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Correlation between the Epidemiology of COVID-19 and Exposure to Malaria Disease and BCG Vaccine across the Globe

Naveen Sharma* **and Priyanka Mishra**

*Independent Researcher, K19/13, K block, DLF Phase 2, Gurgaon, Haryana, Pin code: 122002, India

ABSTRACT

The COVID-19 has outspreaded and proliferated across all regions of the world soaring to the level of a global pandemic. According to WHO, more than 2.1 million people have been affected by the Coronavirus till 20th April 2020. The present study delineated two aspects of COVID-19 pandemic, first, the comparison of COVID-19 incidences in Malaria affected areas against non-affected area. The second comparison of the COVID-19 incidences in the countries with BCG policy against no BCG policy countries. The present study depicted that the incidences of COVID-19 per million populations are 9.75 times higher in regions of the world (Europe, and US) with zero incidences of Malaria compared to those (Asia and Africa) who have reported maximum incidences (98.6% cases) of Malaria. The combined average of COVID-19 incidences per million is reported as 7.896 times higher in the Europe, US and Canada in comparison with combined average of Asia and Africa. The present study also deciphered a possible inverse relation between COVID-19 Incidences and BCG vaccine policy. The incidences of COVID-19 per million populations are reported to be 9.798 times higher in regions of the world (Europe, UK and US) with No BCG vaccine policy in comparison to the countries that have ongoing BCG vaccination policy included in the immunization schedule.

Keywords: COVID-19, Malaria, BCG, Vaccination

INTRODUCTION

As per World Health Organization (WHO) [1], Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered corona virus. The major signs and symptoms of the diseases are mild to moderate respiratory illness that can recover without requiring special treatment. The probability of complication development can be higher in older people, and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer. The mode of transmission of COVID-19 virus is primarily through the droplets of saliva or discharge from the nose of an infected person's cough or sneeze (WHO, 2019).

CASE DEFINITION

As per WHO [1] updates on the Global Surveillance for human infection with Coronavirus disease, COVID-19 can be defined as follows: "A patient with acute respiratory illness (fever and at least one sign/symptom of respiratory disease, e.g., cough, shortness of breath), AND a history of travel to or residence in a location reporting community transmission of COVID-19 disease during the 14 days prior to symptom onset".

OR

***Corresponding Author:**
dr.naveenshandilya[at]gmaildotcom

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"A patient with any acute respiratory illness and having been in contact with a confirmed or probable COVID-19 case (see definition of contact) in the last 14 days prior to symptom onset"

OR

"A patient with severe acute respiratory illness (fever and at least one sign/symptom of respiratory disease, e.g., cough, shortness of breath; and requiring hospitalization) and in the absence of an alternative diagnosis that fully explains the clinical presentation [2]".

Epidemiology

As per the MSD Manual reports [1], 1st case of COVID-19 was reported in China in Wuhan city in December 2019 proceeding which the spread of virus has been observed in China and globally (MSD Manual, 2020). As per National Institute of Allergy and Infection Diseases [3,4] nearly 1 million people were affected in first three months of pandemic origin and 50000 deaths were reported. A study published by Huang et al [5] in January 2020 delineated that the disease was first observed in December 2019 in Wuhan, Hubei, China, with clinical presentations greatly resembling viral pneumonia. The Huanan seafood market is considered as the ground zero for the origin of virus. 66% of total 41 confirmed COVID-19 cases were having a history of direct exposure to the Huanan seafood market. (Huang et al, 2020). MSD Manual reports [4] confirmed the linkage of a live animal market in Wuhan, China to virus spread, which delineated that COVID-19 may have come from animals (MSD Manual, 2020). The cause and route of human contamination from animal reservoir has not been proved till now. As per National Institute of Allergy and Infection Diseases4 it is yet to be discovered how COVID-19 entered the human being. The research pertaining to the same is perpetually progressing.

A strong geographical disparity is observed in the spread of COVID-19 cases. Europe, UK and U.S have reported significantly higher incidences of COVID-19 as compared to Asian and African countries. The Malaria and Tuberculosis spread has also shown geographical distinctions but depicted a reverse trend to COVID-19 spread, so the current study explores the relation between Malaria & BCG vaccine exposure to COVID-19 spread across the globe and describes the probability of a potential correlation.

METHODOLOGY

Aim: The aim of the study is to explore the correlation between Malaria & BCG Vaccine exposures to COVID-19 spread across the globe.

Study Design: The current study utilizes the exploratory study design and Quantitative research methodology.

Statistical Analysis: The current study depicted an Excel based statistical model to delineate the COVID-19 Incidences, Malaria incidences and BCG Vaccine policy.

The model utilizes the data from the following sources: A) WHO COVID-19, Situation Report – 88 B) Worldometers Corona Pandemic Information Reports April 20th, 2020 C) WHO COVID-19, Situation Report – 91D) WHO World Malaria Report, 2018 E) WHO World Malaria Report, 2019F) World Bank Malaria Incidence Reports G) Malaria Incidence reports by Our World in Data (University of Oxford researchers based organization) BCG World Atlas. The model encompasses only the data of countries which have reported 100 or greater COVID-19 cases till 20thApril 2020 to plunge the selection bias and to exclude the outliers. The model also encompassed the followings:

a. List of countries who have adopted BCG vaccination policy

b. List of countries who either never had or ceased BCG vaccination policy in past. These lists are compiled based on data from BCG World Atlas.

Malaria and COVID-19 Incidences Analysis Model

Firstly, the model incorporates WHO region-wise share of COVID-19 cases till 17th April in comparison to Malaria prevalence share of 2018 by utilizing WHO World Malaria Report, 2018. Secondly, model encompasses the country wise incidences of Malaria and utilizes the average incidence of Malaria from 2010-2017 by deciphering data from World Bank Malaria Incidence Reports & Malaria Incidence reports by "Our World in Data". Country wise Malaria incidences were compared with country wise incidences of COVID-19 till 20thApril 2020. The COVID-19 data was taken from Worldometer and WHO COVID-19, Situation Report – 91. The model also deciphered the comparison of WHO region-wise COVID-19 and Malaria Incidences for further and deep analysis. The model also includes the country-wise and region-wise COVID-19 Case Fatality Rate and compared it with Malaria exposure.

BCG Vaccine Exposure and COVID-19 Incidences Analysis Model

The model incorporates country wise share of COVID-19 cases till 20th April from Worldometer and WHO COVID-19, Situation Report – 91. The model encompassed the list of countries with BCG vaccination policy and countries with either no BCG vaccination policy or ceased it in past. The COVID-19 incidences of these countries were deciphered from Worldometer and list of countries for BCG policy was deciphered from BCG world atlas. The COVID-19 incidences of the countries exposed to BCG vaccine were compared with the incidences of countries with no BCG vaccine exposure or limited BCG vaccine exposure.

RESULTS

Malaria Incidences: According to WHO [6], Africa shared 93.13% of Malaria cases in 2018 followed by South East Asia sharing 3.45%of total Malaria cases. East Mediterranean shared 2.14% cases where America shared a negligible of 0.41% cases and Europe, USA and Canada did not report any cases of Malaria in year 2018 (*WHO World Malaria Report, 2018).* According to WHO [7], "nineteen countries in sub-Saharan Africa and India carried almost 85% of the global malaria burden. Six countries accounted for more than half of all malaria cases worldwide: Nigeria (25%), the Democratic Republic of the Congo (12%), Uganda (5%), and Côte d'Ivoire, Mozambique, Niger (4% each). India also contributes 4% of total cases of Malaria" (WHO World Malaria Report, 2019). The average incidence of Malaria [8,9] between 2010-2017 in top 20 countries of WHO's list of most effected countries is 334.87 cases per 1000 population at risk and 232.79 cases per 1000 population at risk for top 50 countries, most of these countries belong to African continent *(Our World in Data Reports and World Bank Reports on malaria Incidences.)*

Comparison of COVID-19 Incidences and Malaria Incidences

The regions of world with highest COVID-19 burden [10] have reported least Malaria burden and vice-a-versa. Africa and South East Asia shared 96.6% burden of Malaria in 2018 [6] but only shared 1.71% of COVID-19 incidences per 1M population till 17thApril 2020. America and Europe reported merely 0.41% incidences of Malaria in 2018 but has reported 86.37% of total incidences of COVID-19 per 1M population till 17thApril 2020. Europe and America's combined reported 50.35 times more cases of COVID-19 than Africa & South East Asia combined. Africa & South East Asia combined reported 237.78 times more cases of Malaria in 2018 than combined cases of Europe and America. Figure 1 and Figure 2

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delineates the comparison Malaria and COVID-19 incidences. The below mentioned maps showed a completely opposite distribution of Malaria [6] and COVID-19.

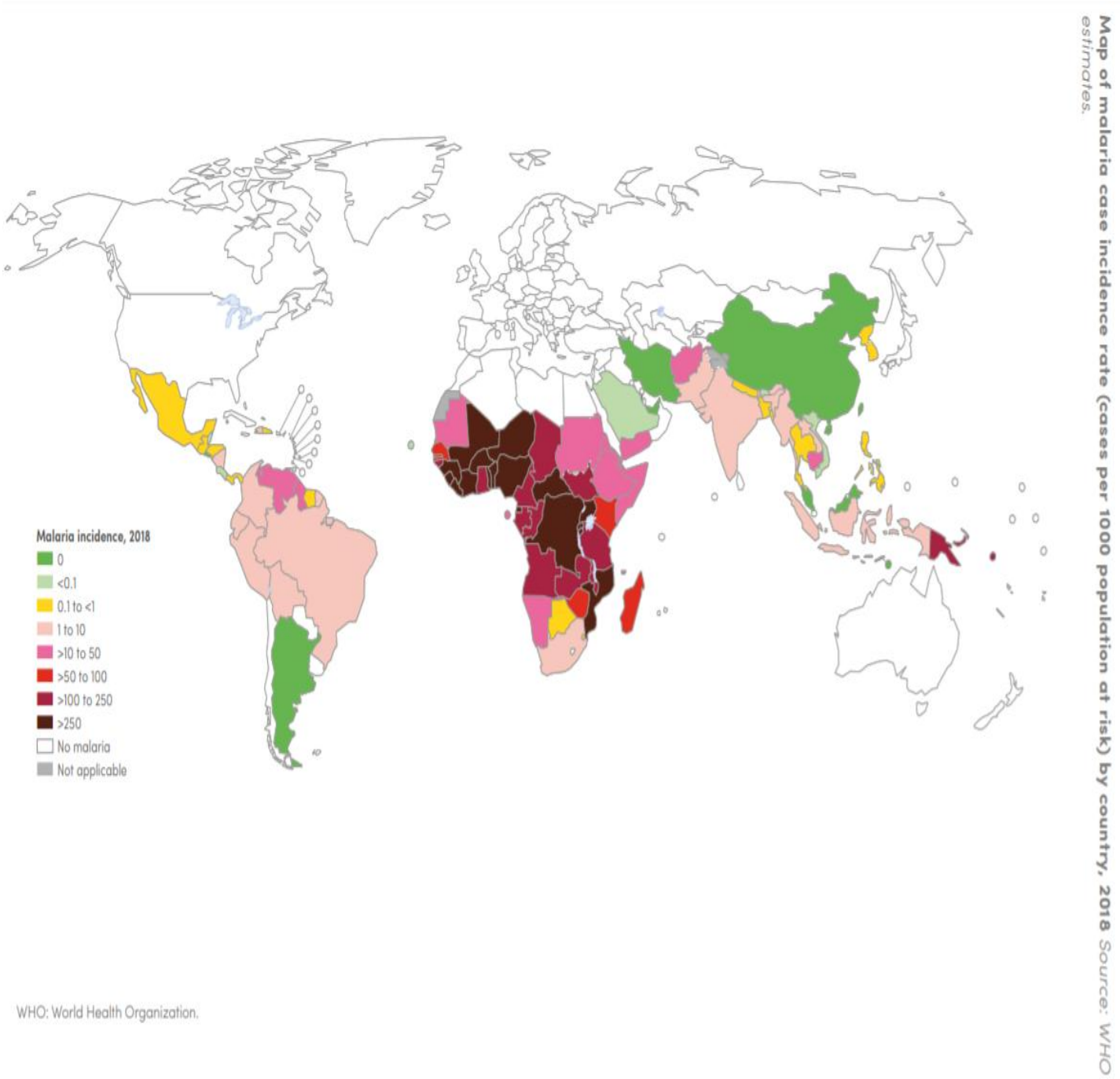

Figure 1: Delineates the spread of Malaria by showing its incidence on world map

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Comparison of Malaria Incidences and COVID-19 Incidences across the globe [10]

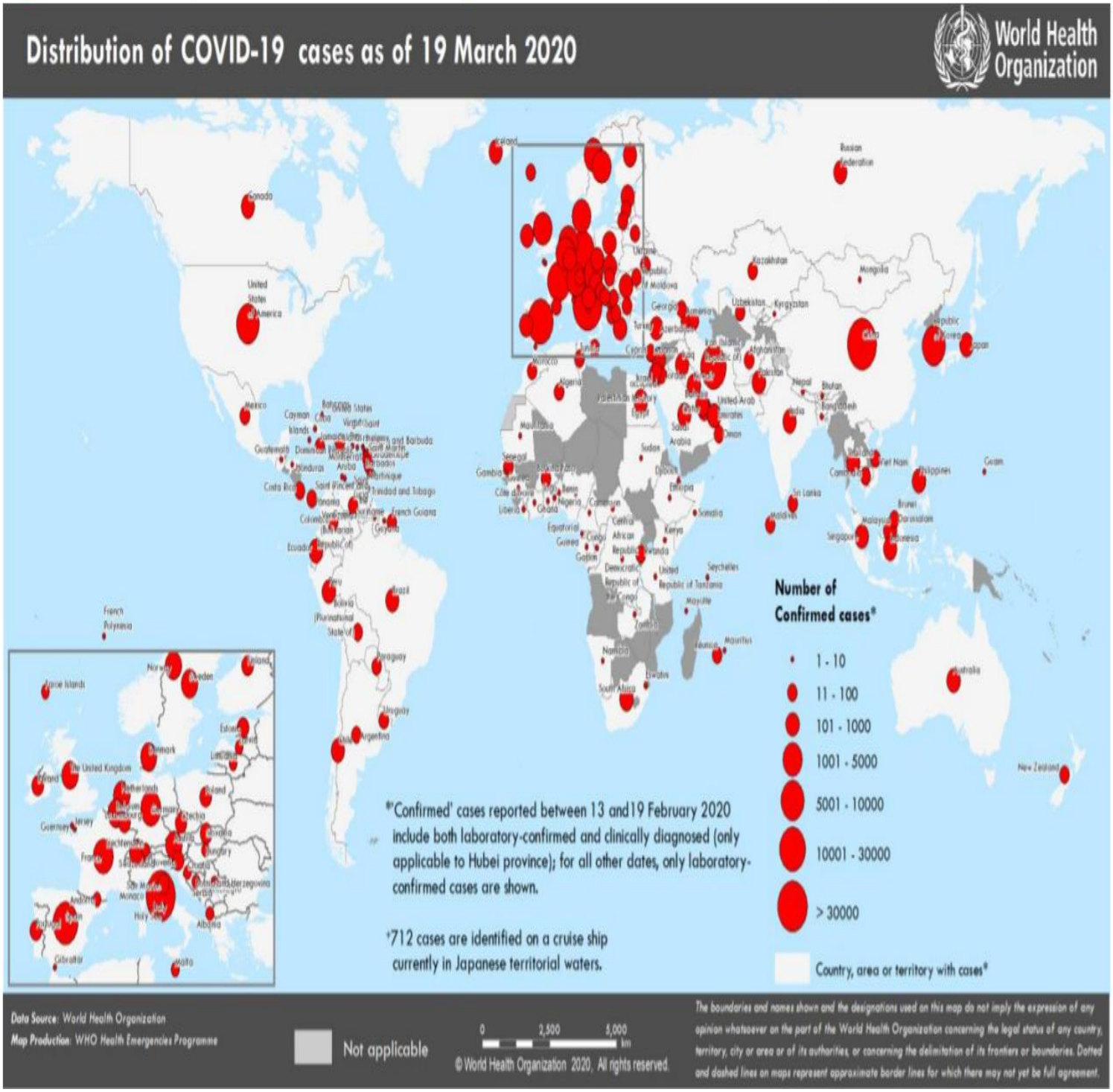

Figure 2: Delineates the spread of COVID-19 till 20th April 2020 by showing its incidence on world map

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We complied a WHO region-wise geographical distribution of Malaria and COVID incidence share. This geographical distribution delineated an inversely proportional relationship between COVID-19 spread and Malarial spread.

Table 1: The share of COVID-19 and Malaria across various regions of world

	Malaria in 2018		**COVID-19 in 2020 (till 17th April, 2020)**	
Name of Region/Country	Total Cases	Percentage out of total	Total Cases	Percentage out of total
Africa	213000	93.13%	12360	0.60%
America	929	0.41%	743607	35.84%
East Mediterranean	4900	2.14%	115824	5.58%
South East Asia	7900	3.45%	23560	1.14%
Europe Region	0	0.00%	1050871	50.66%
Western Pacific	1980	0.87%	127595	6.15%
Others	0	0.00%	712	0.03%
Total	228709	100.00%	2074529	100.00%

Source: WHO World Malaria Report, 2018[6] and WHO Coronavirus disease 2019 (COVID-19) Situation Report – 88 [2]

The combined incidences [8] of COVID-19 per million population is 9.75 times higher in regions of the world (Europe, and US) with zero incidences of Malaria (during 2010-2017) than Asia and Africa combined who have reported maximum incidences (98.6% cases) of Malaria. COVID-19 incidences are 7.896 times higher if average of Europe, US and Canada is compared against average of Asia and Africa.

*(*comparative incidence calculation includes Asia as combination of South East Asia and East Mediterranean for Malaria incidences due to unavailability of Asian Malarial data, and comparative incidence calculation represents Asia figure of COVID-19 incidences including all Asia countries with COVID-19 incidences equal to or greater than 100 till 17th April 2020)*

Europe [8] (least exposure to Malaria) has reported 16.98 times more incidences of COVID-19 [11] as compared to Africa (maximum exposure to Malaria) till 20th April 2020. The data is delineated in succinct details in Table 2.

Table 2: COVID-19 incidences and case fatality rate in various regions of world

Name of Region/Country	**Incidence of COVID-19/1M Population**	**Deaths/1M**	**Case Fatality Rate (%)**
USA	2309	123.0	5.30
Europe	2021	117.6	9.34

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Canada	929	42.0	4.53
World	840	43.3	6.85
North America	431	20.7	5.28
Asia	326	4.8	3.84
Oceania	280	2.5	1.03
South America	210	7.2	4.68
Africa	119	2.2	4.92
India	13	0.4	3.17

Source; Worldometer reports [11] https://www.worldometers.info/coronavirus/

Case Fatality Rate (CFR) Comparison

The case fatality rate (CFR) reported [11] is also higher in the countries which were not exposed to Malaria than to those who were exposed. The combined average of case fatality rate of Europe and America is 3 times higher than Asia and Africa's combined average. Europe has reported highest CFR of 9.34%, followed by USA with CFR of 5.30% and North America with CFR of 5.3%. The combined reported CFR average of Malaria exposed regions was 2.48%. The countries with maximum Malaria burden Nigeria (25%), the Democratic Republic of the Congo (12%), Uganda (5%), and Côte d'Ivoire, Mozambique, Niger and India (4% each) have reported least incidences of COVID-19. The combined average of incidence rates of COVID in Nigeria, the Democratic Republic of the Congo Uganda, Côte d'Ivoire and Niger was reported as 21.5 cases per 1 M population [8,9,11]. Mozambique has reported a total of only 39 cases of COVID-19 till 20th April 2020.

In Asia, the top 15 COVID-19 countries [8,9,11] (Qatar, Israel, Singapore, Bahrain, Turkey, Iran, UAE, Cyprus, Kuwait, Armenia, Brunei, Oman, Saudi Arabia, S. Korea and Malaysia) reported an average of 762 COVID-19 cases per 1M whereas all these top-15 COVID-19 countries have reported negligible incidences of Malaria. The bottom 10 countries [8,9,11] (Iraq, Afghanistan, Indonesia, Taiwan, Bangladesh, Sri Lanka, India, Cambodia, Vietnam and Myanmar) in the list of COVID-19 incidences reported maximum Malaria incidences in Asia during 2010-2017. India alone shared the 4% burden of world Malaria cases in 2019 whereas India only has 0.66% of total COVID cases till April 2020 despite of having 2nd largest population of 1.35 billion in the world.

The above-mentioned data points delineated an inverse relation between Malarial and COVID-19 spread which cue to the fact that there can potentially be a correlation between the COVID-19 incidences and Malaria exposure.

BCG Vaccine Exposure and COVID-19 Incidences

We prepared the lists of countries with BCG policy or with no BCG policy (either never had a BCG vaccination policy or ceased it in past). No BCG policy countries list encompassed the following countries: Finland, France, Italy, Slovenia, Sweden, Austria, Czechia, Greece, Ireland, Israel, Malta, Portugal, Slovakia, USA, Germany, UK and Spain.

We deciphered the COVID-19 incidences of the non-BCG vaccination policy countries and compared with COVID-19 incidences of the countries with BCG vaccination policy [14]. The incidences of COVID-19 per million population is 9.798 times higher in countries/regions of the world (Europe, UK and US) where BCG vaccine either has never been included in immunization policy or has been curbed a long time ago. Average incidence of COVID-19 in countries with no BCG vaccine exposure was repoted as

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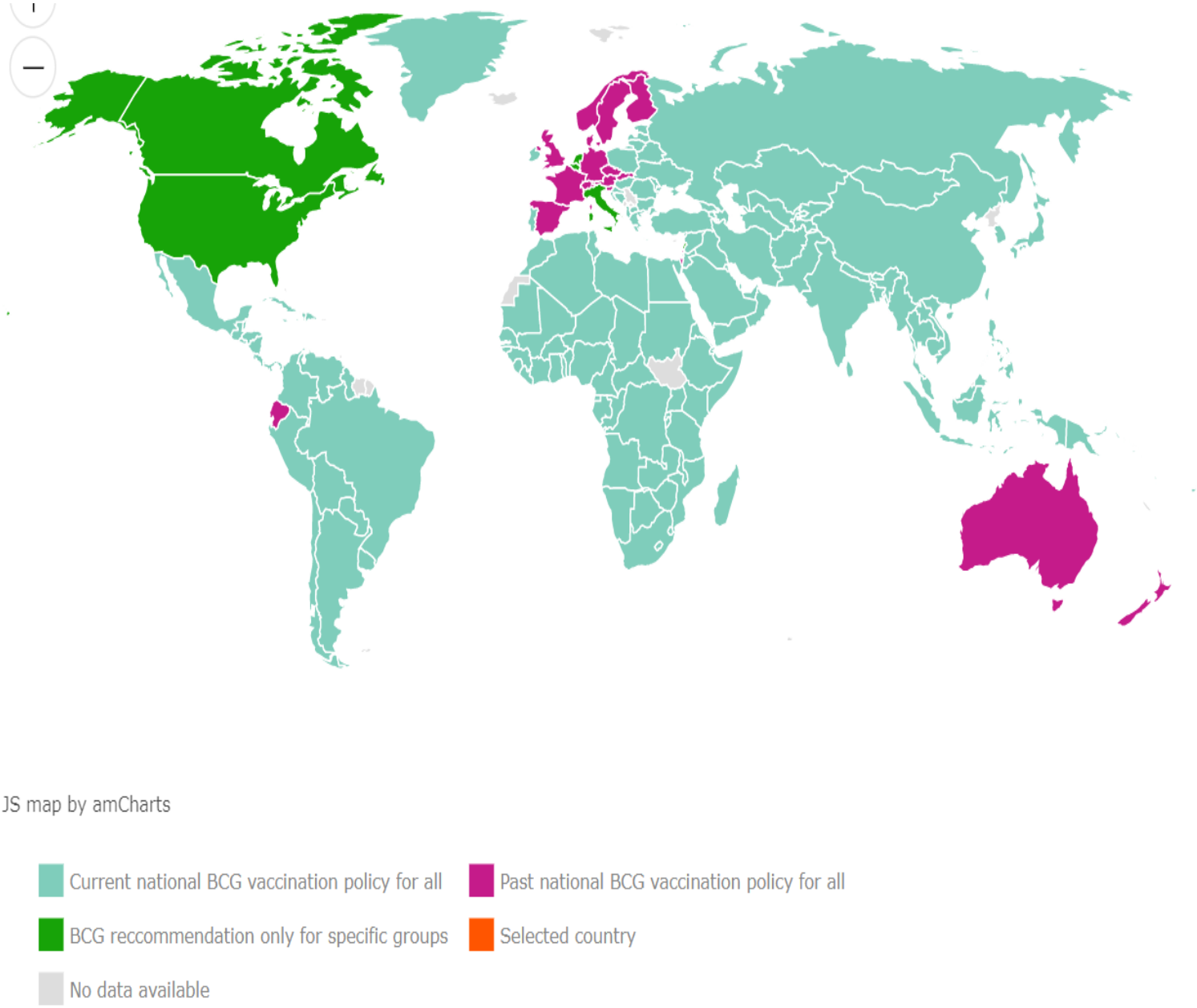
1675.3 cases per 1M population at risk whereas the same was reported as 170.96 cases per 1M population in countries with vaccination policy. The Table 3 and 4 delineates the list of countries with & without BCG vaccination policy along with respective COVID-19 incidences.



Source: ***Zwerling et al, 2011*** ***http://www.bcgatlas.org/*** **[12,13]**

Figure 3: Delineates BCG vaccination policy status across the world (countries with current/past/no BCG vaccination policy)

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Table 3: COVID-19 Incidences in the countries with No Vaccine policy

Countries with No BCG or Limited Exposure to BCG	COVID-19 Incidences till 20th April, 2020
Finland	698
France	2342
Italy	2960
Slovenia	642
Sweden	1424
Austria	1638
Czechia	634
Greece	214
Ireland	3089
Israel	1577
Malta	967
Portugal	1982
Slovakia	213
USA	2309
Germany	1740
UK	1769
Spain	4282
Average of All	**1675.29**

Source; Worldometer reports https://www.worldometers.info/coronavirus/ [11]

Table 4: COVID-19 Incidences in the countries with BCG Policy

BCG Policy Countries	COVID-19 Incidences till 20th April, 2020
India	13
China	57
Indonesia	25
Nigeria	3
Bangladesh	18
South Africa	53
Ethiopia	0.9
Pakistan	38
Philippines	59
Congo	26
Kenya	5
Russia	323
Vietnam	3
Tanzania	3

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Uganda	1
Thailand	40
Mozambique	1
Brazil	182
Myanmar	2
Zimbabwe	2
Cambodia	7
Afghanistan	26
Armenia	452
Belarus	506
Croatia	456
Czechia	634
Fiji	20
Kazakhstan	94
Macedonia	588
Moldova	613
Norway	1310
Ukraine	131
Tunisia	74
Uzbekistan	47
Average of all	**170.97**

Source; Worldometer reports https://www.worldometers.info/coronavirus/ [11]

Limitations of study

The present study is based on data triangulation model and cue a correlation between COVID-19 spread and Malaria & BCG vaccine. The study utilizes a simple excel based model and does not encompass statically analysis tools typically used in quantitative research. The study delineates the correlation between COVID-19 incidences and Malaria& BCG exposure but does not encompass the other associated factors which can influence the correlation like diagnosis percentage per million population, environmental factors, geographical factors, epidemic spread timing etc.

DISCUSSION

There is dearth of published literature on the correlation of COVID-19 and Malaria or COVID-19 and BCG. One news article [15] published in Economics times of India described similar findings on relationship between COVID-19 and BCG exposure by mentioning that “incidence of Covid-19 was 38.4 per million in countries with BCG vaccination compared to 358.4 per million in the absence of such a program. The present study delineated a possible correlation between Malaria and BCG exposure to COVID-19 incidences, but further research is required to explore the mentioned issue in detail considering lack of studies and limitation of current study.

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ABBREVIATIONS

- World Health Organization (WHO)
- Coronavirus Disease (COVID-19)
- Bacille Calmette-Guerin Vaccine (BCG vaccine)

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