.43	2.754	18.884	356.598
Periodontal Disease	47	77	22	99	68.30	3.135	21.490	461.822
Valid N (listwise)	47							

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Schneiderian Membrane	260	1	0	1	.02	.009	.138	.019
Maxillary Sinus	260	3	1	4	2.64	.037	.589	.346
Sinus Lift	260	1	1	2	1.27	.028	.446	.199
Endodontics	260	18	16	34	25.59	.169	2.729	7.448
Periodontal Disease	260	66	34	100	54.38	.377	6.075	36.901
Valid N (listwise)	260							

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Table 4. Geo-Mapping: Paired Samples Correlation (top) and Paired Sample Student's t-test (bottom).

		N	Correlation	Sig.
Pair 1	Schneiderian Membrane & Maxillary Sinus	47	.	.
Pair 2	Schneiderian Membrane & Sinus Lift	47	.	.
Pair 3	Schneiderian Membrane & Endodontics	47	.	.
Pair 4	Schneiderian Membrane & Periodontal Disease	47	.	.
Pair 5	Maxillary Sinus & Sinus Lift	47	-.100	.506
Pair 6	Maxillary Sinus & Endodontics	47	.293	.046
Pair 7	Maxillary Sinus & Periodontal Disease	47	-.445	.002
Pair 8	Sinus Lift & Endodontics	47	.330	.023
Pair 9	Sinus Lift & Periodontal Disease	47	-.398	.006
Pair 10	Endodontics & Periodontal Disease	47	-.979	.000

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Schneiderian Membrane - Maxillary Sinus	-2.809	4.297	.627	-4.070	-1.547	-4.481	46	.000
Pair 2	Schneiderian Membrane - Sinus Lift	-1.468	2.733	.399	-2.271	-.666	-3.682	46	.001
Pair 3	Schneiderian Membrane - Endodontics	-27.426	18.884	2.754	-32.970	-21.881	-9.957	46	.000
Pair 4	Schneiderian Membrane - Periodontal Disease	-68.298	21.490	3.135	-74.608	-61.988	-21.788	46	.000
Pair 5	Maxillary Sinus - Sinus Lift	1.340	5.317	.776	-.221	2.902	1.728	46	.091
Pair 6	Maxillary Sinus - Endodontics	-24.617	18.098	2.640	-29.931	-19.303	-9.325	46	.000
Pair 7	Maxillary Sinus - Periodontal Disease	-65.489	23.715	3.459	-72.452	-58.526	-18.932	46	.000
Pair 8	Sinus Lift - Endodontics	-25.957	18.165	2.650	-31.291	-20.624	-9.797	46	.000
Pair 9	Sinus Lift - Periodontal Disease	-66.830	22.716	3.313	-73.499	-60.160	-20.169	46	.000
Pair 10	Endodontics - Periodontal Disease	-40.872	40.165	5.859	-52.665	-29.079	-6.976	46	.000

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Table 5. Temporal Trends: Paired Samples Correlation (top) and Paired Sample Student's t-test (bottom).

		N	Correlation	Sig.
Pair 1	Schneiderian Membrane & Maxillary Sinus	260	-.010	.871
Pair 2	Schneiderian Membrane & Sinus Lift	260	.166	.007
Pair 3	Schneiderian Membrane & Endodontics	260	.011	.861
Pair 4	Schneiderian Membrane & Periodontal Disease	260	-.055	.377
Pair 5	Maxillary Sinus & Sinus Lift	260	.226	.000
Pair 6	Maxillary Sinus & Endodontics	260	.516	.000
Pair 7	Maxillary Sinus & Periodontal Disease	260	.495	.000
Pair 8	Sinus Lift & Endodontics	260	.330	.000
Pair 9	Sinus Lift & Periodontal Disease	260	.218	.000
Pair 10	Endodontics & Periodontal Disease	260	.669	.000

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Schneiderian Membrane - Maxillary Sinus	-2.623	.606	.038	-2.697	-2.549	-69.814	259	.000
Pair 2	Schneiderian Membrane - Sinus Lift	-1.254	.445	.028	-1.308	-1.200	-45.452	259	.000
Pair 3	Schneiderian Membrane - Endodontics	-25.569	2.731	.169	-25.903	-25.236	-150.966	259	.000
Pair 4	Schneiderian Membrane - Periodontal Disease	-54.362	6.084	.377	-55.104	-53.619	-144.082	259	.000
Pair 5	Maxillary Sinus - Sinus Lift	1.369	.653	.041	1.289	1.449	33.793	259	.000
Pair 6	Maxillary Sinus - Endodontics	-22.946	2.477	.154	-23.249	-22.644	-149.366	259	.000
Pair 7	Maxillary Sinus - Periodontal Disease	-51.738	5.806	.360	-52.447	-51.029	-143.694	259	.000
Pair 8	Sinus Lift - Endodontics	-24.315	2.616	.162	-24.635	-23.996	-149.889	259	.000
Pair 9	Sinus Lift - Periodontal Disease	-53.108	5.993	.372	-53.840	-52.376	-142.884	259	.000
Pair 10	Endodontics - Periodontal Disease	-28.792	4.707	.292	-29.367	-28.217	-98.629	259	.000

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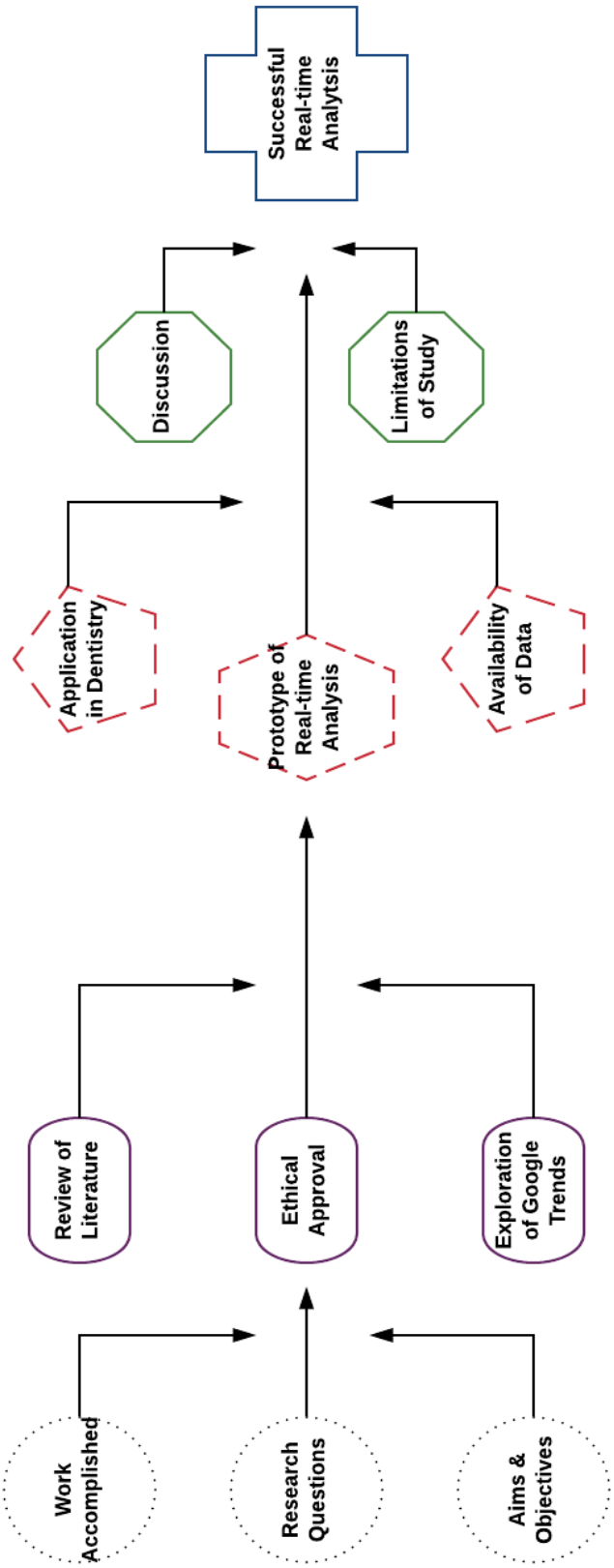

Figure 1. Flowchart of the Implemented Methods of Research.

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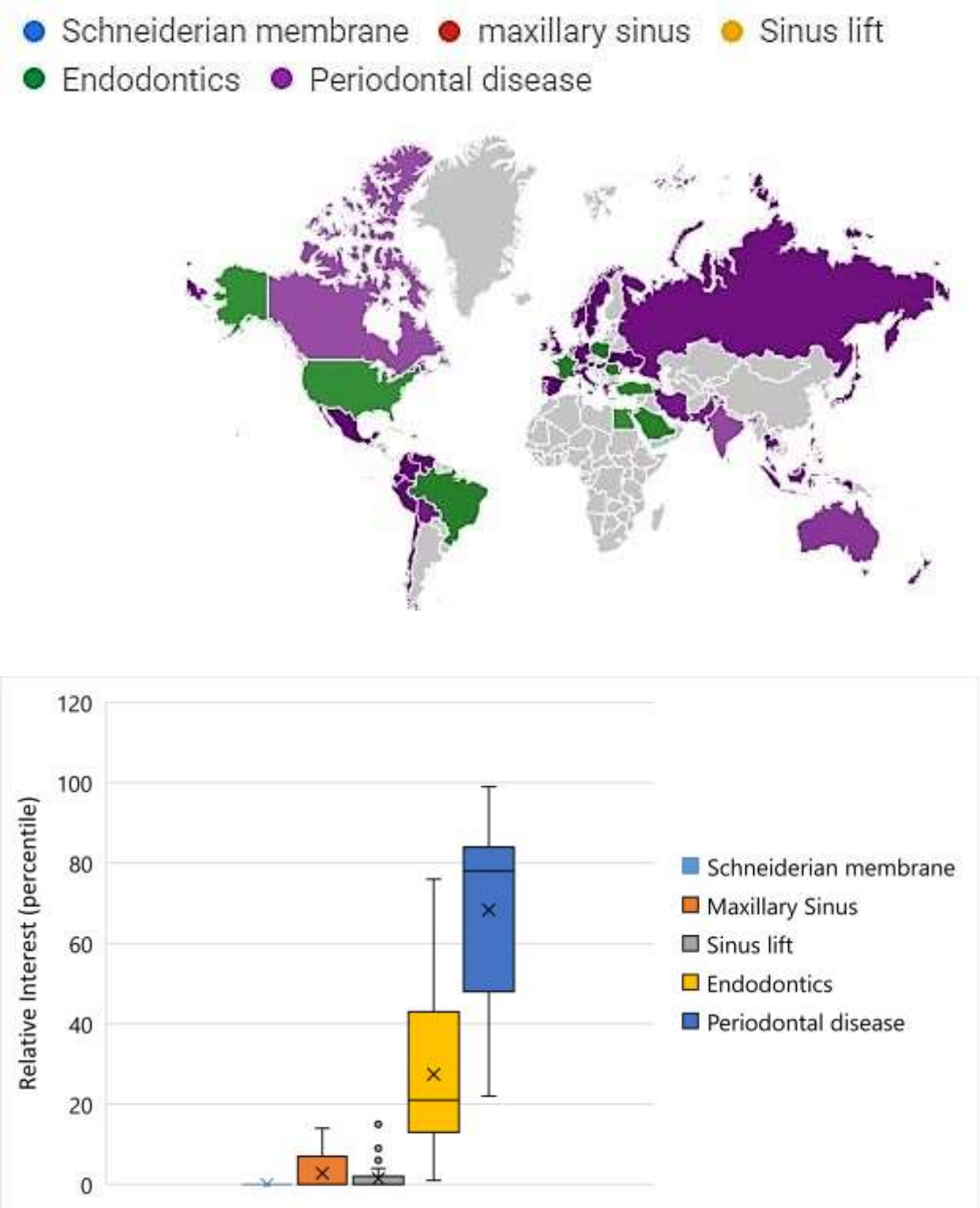

Figure 2. Geographic Mapping: Map Chart (top) and Boxplot Presentation (bottom).

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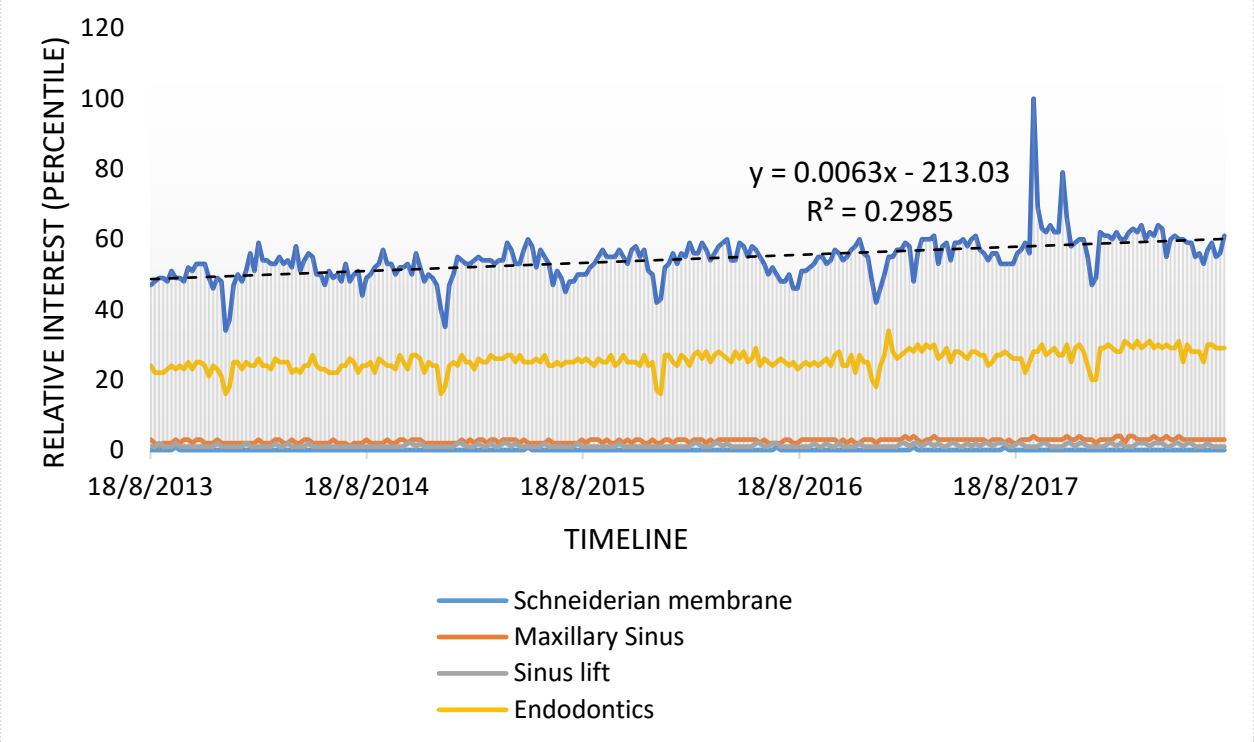

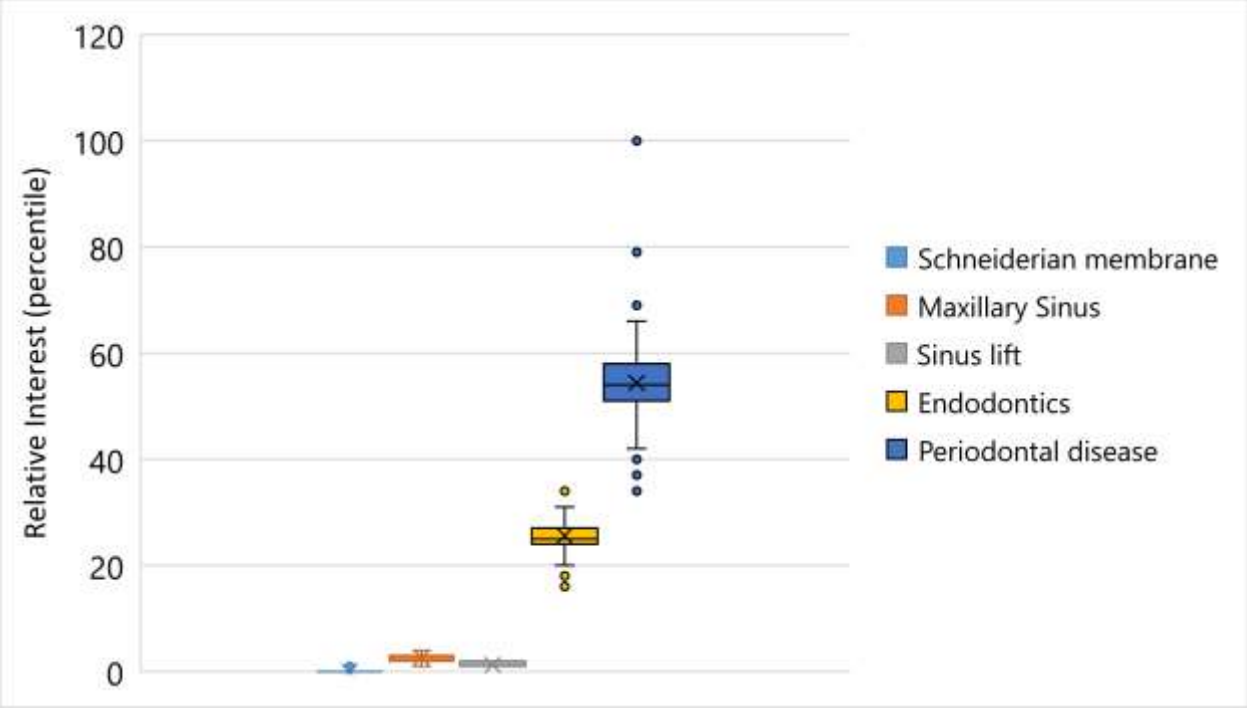

Figure 3. Temporal Trends: Trends (top) and Boxplot Presentation (bottom).

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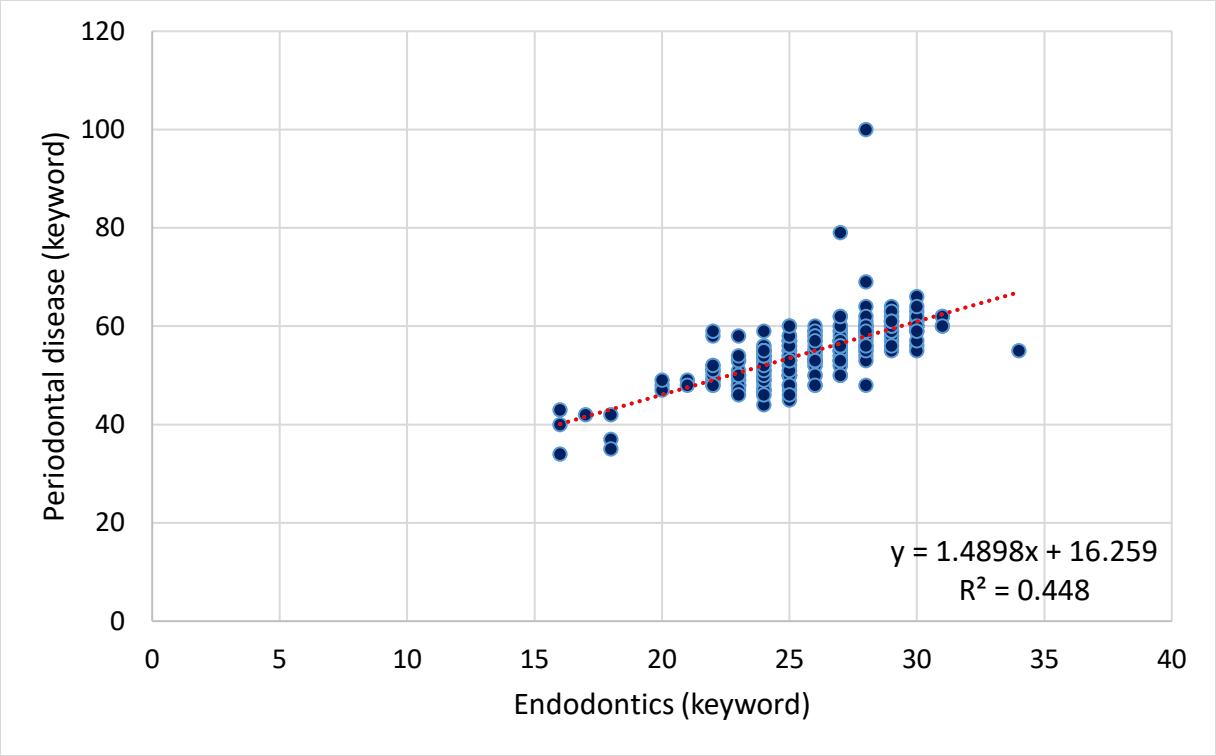

Figure 4. Scattered Correlation and Regression Analysis: Endodontics versus Periodontal Disease.