



The Use of Biosensor as a New Trend in Cancer: Bibliometric Analysis from 2007 to 2017



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Abstract

Nanotechnology is a multidisciplinary field that covers large areas of chemistry, physics, and biology as well as engineering. The application in medicine for diagnosis, prevention, and treatment of diseases, has become known as nanomedicine and is now an excellent tool for new nanotechnological applications, such as the use of biosensors. This study aimed to analyze bibliometrics related to applications in biosensors and the relative importance of these publications in cancer. The search base for articles was Google Scholar, due to the higher coverage of articles published in comparison to other databases of scientific publications, such as Pubmed and Science Direct. The obtained results showed that there was a decrease in the number of publications referring to cancer at the last decade (2007-2017), but there was an increase in the number of publications regarding the use of biosensors, showing an interest and tendency using new technologies for clinical diagnosis. Nanotechnology is a promising tool for the development of new diagnostic methods and its growth for the next decades is undeniable, including biosensors.

Keywords: Biosensor; Cancer; Nanotechnology

Introduction

Nanotechnology is a multidisciplinary science, encompassing the areas of engineering, biology, chemistry and physics, being more and more applied in medicine and pharmacy [1-6]. Nanotechnology's applications range from drug release studies to the use of biosensors as a tool for the early diagnosis in several diseases, as well as the treatment of drugs and antibodies in target systems in diseases such as cancer [7-10].

Biosensors are small devices that combine a biological component with a target substrate, which allows for the formation of the electrochemical signal through a bio-reacquisition reaction, allowing this signal to be measured through a physical transducer [7,11-18]. This biomolecular recognition is essential for a biosensor and, initially, the recognition elements of a biosensor were isolated from living systems. However, it is now possible to synthesize these elements in laboratories [19]. Their applications may include detection of proteins [20-37], viruses [38-56], antibodies [57-74], DNA [75-89], drugs [90-100], pesticides [101-119] and other low molecular weight compounds [120-123].

The interest of the use of biosensors for early detection in cancer using nanotechnology is of great importance for early clinical diagnosis and consequently to contribute to the reduction

of mortality as well as to the improvement of the quality of life of the population [124-133].

Cancer is the second leading cause of death worldwide [134-144]. Thus, the use of biosensors has become a promising tool for early diagnosis, since the risk of metastasis is a critical point in the development of the disease, rapidly causing the death of the individual. Because tumor cells are present at shallow levels in peripheral blood, they can be detected in patients with advanced tumors with or without metastasis. Thus, the present study analyzed bibliometrics related to applications in biosensors and the relative importance of these publications in cancer. The obtained results showed that there was a decrease in the number of publications referring to cancer at the last decade (2007-2017), but there was an increase in the number of publications regarding the use of biosensors, showing an interest and tendency using new technologies for clinical diagnosis

Experimental

The methodology used in this study was based on the use of the Google Scholar database for the bibliometrics of scientific productions. In this database it is possible to have a broader search of publications, due to the more excellent coverage of journals.

Search bases such as Scopus®, Web of Science®, and Compendex® have their metrics, and when we join these three databases in a single search, there may be discrepancies in citation numbers, as well as articles contained in all of them [145]. Google Scholar® will fetch all articles using the same metric. For the bibliometrics of scientific productions in the last decade, keywords were used for the use of biosensors and their applications in cancer in specific periods from 2007 to 2017. The applications in biosensors used were diagnostic, bio-detection, biomarker, prevention, biomaterial, nanoparticles, graphene, tattoos and Point-of-care (POC).

To analyze the impact of nanotechnology with biosensors on the scientific production of cancer in the last decade, a calculation was performed aiming to obtain the relative importance based on the publications of biosensors and their applications in cancer and the total number of scientific productions in cancer (Table 1).

Table 1: Relative Importance and Tendency in cancer and biosensors applications.

Year	Biosensor+Cancer+Diagnosis	Cancer	RI (%)
2007	2.78	1.240.000	0.181

From the relative importance of publications in biosensors for each application in cancer followed year by year, a tendency curve was prepared using an exponential model for a higher sensitivity of the obtained data, as well as the equation and value of R^2 (coefficient of determination) for a better fit of the statistical model. The value of $R^2 \geq 0.9$ (90%) was used as the reliability criterion of the results obtained through bibliometrics analysis.

Results and Discussion

In the last decade, the publications about cancer suffered a decrease. For instance, 2017 produced around 144K scientific publications, whereas in 2007 more than 1.1 million publications were produced. This observed decrease in bibliometrics during the last decade is shown in Table 2 and Figure 1. Regarding cancer, in 2007, around 0.18% of cancer publications were associated with the use of biosensors for diagnosis and in 2017, this number increased to 6.62% of total cancer publications, as shown in Table 3. Figure

2 shows the Tendency Curve for cancer diagnosis, allowing for inferring an exponential increase with R^2 equals to 0.9301 (93%).

Table 2: The bibliometrics in cancer (2007-2017).

Year	Cancer
2007	1.240.000
2008	1.180.000
2009	1.090.000
2010	1.040.000
2011	960
2012	809
2013	655
2014	453
2015	243
2016	155
2017	144
Total	7.969.000

Table 3: The bibliometrics in biosensor and diagnosis in cancer (2007-2017).

Year	Diagnosis	Cancer	RI (%)
2007	2.24	1.240.000	0.181
2008	3.8	1.180.000	0.322
2009	5.95	1.090.000	0.556
2010	6.34	1.040.000	0.61
2011	4.59	960	0.478
2012	5.56	809	0.687
2013	6.24	655	0.953
2014	7.1	453	1.567
2015	8.06	243	3.317
2016	8.66	155	5.587
2017	9.54	144	6.625

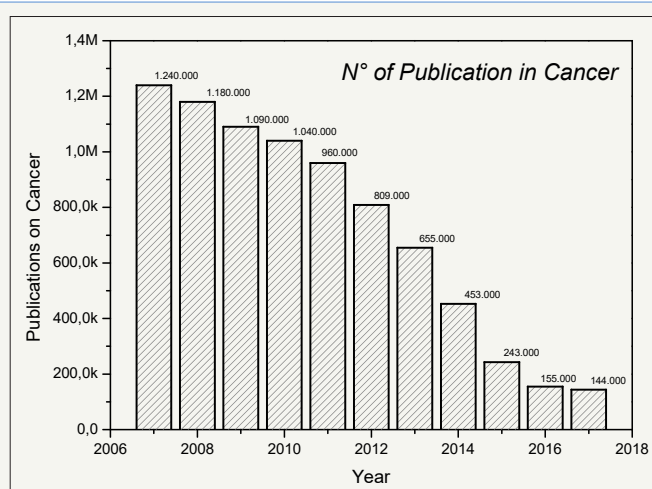


Figure 1: The decrease of publications in cancer (2007-2017).

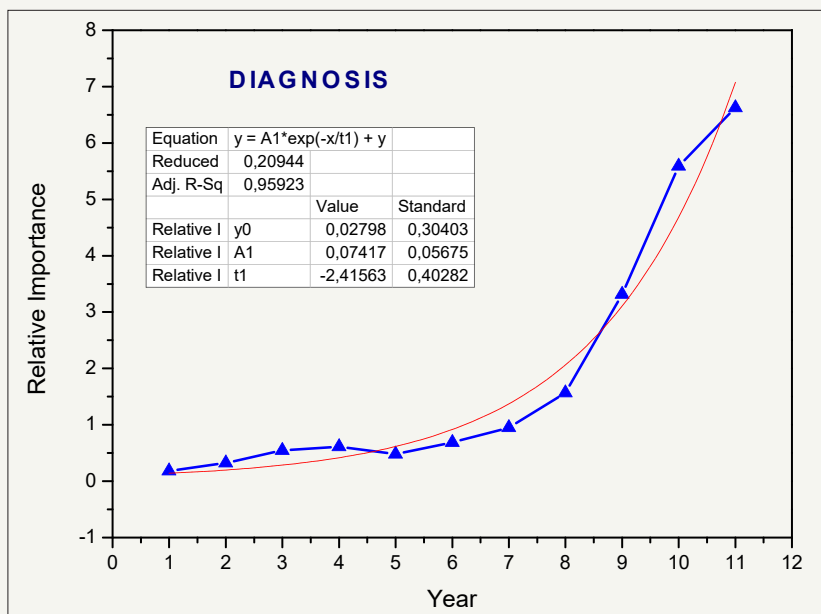


Figure 2: The Relative Importance and Tendency Curve in biosensor and diagnosis in cancer (2007-2017).

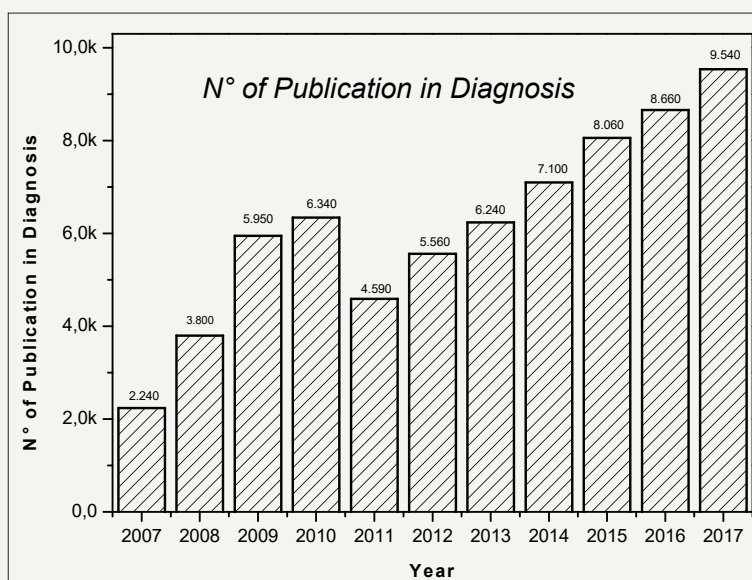


Figure 3: The increase of publications in biosensor and diagnosis in cancer (2007-2017)

Figure 3 shows the growth in the number of publications regarding the use of diagnostic biosensors in cancer. In 2007 there were equal to 2.24K publications; in 2017, the number of publications was of 9.54K. Between 2010 and 2011 there was a decrease in the number of publications, but after 2012 the growth of publications took place again, evidencing an interest in research using biosensors for diagnosis in cancer.

Table 4: The bibliometrics in biosensor and biodetection in cancer in the last decade.

Year	Biodetection	Cancer	RI (%)
2007	170	1.240.000	0.014
2008	219	1.180.000	0.018

2009	246	1.090.000	0.023
2010	334	1.040.000	0.032
2011	357	960	0.037
2012	398	809	0.049
2013	464	655	0.071
2014	563	453	0.124
2015	588	243	0.242
2016	552	155	0.356
2017	683	144	0.474

In cancer, the relative importance of publications in biosensors and bio-detection was of 0.013% in 2007. Over the past few years,

Relative Importance has increased. In 2017, its approximate value was 0.47%, showing that research on biosensor tumor markers using biosensors are increasing. This increase can be observed in Table 4 and Figure 4. Figure 5 shows the increase in the number of publications in biodetection in the last decade. The relative importance of biosensor and biomarker publications in cancer has increased in the last decade. In 2007, 0.078% of the publications in tuberculosis were directly related to biosensors and biomarker; in 2017, this value was of 4.49%. Table 5 and Figure 6 show the treated data. Figure 7 shows the number of publications in the last decade of the use of biosensors as a biomarker in cancer.

Table 5: The bibliometrics of biosensor and biomarker in cancer (2007-2017).

Year	Biomarker	Cancer	RI (%)
2007	970	1.240.000	0.782

2008	1.21	1.180.000	0.103
2009	1.6	1.090.000	0.147
2010	1.99	1.040.000	0.191
2011	2.52	960	0.263
2012	3.07	809	0.379
2013	3.65	655	0.557
2014	4.28	453	0.945
2015	4.91	243	2.021
2016	5.69	155	3.671
2017	6.47	144	4.493

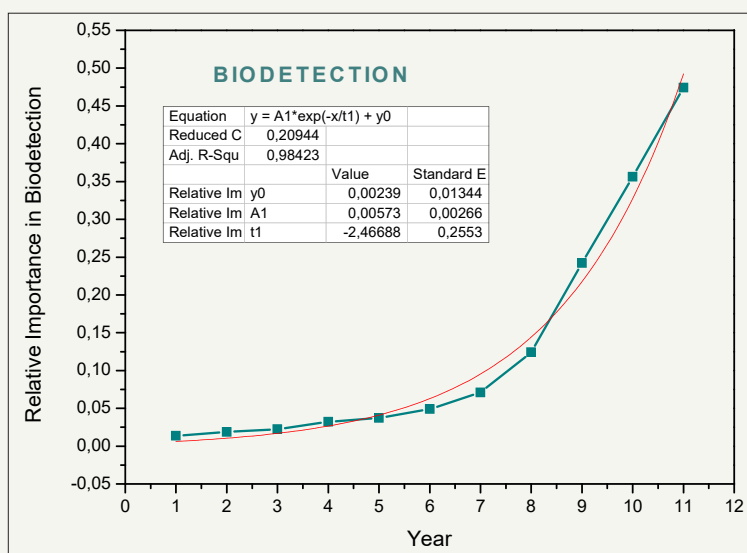


Figure 4: The Relative Importance and Tendency Curve in biosensor and biodetection in cancer in the last decade.

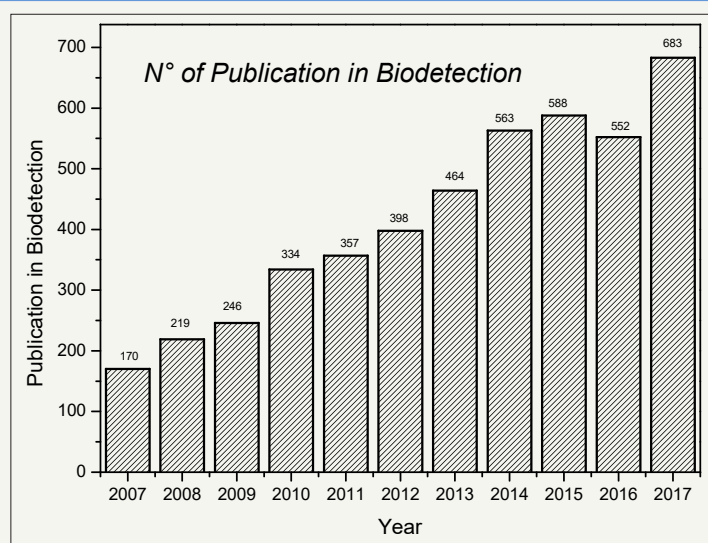


Figure 5: The bibliometrics of biodetection in cancer using biosensors in the last decade.

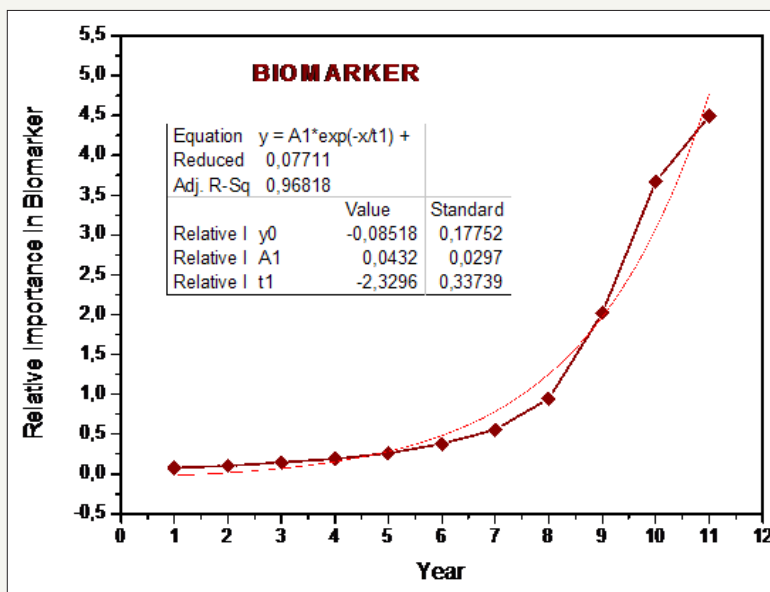


Figure 6: The Relative Importance and Tendency Curve in biosensor and biomarker in cancer in the last decade.

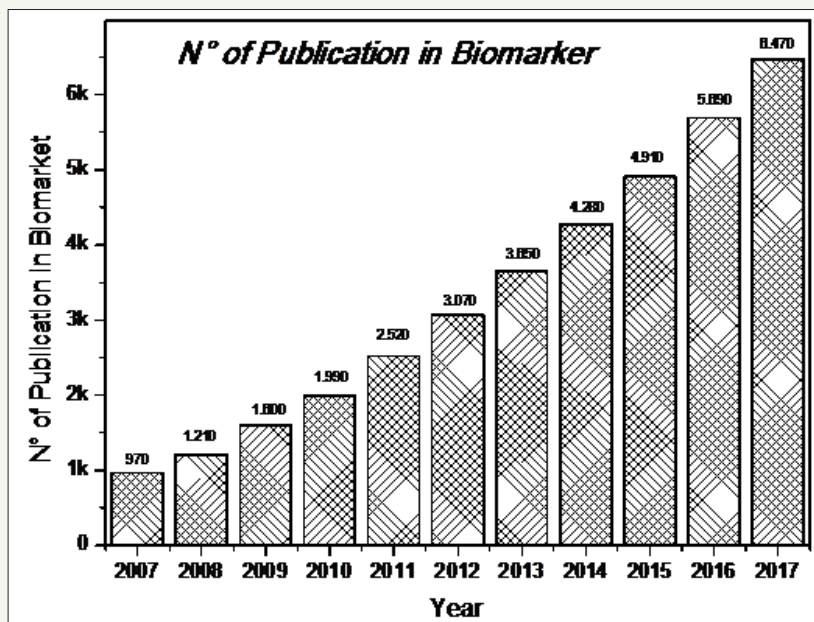


Figure 7: The bibliometrics of biosensor and biomarker in cancer in the last decade.

The Relative Importance of biosensor publications and cancer prevention has increased in the last decade. In 2007, 0.11% of cancer publications were directly related to biosensors and prevention; in 2017, this value was of 3.86%. Table 6 and Figure 8 show the treated data. Figure 9 shows the number of publications of biosensor and prevention in cancer in the last decade

Table 6: The bibliometrics of biosensor and prevention of cancer in the last decade.

Year	Prevention	Cancer	RI (%)
2007	1.41	1.240.000	0.114
2008	1.64	1.180.000	0.139

2009	2.49	1.090.000	0.229
2010	2.84	1.040.000	0.273
2011	2.82	960	0.294
2012	3.41	809	0.421
2013	3.87	655	0.591
2014	4.27	453	0.943
2015	4.93	243	2.029
2016	5.02	155	3.239
2017	5.57	144	3.868

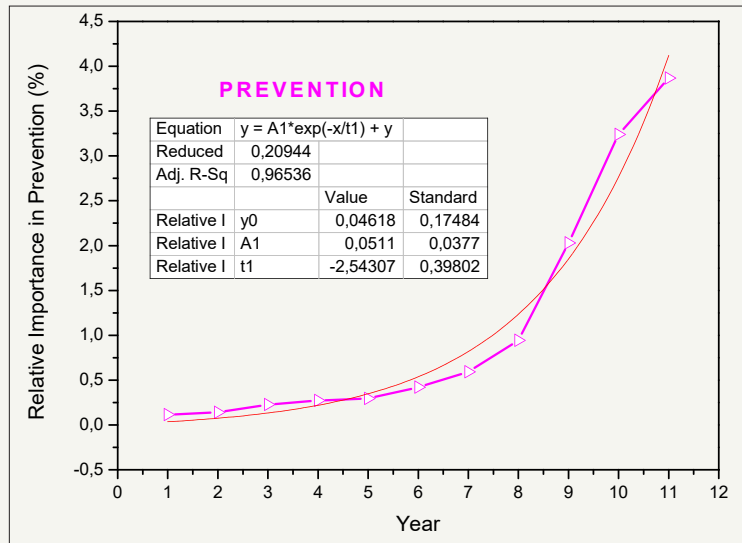


Figure 8: The Relative Importance and Tendency Curve using biosensor for prevention in cancer in the last decade.

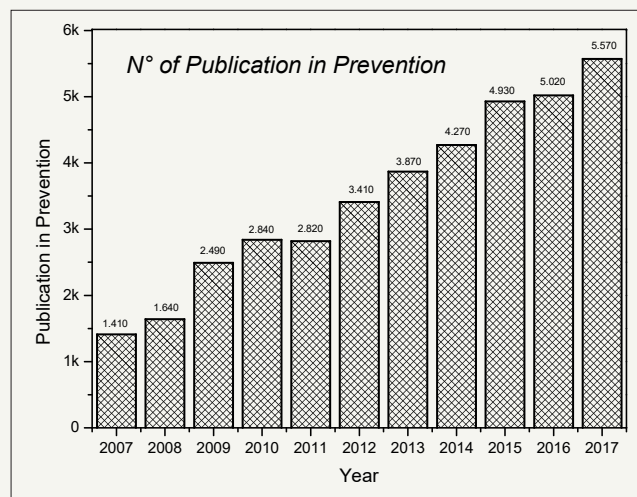


Figure 9: The bibliometrics of publications of biosensor and prevention of cancer in the last decade.

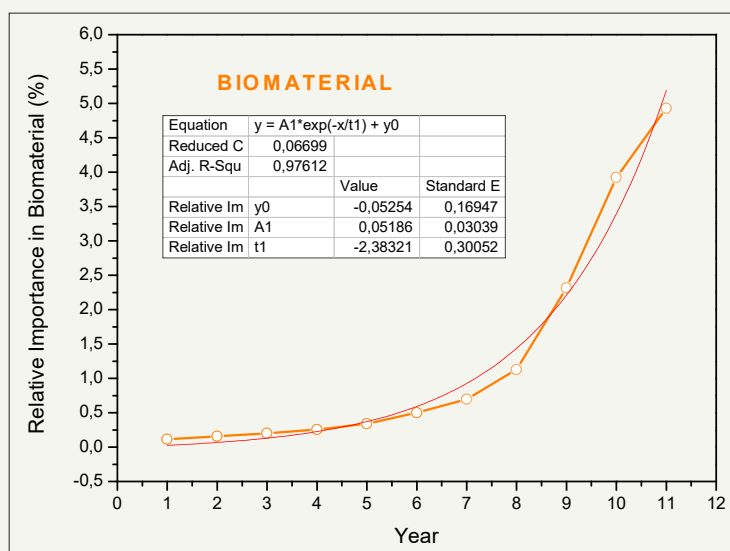


Figure 10: The Relative Importance and Tendency Curve of biosensor and biomaterial in cancer in the last decade.

Table 7: The bibliometrics of biosensor and biomaterial in cancer in the last decade.

Year	Biomaterial	Cancer	RI (%)
2007	1.39	1.240.000	0.112
2008	1.86	1.180.000	0.158
2009	2.2	1.090.000	0.202
2010	2.66	1.040.000	0.256
2011	3.27	960	0.341
2012	4.05	809	0.501
2013	4.57	655	0.698
2014	5.11	453	1.128
2015	5.63	243	2.317
2016	6.08	155	3.923
2017	7.1	144	4.931

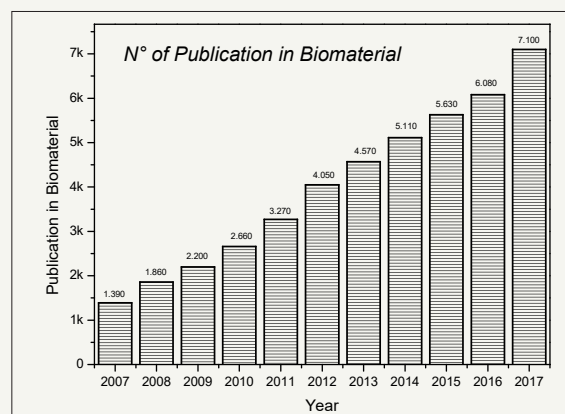
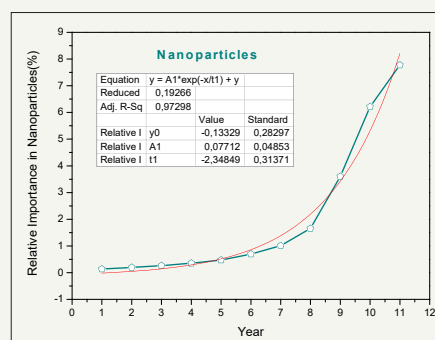
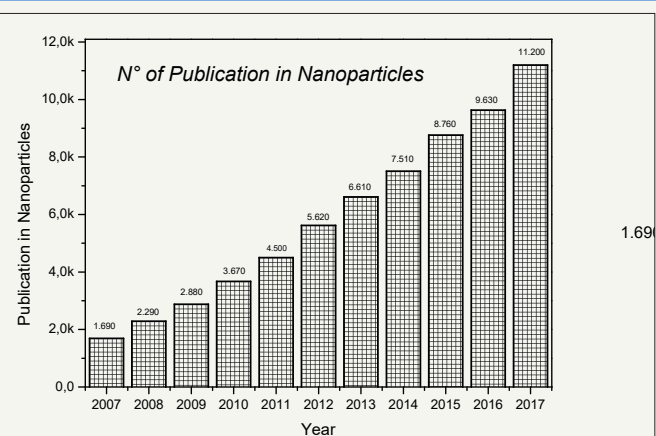
The relative importance of biosensor and biomaterial publications in cancer has increased in the last decade. In 2007, 0.11% of cancer publications were directly related to biosensors and biomaterials; in 2017, this value was of 4.93%. Table 7 shows these values during the last decade, while Figure 10 presents the tendency line, the value of R^2 , as well as the Relative Importance.

The number of publications about biosensors and biomaterials in cancer has increased over the last decade, as can be seen in Figure 11. In 2007, there were 1.39K publications; in 2017, the number increased reaching 7.10K publications. The relative importance of publications of biosensors and nanoparticles in cancer has increased in the last decade. In 2007, 0.13% of cancer publications were directly related to biosensors and nanoparticles; in 2017, this value was of 7.77%. Table 8 and Figure 12 show the treated data. The number of publications on biosensors and nanoparticles in cancer has increased over the last decade, as can be seen in Figure 13. In 2007, the number of publications was equal to 1.69K publications; in 2017, the number reached 11.20K publications.

Table 8: The bibliometrics of biosensors using nanoparticles in cancer in the last decade.

Year	Nanoparticles	Cancer	RI (%)
2007	1.69	1.240.000	0.136
2008	2.29	1.180.000	0.194
2009	2.88	1.090.000	0.264
2010	3.67	1.040.000	0.353
2011	4.5	960	0.469

2012	5.62	809	0.695
2013	6.61	655	1.009
2014	7.51	453	1.658
2015	8.76	243	3.605
2016	9.63	155	6.213
2017	11.2	144	7.778

**Figure 11:** The bibliometrics of biosensor using biomaterial in cancer in the last decade.**Figure 12:** The Relative Importance and Tendency Curve of the biosensor using nanoparticles in cancer in the last decade.**Figure 13:** The bibliometrics of biosensor and nanoparticles in cancer in the last decade.

The relative importance of publications of biosensors and graphene in cancer has increased in the last decade. In 2007, 0.01% of cancer publications were directly related to biosensors and graphene; in 2017, this value was of 3.99%. Table 9 and Figure 14 show the treated data. The Relative Importance of biosensor and tattoos publications on cancer has increased in the last decade. In 2007, 0.001% of cancer publications were directly related to

biosensors and tattoos; in 2017, this value was of 0.07%. Table 10 shows these values during the last decade; and in Figure 15 it is possible to observe the tendency line, the value of R^2 , as well as the Relative Importance. The number of publications on biosensors and tattoos in cancer has increased over the last decade, as can be seen in Figure 16.

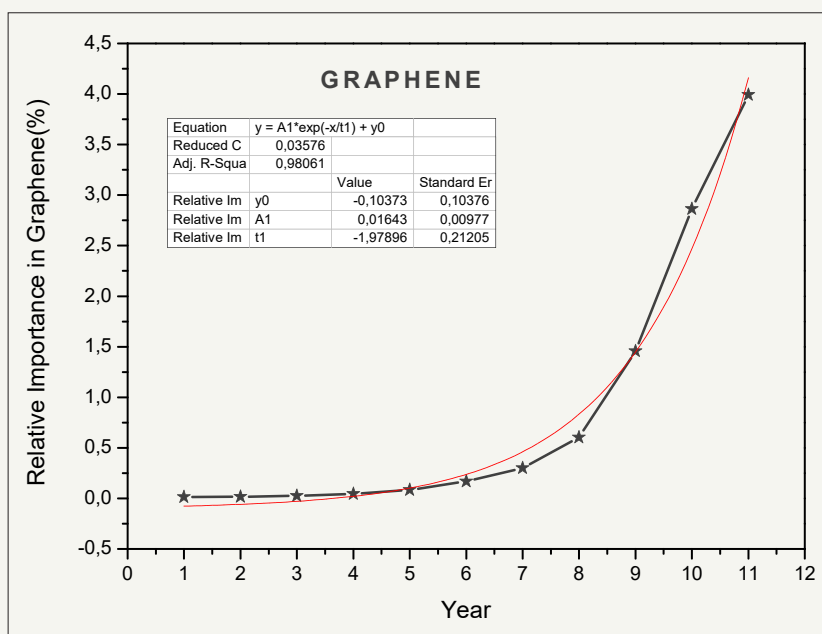


Figure 14: The Relative Importance and Tendency Curve of biosensors using graphene in cancer in the last decade.

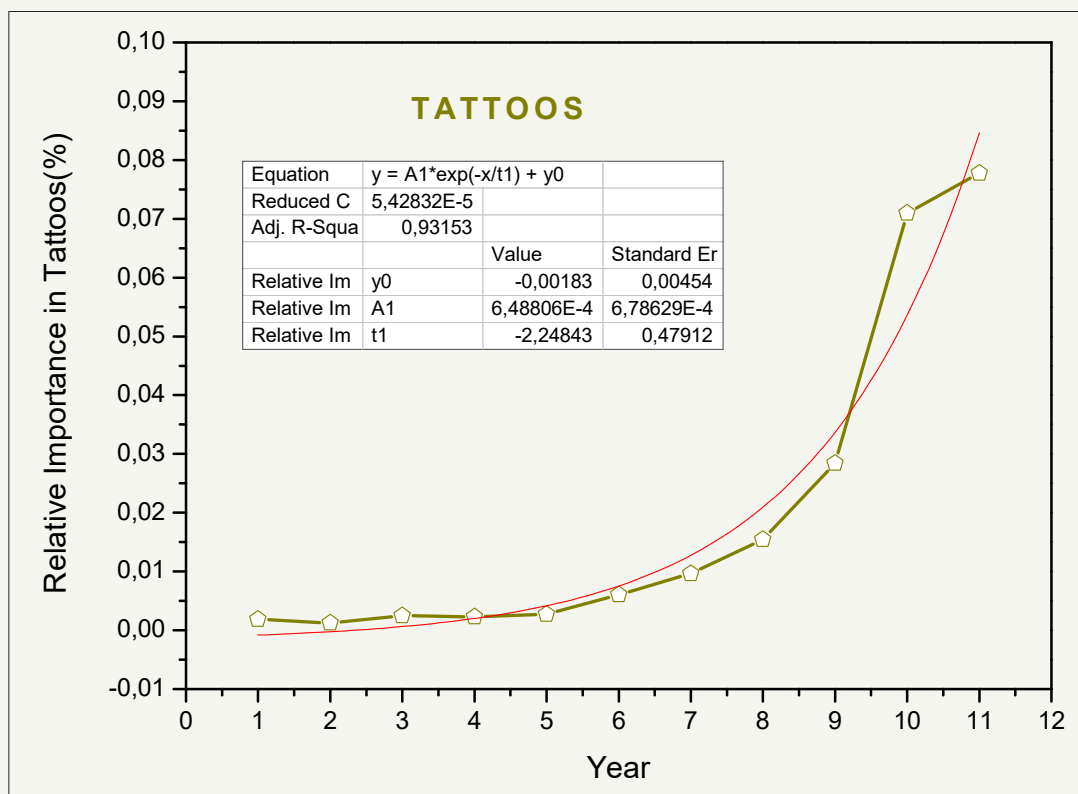


Figure 15: The Relative Importance and Tendency Curve of the biosensor used in tattoos in cancer.

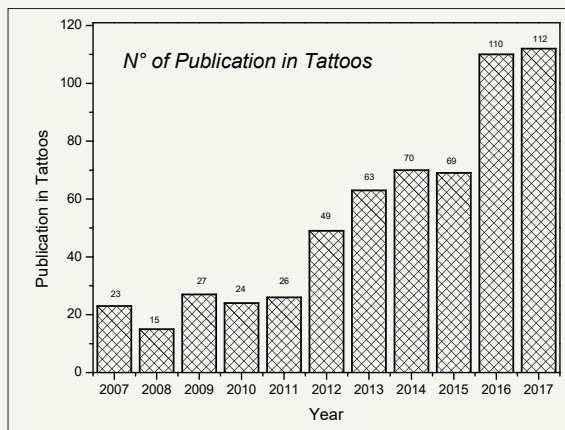


Figure 16: The bibliometrics of biosensor and tattoos in cancer in the last decade.

Table 9: The bibliometrics of the biosensor using graphene in cancer in the last decade.

Year	Graphene	Cancer	RI (%)
2007	155	1.240.000	0.013
2008	190	1.180.000	0.016
2009	281	1.090.000	0.026
2010	461	1.040.000	0.044
2011	801	960	0.083
2012	1.35	809	0.167
2013	1.96	655	0.299
2014	2.73	453	0.603
2015	3.54	243	1.457
2016	4.44	155	2.865
2017	5.75	144	3.993

Table 10: The bibliometrics of biosensor using tattoos in cancer in the last decade.

Year	Tattoos	Cancer	RI %
2007	23	1.240.000	0.002
2008	15	1.180.000	0.001
2009	27	1.090.000	0.002
2010	24	1.040.000	0.002
2011	26	960	0.003
2012	49	809	0.006
2013	63	655	0.01
2014	70	453	0.015
2015	69	243	0.028
2016	110	155	0.071
2017	112	144	0.078

The relative importance of biosensor and point-of-care (POC) publications in cancer has increased in the last decade. In 2007, 0.02% of cancer publications were directly related to biosensors and POCs; in 2017, this value was of 1.77%. Table 11 shows these

values during the last decade; and in Figure 17 it is possible to observe the tendency line, the value of R^2 , as well as Relative Importance. The number of publications on biosensors and Point-of-care in cancer has increased over the last decade, as can be seen in Figure 18.

Table 11: The bibliometrics of biosensor Point-of-care in cancer.

Year	Point-of-Care	Cancer	RI (%)
2007	300	1.240.000	0.024
2008	387	1.180.000	0.033
2009	513	1.090.000	0.047
2010	686	1.040.000	0.066
2011	828	960	0.086
2012	1.05	809	0.13
2013	1.27	655	0.194
2014	1.62	453	0.358
2015	1.91	243	0.786
2016	2.21	155	1.426
2017	2.55	144	1.771

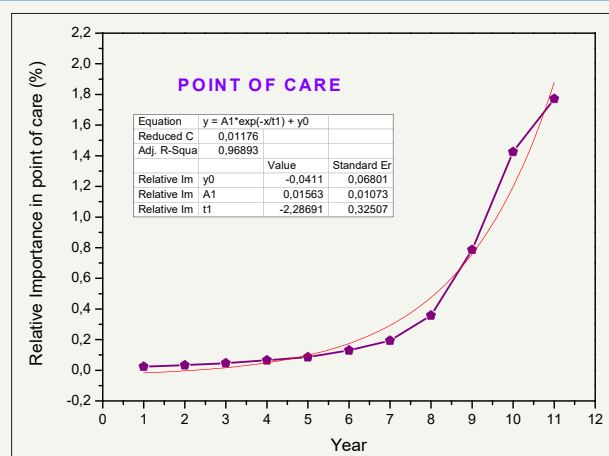


Figure 17: The Relative Importance and Tendency Curve of biosensor and Point-of-care in cancer.

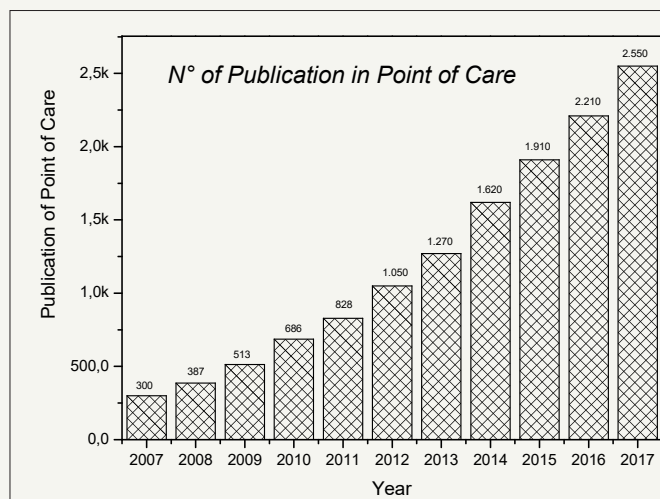


Figure 18: The bibliometrics of biosensor and Point-of-care in cancer in the last decade.

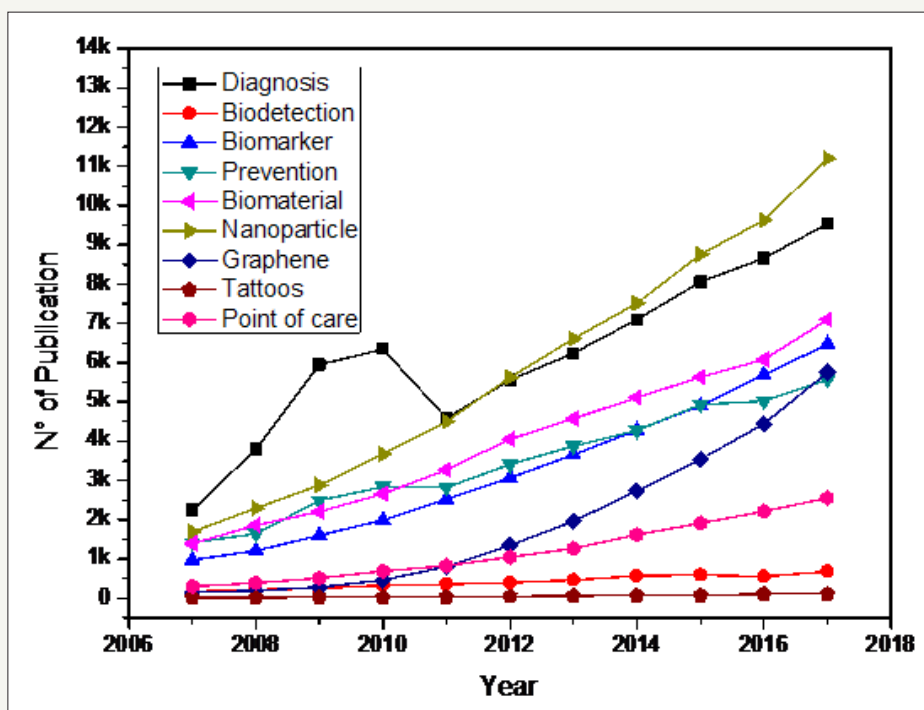


Figure 19: Comparison of the number of biosensor publications in the cancer applications that this study considered.

Figure 19 shows a comparison of the number of biosensor publications in the cancer applications that this study considered. Despite the more significant number of publications being diagnosed, it can be observed that the number of publications in the year 2017 using nanoparticles in cancer was higher than in diagnosis. The second highest number of applications was diagnosed, followed by biomaterial, biomarker, prevention, graphene, point-of-care, bio-detection, and tattoo, respectively. Some factors may have contributed to the decline of bibliometrics in cancer. One such factor was the global crisis that occurred in the period from 2008 to 2013, which directly affected investment in R & D in several countries around the world, as shown in a study by OECD [146].

Although the fall in investment may have directly affected cancer research, it has been observed that concerning nanotechnology, the bibliometrics in cancer biosensors have increased considerably, evidencing a trend in new technologies applied to medicine.

Figure 20 shows the values of the relative importance of biosensor applications in cancer. As can be observed, the use of nanoparticles in the year 2016 and 2017 has become the largest of all applications, followed by diagnosis, biomaterial, biomarker, graphene, prevention, point-of-care, bio-detection, and tattoos. As it was shown throughout this work, all the curves of tendency had behavior that corresponds to the increase of the publications using biosensors in cancer, confirming, thus, a tendency in the use of the same one.

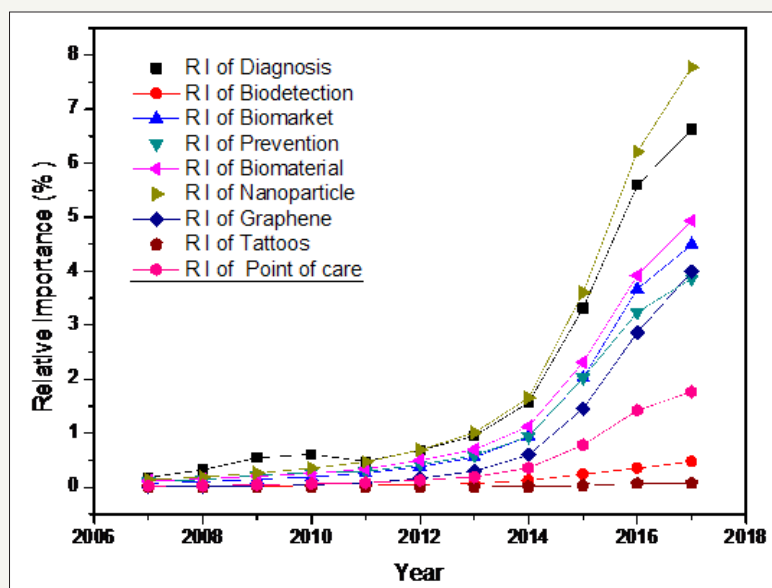


Figure 20: The values of Relative Importance in the last decade of biosensor applications in cancer.

Conclusion

The use of biosensors has been growing over the last decade, evidencing a search for new applications in it. However, despite significant budget cuts in R & D, this seems to have not affected the use of biosensors and their diverse applications in cancer, showing that the use of technologies applied to health, such as medicine, is a trend in clinical research.

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