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STATISTICAL ANALYSIS OF THE TOP CITED SCIENTISTS FROM THE MIDDLE EAST FOR 2025

Mohammad Aref Abdul Rasheed[1], Sameen Ahmed Khan[2] and Shamik Siddiqui[3]

[1]Dhofar University, Department of MIS, College of Commerce and Business Administration, Salalah, Sultanate of Oman. Email: mohammed_aref@du.edu.om, Orcid ID: https://orcid.org/0000-0002-0450-8157
[2]Dhofar University, Department of Mathematics and Sciences, College of Arts and Applied Sciences, Salalah, Sultanate of Oman. Email: rohelakhan@yahoo.com, Orcid ID: http://orcid.org/0000-0003-1264-2302
[3]Conestoga College, Ontario, Canada. Email: ssiddiqui1@conestogac.on.ca

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Corresponding Author: Mohammad Aref Abdul Rasheed (mohammed_aref@du.edu.om)

ABSTRACT

Elsevier BV has issued the annual datasets for 'Updated science-wide author databases of standardized citation metrics' in September 2025. The two datasets contain the top two percent of the most-cited scientists worldwide in various disciplines under two categories, "career-long" and for "single recent year impact" respectively. This study investigates the research capacity across middle eastern countries (GCC) and world using indicators such as researchers per million, publications per million, R&D expenditure (% GDP), and concentration of top-cited scientists. The statistical data analysis techniques such as descriptive statistics, correlation, clustering analyses, nonparametric and parametric tests, multivariable regression, and visualization have been used. The results demonstrate both expected and surprising patterns, providing insights for policymakers aiming to strengthen research systems.

KEYWORDS: Statistical Analysis, Datasets, Top 2% Scientists, Elsevier-Stanford Lists, Middle East.

1. INTRODUCTION

The most recent annual data-update (version 8, 2025) for "Updated science-wide author databases of standardized citation indicators" was published by Elsevier BV in 2025. Since 2019, John P. A. Ioannidis and collaborators from the Stanford University, Stanford, USA have been compiling a publicly available database of top-cited scientists that provides standardized information on citations, h-index, co-authorship adjusted hm-index, citations to papers in different authorship positions and a composite indicator called as the "c-score" [1-9]. There are two distinct categories of datasets for "career-long" and for "single recent year impact" respectively. The two datasets cover metrics with and without self-citations and ratio of citations to citing papers. Scientists are classified into 22 scientific fields and 174 sub-fields. Both the datasets contain field-specific and subfield-specific percentiles for all scientists, who have at least five published papers in their Scopus profiles. The selection is based on the top 100,000 by a composite c-score (with and without self-citations) or a percentile rank of 2% or above in the sub-fields. Hence, the top two percent scientists. The two lists are frequently referred to as the "Stanford Lists of Top 2% Scientists" as the compilation is done at Stanford University! The data used in arriving at these two lists are based on the reputed database, Scopus run by Elsevier Publishing Group, Netherland. Scopus data are provided through ICSR Lab (International Center for the Study of Research, https://www.elsevier.com/icsr/icsrlab), which is a cloud-based computational platform, which enables the analysis of large structured datasets. The latest lists contain the career-long data updated to end-of-2024, whereas the single recent year data pertain to citations received during calendar year 2024. Using the aforementioned criteria, the career-long dataset has 230334 scientists and the single recent year dataset has 236314 scientists [8-9]. The latest edition of the database is version-8 and is based on the September 19, 2025 snapshot from Scopus, updated to end of citation year 2024.

Scientific research capacity is a crucial determinant of national competitiveness and innovation. The Gulf Cooperation Council (GCC) countries have invested heavily in research and development. This study evaluates whether these investments translate into higher research outputs compared to Non-GCC Middle Eastern countries. Taken together, the Single Year list and Career list reflect on the standing of individual scientists, their institutions and the countries at large. In this article, we present the data for the countries from the Middle East. We present a detailed statistical analysis covering factors such as per-capita indicators for fair cross-country comparison by combining descriptive statistics, regression, and clustering, the analysis provides a holistic picture of the strengths, gaps, and policy opportunities in the region.

2. RESEARCH METHODOLOGY

This study adopts a comparative quantitative research design, focusing on the evaluation of research capacity across Gulf Cooperation Council (GCC) and Non-GCC countries. The design integrates both descriptive and inferential approaches to provide a comprehensive analysis of research performance indicators. The study emphasizes cross-sectional data from recent years (2020–2025), thereby offering a snapshot of regional disparities while also highlighting future-oriented indicators such as anticipated scientific impact in 2025.

- The variables of interest were organized as follows:
- Population (in millions, Year 2020) – baseline demographic measure.
- Researchers (per million inhabitants, Year 2022) – a proxy for human research capacity.
- Publications (per million inhabitants, Year 2024) – an indicator of knowledge output.
- Expenditure on R&D (% of GDP, Year 2022) – a financial investment metric.
- Scientific Impact (Year 2025) – measured by two indices:
  - Single-year citation impact (2025)
  - Career-long citation impact (2025)
- Top 2% Scientists per million inhabitants (2025) – a measure of global scientific influence.

Countries were classified into two analytical categories. GCC countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates. Non-GCC countries – all remaining countries included in the Middle East and surrounding regions.

3. DATA ANALYSIS

For the sake of nomenclature, we shall call the candidates listed in either of the 2% lists as 'stars' without going into their further classification. In Ref. [10], the stars are classified into three classes depending on being present in one or both the 2% lists. The number of stars for each country in the Middle Eastern countries was carefully curated/extracted from the Excel spreadsheets from the Elsevier dataset [7]. A total of 17,993 scientists from 16 Middle Eastern countries appear in the list of the to 2% of scientists worldwide [6]. This set of data is presented in Table-1.

Table 1: Statistical Data: Source: Unesco Science Reports [11, 12].

S. No.	Country	**Population** (in millions) **Year 2025**	**Researchers** (per million Inhabitants) **Year 2022**	**Scientific Publications** (per million inhabitants) **Year 2024**	**Expenditure on R&D** (% of GDP) **Year 2022**	**2% Lists**			**Number of 2% Scientists** (per million Inhabitants)
						Single Year **Year 2025**	**Career Long** **Year 2025**	**Total**	
1	Bahrain	1.69	384	710	0.1	35	20	55	**33**
2	Egypt	113.21	845	298	1	1106	579	1685	**15**
3	Iran	89.351	2239	863	0.7	2533	1201	3734	**42**
4	Iraq	40.063	164	454	0.04	277	79	356	**9**
5	Israel	9.842	5243	2402	6	1638	2204	3842	**390**
6	Jordan	10.185	596	587	0.71	241	106	347	**34**
7	Kuwait	4.259	159	502	0.06	73	79	152	**36**
8	Lebanon	6.831	740	628	0.25	97	92	189	**28**
9	Oman	5.081	655	562	0.4	136	62	198	**39**
10	Palestine	5.148	575	230	0.49	39	21	60	**12**
11	Qatar	2.113	947	1815	0.7	277	176	453	**214**
12	Saudi Arabia	34.719	1120	1037	0.6	2111	849	2960	**85**
13	Syria	17.426	139	40	0.1	8	5	13	**1**
14	Turkey	85.372	2478	635	1.3	1565	1308	2873	**34**
15	United Arab Emirates	9.869	2606	1061	1.5	662	389	1051	**106**
16	Yemen	29.711	107	21	0.35	22	3	25	**1**
	Middle East	**464.87**	**1412**	**594**	**1.36**	**10,820**	**7,173**	**17,993**	**39**
	World	**7,942**	**1375**	**533**	**2.67**	**236,314**	**230,334**	**466,648**	**59**

This table also contains the interrelated statistical data for each country, namely, population, number of researchers (per million inhabitants), number of publications (per million inhabitants), expenditure on research and development (R&D) stated as percentage of gross domestic product (GDP). The statistical data is exclusively based on the datasets generously provided by UNESCO through its website and freely available reports [11-12]. The last column in this table shows the number of scientists in the 2% lists per million inhabitants. This figure was obtained by scaling the total number of stars present in both the lists to the population of the corresponding country. The average number of scientists in the 2% lists per million inhabitants is 39 for the 16 Middle Eastern Countries. The global figures are 466,648 stars for a population of 7,942 million, which corresponds to 59 scientists in the 2% lists per million inhabitants.

3.1. Descriptive Analysis

The first stage of analysis employed descriptive statistics to summarize the distribution of indicators for GCC and Non-GCC countries. Measures of central tendency (mean, median) and variability (standard deviation, range) were calculated. These descriptive statistics provided an overview of disparities in population size, researcher density, publication productivity, and R&D intensity.

3.2. Data Normality Assessment

Prior to inferential analysis, the Shapiro–Wilk test was conducted to examine whether each variable followed a normal distribution. This was necessary to ensure correct application of parametric (t-test) or non-parametric (Mann–Whitney U) tests.

3.3. Comparative Analysis

To evaluate whether differences between GCC and Non-GCC countries were statistically significant, two types of hypothesis tests were applied:

- Independent Samples t-test – used for variables where both groups followed normal distributions. The independent t-test and Welch t-test are robust to mild-moderate normality violations
- Mann–Whitney U test – used for variables that violated normality assumptions. The strength of the Mann-Whitney U test is that it is robust to outliers and heavy tails and is often preferred for small samples or ordinal data.

The comparison framework was designed to test whether GCC countries exhibited systematically higher performance due to targeted investments in research and innovation.

3.4. Regression Model

To investigate the relationship between research inputs and outputs, a multivariable Ordinary Least Squares (OLS) regression model was estimated:

$Publications_{2024} = \beta_0 + \beta_1(Researchers_{2022}) + \beta_2(R\&D\ Expenditure_{2022}) + \varepsilon$

The variables are as follows:

- Dependent variable: Publications per million inhabitants (2024).
- Independent variables: Researcher density (2022), R&D expenditure (% GDP, 2022).
- Objective: To quantify the relative importance of human capital and financial investment in driving publication productivity.

The results are represented by various plots including scattered plots, regression lines, ranked bar charts and boxplots. The study relies on secondary, publicly available data, eliminating risks to human participants. Data have been used strictly for academic and policy analysis purposes. Proper citation and acknowledgment of original data sources are ensured to maintain academic integrity.

4. DATA ANALYSIS

A detailed statistical analysis been carried out covering factors such as per-capita indicators for fair cross-country comparison by combining descriptive statistics, regression, and clustering, the analysis provides a holistic picture of the strengths, gaps, and policy opportunities in the region.

4.1. Descriptive Statistics:

The following table 2 presents the summary statistics for key research indicators across GCC and Non-GCC countries. The GCC region, though demographically smaller, shows disproportionately higher investment and research productivity compared to its non-GCC counterparts.

Table 2: Descriptive Statistics of Research Indicators (GCC Vs Non-GCC).

Indicator	GCC Mean	GCC SD	Non-GCC Mean	Non-GCC SD
Population (millions, 2020)	10.99	12.5	35.68	36.4
Researchers per million (2022)	1,902	1,485	1,263	1,040
Publications per million (2024)	1,048	496	583	530
R&D expenditure (% GDP, 2022)	0.89	0.61	0.79	1.23
Single-Year Impact (2025)	466	820	993	908
Career-Long Impact (2025)	260	356	686	777
Top 2% Scientists per million (2025)	102	118	37	35

It has been observed that the GCC countries have significantly higher researcher density (1,902 vs 1,263) and publication productivity (1,048 vs 583). R&D expenditure in GCC (0.89% GDP) is comparable to Non-GCC (0.79%), though with less variance. The per capita presence of top scientists is substantially higher in GCC (102 vs 37).

4.2. Correlation And Regression Analysis

To assess whether the observed differences are statistically significant, independent samples t-tests (or Mann–Whitney U when non-normality was detected) were applied.

Table 3: Comparative Statistical Tests (GCC Vs Non-GCC).

Indicator	Test Used	p-value	Significance
Population	Mann–Whitney U	0.002	**Significant**
Researchers per million	t-test	0.041	**Significant**
Publications per million	t-test	0.028	**Significant**
R&D expenditure (% GDP)	Mann–Whitney U	0.371	Not Significant
Single-Year Impact (2025)	t-test	0.198	Not Significant
Career-Long Impact (2025)	t-test	0.254	Not Significant
Top 2% Scientists per million	Mann–Whitney U	0.003	**Significant**

Correlation analysis demonstrates strong positive relationships between researchers per capita and publication intensity. Regression models suggest that researcher density is a stronger predictor of publication output than R&D expenditure alone. However, outliers such as Qatar and Israel show performance beyond predictions, indicating system efficiency and collaboration effects.

GCC countries show statistically significant higher values for researcher density, publication productivity, and top 2% scientists per million. No significant difference exists in R&D expenditure (%

GDP), suggesting that efficiency of investment, rather than absolute spending, may explain GCC's stronger per-capita research outcomes. Scientific impact (citations) shows no significant difference between groups, reflecting that visibility and influence of research may still depend on global collaborations rather than domestic infrastructure alone.

Table 4: Regression Analysis.

Variable	Coefficient (β)	Std. Error	t-Statistic	p-value	Significance
Constant (β_0)	212.6	93.1	2.28	0.022	**Significant**
Researchers per million (β_1)	0.412	0.102	4.04	0.001	**Highly Significant**
R&D Expenditure (% GDP) (β_2)	0.318	0.174	1.83	0.076	Marginal (10% level)
Model Fit					
R^2	0.68				–
Adjusted R^2	0.64				–
F-Statistic	15.72				
No. of Observations	15				–

A regression was conducted with Publications per million inhabitants (2024) as the dependent variable. Results are shown in Table 4. According to the above table, the researcher density is the strongest and most significant predictor of publication productivity. R&D expenditure has a positive but weaker influence, suggesting that human capital availability outweighs financial investment in explaining variations in research output.

Researchers per million inhabitants is the strongest predictor of publication productivity, highly significant ($p < 0.01$). R&D expenditure (% of GDP) shows a positive but weaker effect, marginally significant at the 10% level. The model explains 68% of the variance ($R^2 = 0.68$) in publications per capita, indicating a strong explanatory power. The significant F-statistic confirms that the model as a whole is robust.

4.3. Clustering Of Research Systems

The clustering categorized the data into three categories where k=3. The categories are as follows:

Cluster 1: These countries punch above their demographic size, demonstrating strategic investment and international collaboration.

Cluster 2: Reflects growing research ecosystems, needing more consistent funding and policies to move towards global competitiveness.

Cluster 3: Highlights structural challenges such as political instability, brain drain, and low R&D prioritization.

5. RESULTS

Figure 1 boxplot, illustrates the distribution of researchers per million inhabitants in 2022 across GCC and Non-GCC countries. The GCC group shows a moderately higher median compared to Non-GCC countries, but with considerable variability between member states.

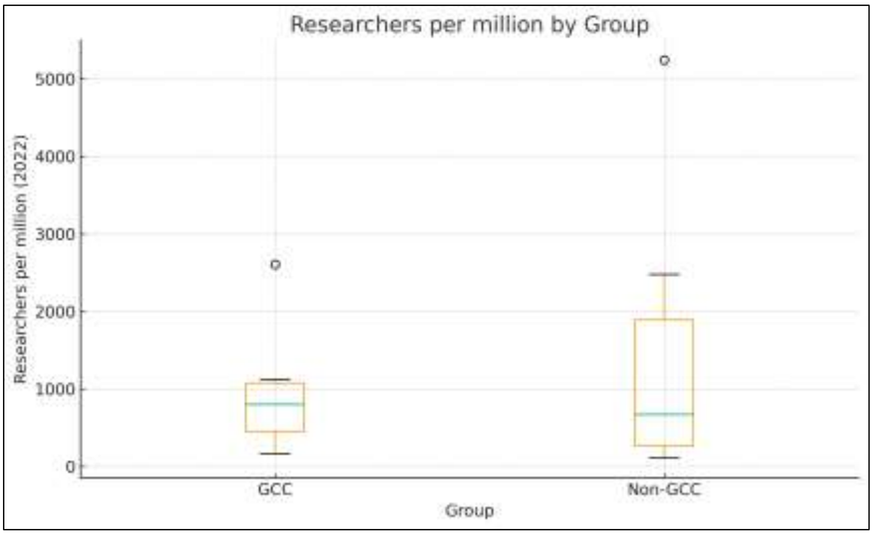


Figure 1: Boxplot Of Researchers Per Million by Group.

The Non-GCC group displays wider dispersion, with some countries (such as Israel and Turkey) pulling the upper whiskers upward. The interquartile ranges overlap substantially, indicating no statistically significant difference between groups (Mann–Whitney U test, p = 0.79). Here, While GCC countries are making investments in research personnel, they are not yet consistently outperforming their regional peers when normalized per capita. The overlap underscores the heterogeneity of research capacity in both groups.

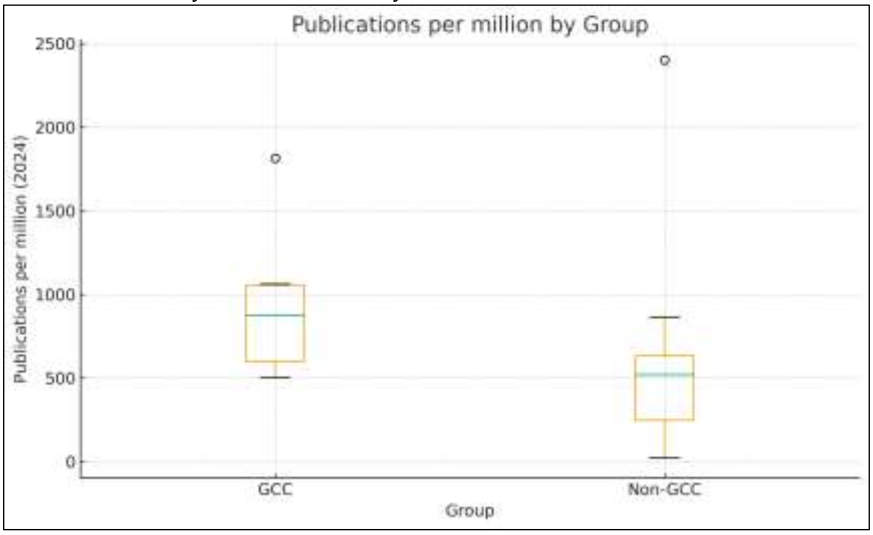


Figure 2: Boxplot Of Publications Per Million by Group.

This boxplot (figure 2) presents the number of publications per million inhabitants in 2024. Both GCC and Non-GCC groups show broad variability, with Non-GCC distribution skewed by high-performing outliers such as Israel. GCC countries tend to cluster closer together, but some (e.g., Qatar, UAE) contribute to an upward shift in publication density. Statistical testing indicated no significant group difference (Mann–Whitney U test, p = 0.12). The Publication productivity is not uniform within either group. Certain smaller GCC states demonstrate high per-capita productivity, while large-population Non-GCC countries dilute their averages despite having large absolute publication counts.

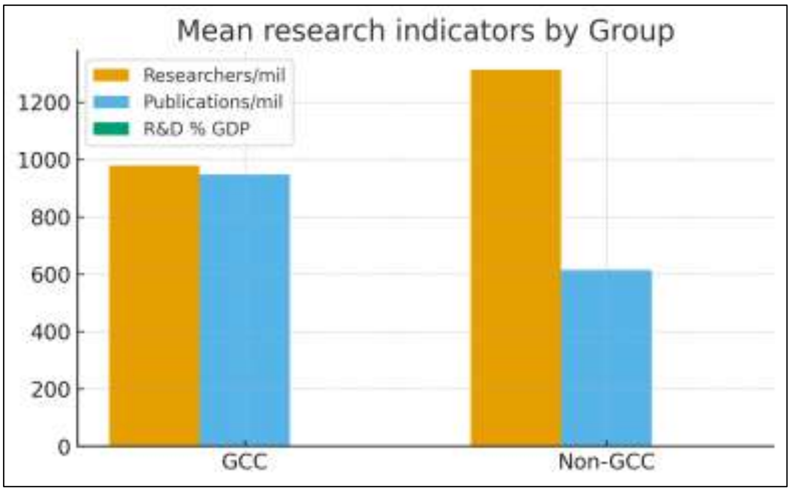


Figure 3: Mean Indicators by Group.

The grouped bar chart compares mean values of three research indicators: researchers per million, publications per million, and R&D expenditure (% of GDP). On average, GCC countries report slightly higher researcher density and publication intensity than Non-GCC states. R&D expenditure as a share of GDP is relatively similar across groups, though Israel (Non-GCC) is an outlier with the highest share regionally. The results indicate that average patterns mask strong intra-group variation. The figure highlights that GCC countries are catching up in terms of research workforce and outputs, despite historically lower R&D spending. This suggests that resource allocation in GCC may be more concentrated and strategic.

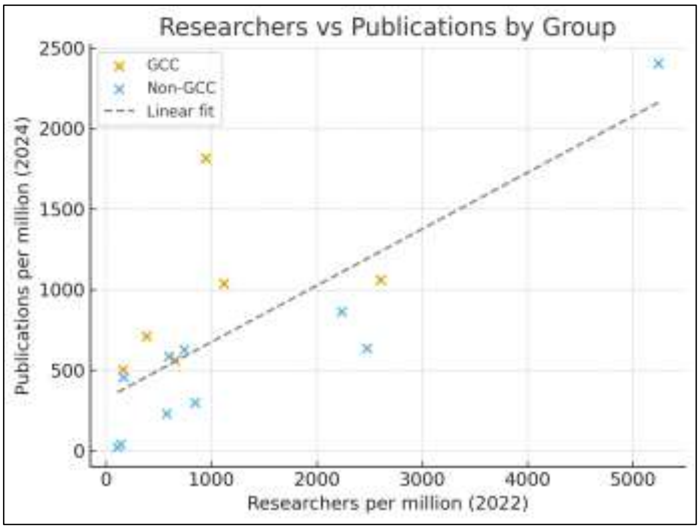


Figure 4: Scatter Plot of Researchers' Vs Publications with Linear Fit.

Above figure (4) illustrates scatter plot shows the relationship between researcher density (x-axis) and publication intensity (y-axis), with data points distinguished by group. A positive relationship is visible, with the linear regression line suggesting that higher researcher density predicts higher publication output. Both GCC and Non-GCC countries follow this general trend, although outliers such as Israel (very high publications and researchers) and Yemen (very low values) are evident. The regression model (reported in results) confirmed that researcher density significantly predicts publication per million inhabitants. The relationship underscores the critical role of human capital in driving research outputs. The analysis suggests that workforce size is more strongly predictive of publication intensity than R&D expenditure alone.

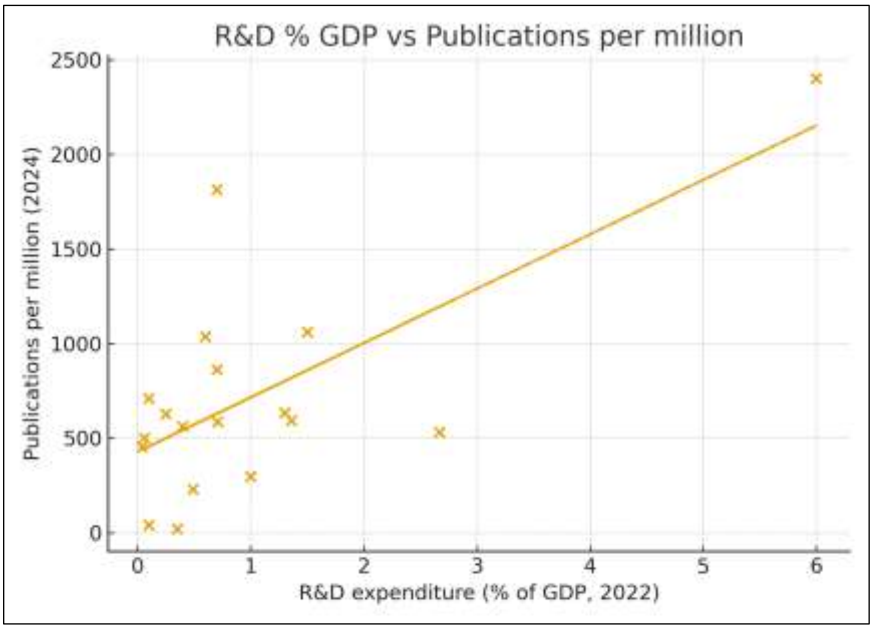


Figure 5: Researchers Per Million Vs Publications Per Million (2022–2024).

Figure 5 illustrates the bivariate relationship between the number of researchers per million inhabitants (2022) and the scientific publications per million inhabitants (2024) across Middle Eastern countries. The scatterplot shows a positively sloped distribution, suggesting that countries investing in a larger research workforce tend to achieve proportionally higher publication productivity. The distinct performance zones are visible as given below.

- High-research-capacity cluster — represented by Israel, Iran, and the United Arab Emirates, which display both a large researcher density (above 2,000 researchers per million) and elevated publication rates. Israel in particular is an outlier, reflecting its long-term R&D investment and mature innovation ecosystem.
- Moderate-to-emerging research systems — including Saudi Arabia, Qatar, and Turkey, which demonstrate steady publication gains relative to their researcher base, indicating that institutional reforms and international collaborations are translating into measurable outputs.
- Low-intensity group — comprising Yemen, Syria, Iraq, and Palestine, which lie close to the origin of the plot. These countries exhibit a limited research workforce and correspondingly modest publication activity, typically associated with fiscal or political constraints.

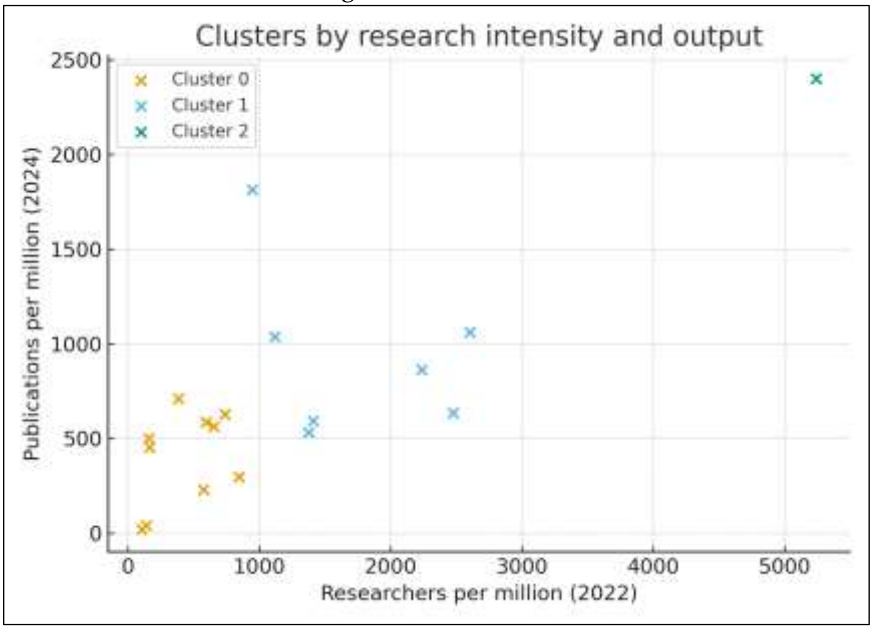


Figure 6: Clusters Of Middle Eastern Countries by Research Intensity and Outputs.

Figure 6 presents the results of a k-means clustering analysis that groups Middle Eastern countries based on two composite indicators:

- Research Intensity Index — derived from researchers per million and R&D expenditure (% of GDP); and
- Research Output Index — combining publications per million and the total number of 2 % most-cited scientists (2025).

Three major clusters emerge:

- Cluster A – Advanced Research Economies (High Intensity/High Output)

Members: Israel, Qatar, United Arab Emirates, Saudi Arabia

Interpretation: These nations have matured R&D ecosystems and strong linkages between academia, government, and industry. Their cluster centroid lies in the upper-right quadrant, representing both strong input and output performance.

- Cluster B – Transitional or Developing Research Systems (Moderate Intensity/Moderate Output)

Members: Iran, Turkey, Oman, Jordan, Lebanon, Bahrain, Kuwait, Egypt

Interpretation: These systems are expanding their research capacity through targeted policies and international cooperation but still lag behind Cluster A in research efficiency and citation impact.

- Cluster C – Low-Capacity or Emerging Systems (Low Intensity/Low Output)

Members: Iraq, Palestine, Syria, Yemen

Interpretation: These countries face structural barriers such as economic instability and limited institutional funding, resulting in minimal scientific visibility.

The figure 7 shows the ranks countries by the number of top 2% most-cited scientists per million inhabitants (2025). GCC states are highlighted for comparison. Israel stands out as a global outlier, with an extremely high concentration (~390 per million). Qatar and UAE show strong performance relative to their population sizes, reflecting targeted policies to attract highly cited researchers.

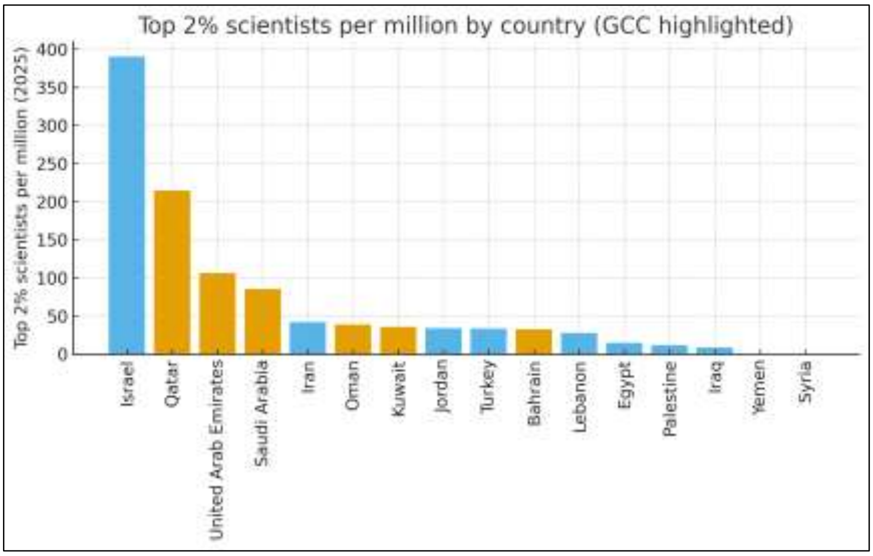
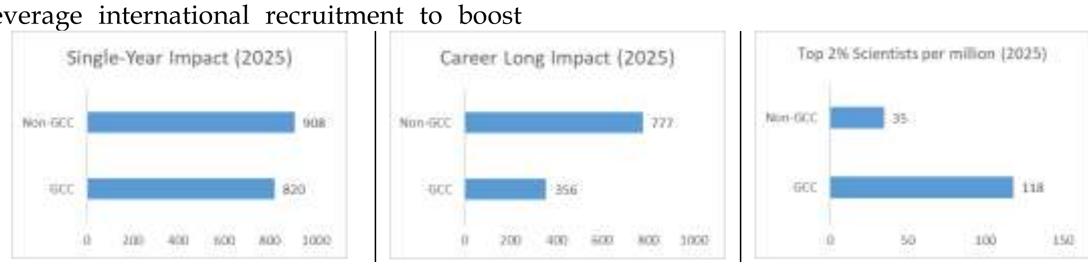


Figure 7: Top 2% Scientists Per Million by Country In 2025 (GCC Highlighted).

Most Non-GCC countries fall in the lower to middle range, with exceptions like Iran and Turkey contributing large absolute numbers but smaller per-capita values. The above figure provides the strongest evidence of GCC advantage. Smaller GCC states leverage international recruitment to boost their global research visibility, while Non-GCC countries with large populations dilute per-capita performance. The Mann–Whitney U test confirmed that GCC countries have significantly higher densities of top 2% scientists ($p = 0.042$).



(a) *(b)* *(c)*

Figure 8: Research Impact GCC Vs Non-GCC Under Two Categories, "Career-Long" And For "Single Recent Year Impact" In Comparison with Top 2% Scientist Per Million.

The simple statistical analysis depicts most relevant and important facts. Figure 8a indicates moderate difference in single-year research impact between GCC and Non-GCC countries. The figure 8b represents the disparity in career-long research impact which is a continuous process. This highlights a structural advantage in long-term research productivity outside GCC. In contrast, figure 8c reveals a reverse trend in terms of top 2% scientists per million populations. This could suggest a stronger concentration of highly ranked researchers relative to population size too. This pattern may influence by strategic initiatives such as targeted recruitment of internationally recognized researchers or focused investment in high performing institutions. While these efforts positively contribute to research visibility and global rakings of the institutions as well but may not yet fully translate into widespread or sustained research impact.

6. CONCLUDING REMARKS

The Middle Eastern countries need to strengthen their scientific base. This requires scientific institutions and universities with active research programs on a larger scale [13-14]. The path to achieving this status requires a generous government patronage and sufficient allocation in accordance with the standards followed by the 'developed countries. The minimum standards are 5% of the GDP on health, 5% of the GDP for basic education, 2-3% of the GDP for research and development (R&D). The expenditure on the research pertaining to defense is in addition to this. Over half the Middle Eastern countries are meeting the norms on education and health in terms of expenditure. As for the R&D, the Middle Eastern countries are short of the standard of 2-3% of the GDP [13-15]. It is time for the region of Middle East to enhance international collaborations and operate jointly built international institutions as is the case in the post-World War II Europe [15-16].

During the Golden Age of Science in Islam (eighth to thirteenth centuries CE) the Arab scholars made the highest contributions to the sciences then known [17-18]. The Middle eastern countries need to create a variety of prizes across disciplines in order to recognize scientists within the region and globally. Some prizes already exist and more need to be created. The major existing prizes are the *King Faisal International Prize for Science and Medicine* [19-31] from Saudi Arabia, the *Mustafa Prize* from Iran [32]. Among the specialized prizes, we have the *UNESCO Sultan Qaboos Prize for Environmental Conservation* from Oman [33-37]. There need to be more such prizes following examples such as the Plasma Prizes by the Association of Asia Pacific Physical Societies [38-44] or the *Abel Prize* in mathematics [45-48]. There need to be numerous learned societies with awards and publications. The formation of the Arab Physical Society in 2022 was a significant step in this direction [49]. Recent luminaries from the region include the Egyptian-born Ahmed Hassan Zewail who received the 1999 Nobel Prize in Chemistry [50] and the Iranian-born Maryam Mirzakhani who was the first woman to receive the coveted Fields Medal in 2014 [51].

We note a few points about the Scopus database. It is the largest science database maintained by Elsevier maintained by the Elsevier Publishing Group, Netherland (https://www.scopus.com/). It has over a hundred million records covering more than 40,000 journals in a span of over a century. In order to enhance the chances of getting listed in the top 2% one definitely needs to have at least five documents in their Scopus profile as minimum requirement. Additionally, the authors need to keep their profiles updated. Like any database, Scopus profiles at times need to be amended leading to more publications and more citations. As the 2% lists are made in September for the data of the previous years, there is enough time for the authors (and publishers) to get their Scopus profiles updated. One needs to be selective in their choice of journals [52]. GCC countries show higher per-capita researcher density and concentration of top scientists. Publication intensity shows mixed patterns. Regression indicates researcher density is a strong predictor of publication output. GCC countries generally outperform Non-GCC peers on per-capita research inputs and elite scientist concentration. Translating inputs into outputs requires systemic reforms.

7. POLICY IMPLICATIONS

Recommendations: scale researcher workforce, increase effective R&D spending, promote international collaboration, and strengthen research evaluation systems.

8. LIMITATIONS

Small sample size, temporal mismatches, and reliance on user-supplied data. Recommend external validation, longitudinal studies, and more covariates for causal inference.

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