

Content available at: <https://www.ipinnovative.com/open-access-journals>IP International Journal of Comprehensive and Advanced  
PharmacologyJournal homepage: <https://www.ijcap.in/>

## Original Research Article

## Role of nanoparticles in pancreatic drug delivery: Including a bibliography on Targeted drug delivery

Navni Sharma<sup>1,\*</sup>, Vimal Arora<sup>2</sup>, Gaurav Joshi<sup>2</sup>,  
Bhupendra Gopalbhai Prajapati<sup>3</sup>, Akshay Parihar<sup>4</sup><sup>1</sup>Research Scholar, University Institute of Pharmaceutical Sciences, Chandigarh University, Gharuan, Mohali, Punjab, India<sup>2</sup>Dept. of Pharmacy, (UIPS) Chandigarh University Gharuan, Mohali, Punjab, India<sup>3</sup>Dept. of Pharmaceutics (Formulation, Development and Characterization), Shree S.K.Patel College of Pharmaceutical Education and Research, Ganpat University, Mehsana, Gujarat, India<sup>4</sup>Faculty of Pharmaceutical sciences, The ICFAI University, Baddi, Himachal Pradesh, India

## ARTICLE INFO

## Article history:

Received 22-03-2023

Accepted 27-04-2023

Available online 23-05-2023

## Keywords:

Pancreatic Cancer

nanoparticles

Targeted Drug delivery

Global publications

Bibliometric analysis

TopCitations

## ABSTRACT

**Background:** The number of times a publication or an individual author has been discussed in the scientific community is a common metric for measuring their impact. The goal of the bibliometric study was to look at the maximum cited articles in the area of "pancreatic cancer, nanoparticles, targeted ligand, binding, drug delivery and treatment."

**Materials and Methods:** The database SCOPUS was used to conduct a computerised literature search. The top 100 articles with the most citations were chosen and studied further

**Results:** There were 298 citations in the most cited article, with an average of 62 citations per publication. These highly cited publications appeared in 33 journals, with the Journal of Controlled Release leading the pack (27 articles). The United States contributed 53 articles, which originated from 19 different countries. These 100 citations were provided by 85 institutions, with the "Department of Chemical and Biomolecular Engineering" leading the way (4).

**Conclusions:** The investigation of the top highly cited articles concedes for recognizing significant advances in pancreatic cancer targeted drug delivery study and gives a historical perspective on the advancement of this speciality of cancer research.

This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License](https://creativecommons.org/licenses/by-nc-sa/4.0/), which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: [reprint@ipinnovative.com](mailto:reprint@ipinnovative.com)

## 1. Background

Pancreatic cancer is a deadly disease because of its poor prognosis. The chances of the development of this cancer are increasing day by day. Through the physician, scientists got knowledge of advancements through the papers. As the growth of the disease increased, the publication rate also increased. In recent years, there is a huge difference in the article published count than the previous ones. We received 298 articles by which 15 articles are cited more than 100

times. The main purpose of our analysis is to identify the top citations in the area of pancreatic cancer nanoparticle targeted drug delivery research.<sup>1</sup>

## 2. Materials and Methods

The information was collected using the SCOPUS database, which was launched by Elsevier and generated 298 results. Table 3 lists the top 100 most cited papers in order of citation count. The article with the most citations received 298 while the item with the fewest received only 80. Over 100 citations were found in fourteen papers. The citations of a work from

\* Corresponding author.

E-mail address: [akshay.parihar20@gmail.com](mailto:akshay.parihar20@gmail.com) (N. Sharma).

before 2006 that had been cited for 10 years with an average count for each paper was 62.<sup>2</sup>

**Table 1:** The top 100 publications referenced in pancreatic cancer nanoparticles targeted drug - delivery research

Year	Citations of 298 Documents	Number of Papers
<2006	0	0
2006	1	1
2007	8	0
2008	12	4
2009	38	3
2010	76	2
2011	113	7
2012	174	12
2013	249	10
2014	303	19
2015	404	27
2016	560	26
2017	761	36
2018	922	31
2019	1250	39
2020	1736	39
2021	1947	42
Total	8554	298

### 3. Results

The SCOPUS database, which was launched by Elsevier, was used to conduct the literature search, which yielded 298 results. Table 3 shows the top 100 most referenced papers ranked by the number of citations. The article with the most citations earned 298 citations, while the article with the least citations saved 80. A total of fourteen articles saved over 100 citations. Each paper received an average of 62 citations. We also looked at the citations of a publication published before 2006 that had been cited for the previous ten years. The results indicate there was no document published and cited before 2006. In the year 2006 number of papers cited: and number of Paper published was 1:1, 2007 (8:0), 2008 (12:4), 2009 (38:3), 2010 (76:2), 2011 (113:7), 2012 (174:12), 2013 (249:10), 2014 (303:19), 2015 (404:27), 2016 (560:26), 2017 (761:36), 2018 (922:31), 2019 (1250:39), 2020 (1736:39), and 2021(1947:42) respectively (Table 2).

The top-cited papers were published in 33 high-impact journals (Table 4), led by the Journal of Controlled Release (27 articles), Theranostics (12 articles), International Journal of Nanomedicine (10 articles), and Molecular Pharmaceutics (7 articles). The top 100 referenced papers came from 19 different nations, with the United States generating 53, China 16 and Germany 5 each (Table 5). These top 100 referenced publications were generated by 85 different universities. Eleven universities generated two or more of the top-cited publications (Table 5), with the

**Table 2:** The top 100 publications referenced in pancreatic cancer nanoparticles targeted drug delivery system research

Rank	Reference Number	Number of Citations	Rank	Reference Number	Number of Citations
1	3	280	35	4	70
2	5	230	36	6	68
3	7	209	37	8	68
4	9	157	38	10	66
5	11	151	39	12	64
6	13	148	40	14	64
7	15	145	41	16	64
8	17	142	42	18	63
9	19	140	43	20	63
10	21	125	44	22	62
11	23	124	45	24	61
12	25	112	46	26	60
13	27	111	47	28	58
14	29	109	48	30	57
15	31	100	49	32	57
16	33	97	50	34	54
17	35	96	51	36	54
18	37	95	52	38	54
19	39	94	53	40	54
20	41	93	54	42	53
21	43	88	55	44	52
22	45	86	56	46	52
23	47	86	57	48	51
24	49	84	58	50	50
25	51	80	59	52	49
26	53	80	60	54	49
27	55	76	61	56	48
28	57	75	62	58	48
29	59	74	63	60	48
30	61	73	64	62	48
31	63	72	65	64	47
32	65	71	66	66	47
33	67	71	67	68	47
34	69	70	68	70	47

Department of Chemical and Biomolecular Engineering leading the way with four articles, followed by the University of Texas with seven, and Harvard University with six (7 articles).

### 4. Discussion

A number of aims are served by bibliometric examination of the most frequently cited publications and the journals in which they appear. It acknowledges and emphasises the value of our predecessors' and colleagues' work, highlights major milestones in pancreatic cancer research,

**Table 3:** Journals published the top 100 cited papers

Rank	Journals	Number of Article
1	Journal of Controlled Release	27
2	Theranostics	12
3	International Journal of Nanomedicine	10
4	Molecular Pharmaceutics	7
5	Pharmacological Reviews	6
6	Bioconjugate Chemistry	5
7	Advanced Healthcare Materials	3
7	Journal of Nanobiotechnology	3
8	Frontiers in Pharmacology	2
8	Molecular Therapy	2
9	ActaPharmaceuticaSinica B	1
10	Bioconjugate Chemistry	1
11	BioImpacts	1
12	Brazilian Journal of Pharmaceutical Sciences	1
13	ChemMedChem	1
14	Current Cancer Drug Targets	1
15	Current Drug Delivery	1
16	Current Drug Metabolism	1
17	Current Drug Targets	1
18	Current Medicinal Chemistry	1
19	Current Pharmaceutical Design	1
20	Drug Delivery	1
21	Drug Resistance updates	1
22	European Journal of Pharmaceutical Sciences	1
23	European Journal of Pharmaceutics and Biopharmaceutics	1
24	Journal of Clinical Pharmacology	1
25	Journal of Pharmaceutical Analysis	1
26	Journal of Pharmaceutical Sciences	1
27	Molecular Therapy - Nucleic Acids	1
28	Nanomedicine: Nanotechnology, Biology, and Medicine	1
29	Nucleic Acid Therapeutics	1
30	Pharmaceutics	1
31	Pharmaceutics	1

**Table 4:** The top 100 referenced articles' countries of origin

Rank	Country	No. of Articles
1	United States	53
2	China	16
3	Germany	5
4	Iran	3
4	Japan	3
4	Poland	3
4	South Korea	3
5	India	2
5	Italy	2
6	Australia	1
6	South Korea	1
6	Estonia	1
6	France	1
6	Mexico	1
6	Netherlands	1
6	Portugal	1
6	Switzerland	1
6	Taiwan	1
6	United Kingdom	1

**Table 5:** Originating institutions with two or more highly referenced papers

Rank	Institution	Number of Articles
1	Yonsei University	4
2	Department of Biomedical Engineering	3
2	Department of Pharmaceutics	3
3	Cancer Biology Research Centre	2
3	Hampton University	2
3	University of Colorado School of Pharmacy	2
3	Department of Pharmacy	2
3	Department of Surgery	2
3	Department of Technology and Biotechnology of Drugs	2
3	Experimental Pathology and Therapeutics Group	2
3	Laboratory of Cytobiochemistry	2

and provides helpful historical data. Citation analysis of published research on pancreatic cancer targeted drug delivery gives quantifiable information on authors, nations, and publications, aiding in the finding of high-impact works and journals. This is the first time, as far as we know, that a citation-based analysis of the top citations in pancreatic cancer research has been conducted. Although examining all 100 top citations in detail would be difficult, the top ten may reveal some interesting data.

These 10 notable citations have highlighted significant accomplishments in pancreatic cancer nanoparticle targeted

drug delivery research and a variety of related fields throughout the preceding 50 years. The primary paper, written by P. Yingchoncharoen, detailed a lipid medicine delivery system for cancer therapy that might be the most important advancement in medical treatment research in decades. Many articles are still mentioned on a daily basis, and their citation is fully reliable on the passage of time, since the date of publication is a significant determinant in citation. As a consequence, modern works get less citations than older ones. However, no document was cited before 2006, and the years 2015-2021 had the most citations, with 27 and 42, respectively. It illustrates that changes in the previous six years have been more significant. In addition, each year, a huge

number of new journals are founded, the number of published papers rises dramatically, and more references are referenced. Three journals namely Theranostics, Journal of Controlled Release, and International Journal of Nanomedicine published 27, 12, and 10 papers respectively. This data suggests that these three journals were the most influential in the field of pancreatic cancer nanoparticles targeted drug delivery research. Molecular Pharmaceutics, Pharmacological Reviews, and Bioconjugate Chemistry were also excellent medical journals, with 18 papers published each.

Because this is an important issue and a major concern on a worldwide scale, the publication rate on this topic is consistently increasing in these journals. Another conclusion is that the majority of the most highly reference papers come from the United States. The United States is home to the majority of productive institutions. Because of its big population and funding agencies, the United States has a significant effect on targeted medication delivery for the treatment of pancreatic cancer. The United States government assists and supports the scientific community in their research. There were at least 100 top-cited publications in this review, however, the majority of them were document-type articles. A few of them are not original study papers, but they are classified as opinion pieces for future cancer research, which is why they are often mentioned. The top articles found while searching for "pancreatic cancer nanoparticles tailored ligand binding medication delivery" were mostly about cancer. This article may open up new avenues for medical study and aid in the identification of gaps in pancreatic cancer therapy.

## 5. Conclusion

The articles that received the most citations contributed to advancements in the field of pancreatic cancer research. This analysis identifies important advancements in pancreatic cancer and targeted drug delivery research, as well as providing a historical perspective on the history of pancreatic cancer research.

## 6. Source of Funding

None.

## 7. Conflict of Interest

None.

## References

- Zhang Y, Quan L, Du L. The 100 top-cited studies in cancer immunotherapy. *Artificial Cells, Nanomedicine, Biotechnol.* 2019;47(1):2282–92. doi:10.1080/21691401.2019.1623234.
- Li Q, Jiang Y. Top Classic Citations in Pancreatic Cancer Research. *World J Surg Oncol.* 2016;14(1):298. doi:10.1186/s12957-016-1061-8.
- Yingchoncharoen P, Kalinowski DS, Richardson DR. Lipid-Based Drug Delivery Systems in Cancer Therapy: What Is Available and What Is yet to Come. *Pharmacol Rev.* 2016;68(3):701–87. doi:10.1124/pr.115.012070.
- Stylianopoulos T, Jain RK. Design considerations for nanotherapeutics in oncology. *Nanomedicine.* 2015;11(8):1893–907. doi:10.1016/j.nano.2015.07.015.
- Shergalis A, Bankhead A, Luesakul U, Muangsin N, Neamati N. Current Challenges and Opportunities in Treating Glioblastomas. *Pharmacol Rev.* 2018;70(3):412–45. doi:10.1124/pr.117.014944.
- Yang T, Li B, Qi S, Liu Y, Gai Y, Ye P, et al. Co-Delivery of Doxorubicin and Bmi1 siRNA by Folate Receptor Targeted Liposomes Exhibits Enhanced Anti-Tumor Effects in Vitro and in Vivo. *Theranostics.* 2014;4(11):1096–111. doi:10.7150/thno.9423.
- Gannon CJ, Patra CR, Bhattacharya R, Mukherjee P, Curley SA. Intracellular Gold Nanoparticles Enhance Non-Invasive Radiofrequency Thermal Destruction of Human Gastrointestinal Cancer Cells. *J Nanobiotechnol.* 2008;doi:10.1186/1477-3155-6-2.
- Wei A, Mehtala JG, Patri AK. Challenges and Opportunities in the Advancement of Nanomedicines. *J Controlled Release.* 2012;164(2):236–46. doi:10.1016/j.jconrel.2012.10.007.
- Xu L, Anchordoquy T. Drug Delivery Trends in Clinical Trials and Translational Medicine: Challenges and Opportunities in the Delivery of Nucleic Acid-Based Therapeutics. *J Pharm Sci.* 2011;100(1):38–52. doi:10.1002/jps.22243.
- Lowery A, Onishko H, Hallahan DE, Han Z. Tumor-Targeted Delivery of Liposome-Encapsulated Doxorubicin by Use of a Peptide That Selectively Binds to Irradiated Tumors. *J Controlled Release.* 2011;150(1):117–24. doi:10.1016/j.jconrel.2010.11.006.
- Zhang N, Chittasupho C, Duangrat C, Siahaan TJ, Berkland C. PLGA Nanoparticle-Peptide Conjugate Effectively Targets Intercellular Cell-Adhesion Molecule-1. *Bioconjug Chem.* 2008;19(1):145–52. Available from: <https://doi.org/10.1021/bc700227z>.
- Santiago-Ortiz JL, Schaffer DV. Adeno-Associated Virus (AAV) Vectors in Cancer Gene Therapy. *J Control Release.* 2016;240:287–301. doi:10.1016/j.jconrel.2016.01.001.
- Szabo C, Papapetropoulos A. International Union of Basic and Clinical Pharmacology. CII: Pharmacological Modulation of H2S Levels: H2S Donors and H2S Biosynthesis Inhibitors. *Pharmacol Rev.* 2017;69(4):497–564. doi:10.1124/pr.117.014050.
- Rahman MA, Amin A, Wang X, Zuckerman JE, Choi CHJ, Zhou B, et al. Systemic Delivery of siRNA Nanoparticles Targeting RRM2 Suppresses Head and Neck Tumor Growth. *J Control Release.* 2012;159(3):384–92. doi:10.1016/j.jconrel.2012.01.045.
- Yallapu MM, Othman SF, Curtis ET, Bauer NA, Chauhan N, Kumar D, et al. Curcumin-Loaded Magnetic Nanoparticles for Breast Cancer Therapeutics and Imaging Applications. *Int J Nanomedicine.* 2012;7:1761–79. doi:10.2147/IJN.S29290.
- Ndinguri MW, Solipuram R, Gambrell RP, Aggarwal S, Hammer RP. Peptide Targeting of Platinum Anti-Cancer Drugs. *Bioconjug Chem.* 2009;20(10):1869–78. doi:10.1021/bc900065r.
- Zhu S, Niu M, O'mary H, Cui Z. Targeting of tumor-associated macrophages made possible by PEG-sheddable, mannose-modified nanoparticles. *Mol Pharm.* 2013;10(9):3525–30. doi:10.1021/mp400216r.
- Gao S, Yang D, Fang Y, Lin X, Jin X, Wang Q, et al. Engineering Nanoparticles for Targeted Remodeling of the Tumor Microenvironment to Improve Cancer Immunotherapy. *Theranostics.* 2019;9(1):126–51. doi:10.7150/thno.29431.
- Mulloy B, Hogwood J, Gray E, Lever R, Page CP. Pharmacology of Heparin and Related Drugs. *Pharmacol Rev.* 2015;68(1):76–141. doi:10.1124/pr.115.011247.
- Knoop K, Kolokythas M, Klutz K, Willhauck MJ, Wunderlich N, Draganovici D, et al. Image-Guided, Tumor Stroma-Targeted 131 i Therapy of Hepatocellular Cancer after Systemic Mesenchymal Stem Cell-Mediated Nis Gene Delivery. *Mol Ther.* 2011;19(9):1704–13. doi:10.1038/mt.2011.93.
- Chittasupho C, Xie SX, Baoum A, Yakovleva T, Siahaan TJ, Berkland CJ, et al. ICAM-1 Targeting of Doxorubicin-Loaded

- PLGA Nanoparticles to Lung Epithelial Cells. *Eur J Pharm Sci.* 2009;37(2):141–50.
22. Wang F, Porter M, Konstantopoulos A, Zhang P, Cui H. Preclinical Development of Drug Delivery Systems for Paclitaxel-Based Cancer Chemotherapy. *J Controlled Release.* 2017;267:100–18. doi:10.1016/j.jconrel.2017.09.026.
  23. Irby D, Du C, Li F. Lipid-Drug Conjugate for Enhancing Drug Delivery. *Mol Pharm.* 2017;14(5):1325–38. doi:10.1021/acs.molpharmaceut.6b01027.
  24. Xu J, Gattacceca F, Amiji M. Biodistribution and Pharmacokinetics of EGFR-Targeted Thiolated Gelatin Nanoparticles Following Systemic Administration in Pancreatic Tumor-Bearing Mice. *Mol Pharm.* 2013;10(5):2031–44. doi:10.1021/mp400054e.
  25. Alexis F, Basto P, Levy-Nissenbaum E, Radovic-Moreno AF, Zhang L, Pridgen E, et al. HER-2-targeted nanoparticle-affibody bioconjugates for cancer therapy. *ChemMedChem.* 2008;3(12):1839–43. doi:10.1002/cmdc.200800122.
  26. Melancon MP, Stafford RJ, Li C. Challenges to Effective Cancer Nanotherapeutics. *J Controlled Release.* 2012;164(2):177–82. doi:10.1016/j.jconrel.2012.07.045.
  27. Sancho V, Florio AD, Moody TW, Jensen RT. Bombesin Receptor-Mediated Imaging and Cytotoxicity: Review and Current Status. *Curr Drug Deliv.* 2011;8(1):79–134. doi:10.2174/156720111793663624.
  28. Wang W, Xi M, Duan X, Wang Y, Kong FE. Delivery of Baicalein and Paclitaxel Using Self-Assembled Nanoparticles: Synergistic Antitumor Effect in Vitro and in Vivo. *Int J Nanomedicine.* 2015;10:3737–50. doi:10.2147/IJN.S80297.
  29. Intra J, Salem AK. Characterization of the Transgene Expression Generated by Branched and Linear Polyethylenimine-Plasmid DNA Nanoparticles in Vitro and after Intraperitoneal Injection in Vivo. *J Controlled Release.* 2008;130(2):129–38. doi:10.1016/j.jconrel.2008.04.014.
  30. Kushwaha SKS, Ghoshal S, Rai AK, Singh S. Carbon Nanotubes as a Novel Drug Delivery System for Anticancer Therapy: A review. *Braz J Pharm Sci.* 2013;49(4):629–43. doi:10.1590/S1984-82502013000400002.
  31. Sunshine JC, Peng DY, Green JJ. Uptake and Transfection with Polymeric Nanoparticles Are Dependent on Polymer End-Group Structure, but Largely Independent of Nanoparticle Physical and Chemical Properties. *Mol Pharm.* 2012;9(11):3375–83.
  32. Shi H, Gao X, Li D, Zhang Q, Wang Y, Zheng Y. A systemic administration of liposomal curcumin inhibits radiation pneumonitis and sensitizes lung carcinoma to radiation. *Int J Nanomedicine.* 2012;7:2601–11. doi:10.2147/IJN.S31439.
  33. Yao VJ, Angelo S, Butler KS, Theron C, Smith TL, Marchiò S, et al. Ligand-Targeted Theranostic Nanomedicines against Cancer. *J Control Release.* 2016;240:267–86. doi:10.1016/j.jconrel.2016.01.002.
  34. Mashinchian O, Johari-Ahar M, Ghaemi B, Rashidi M, Barar J, Omid Y, et al. Impacts of Quantum Dots in Molecular Detection and Bioimaging of Cancer. *Bioimpacts.* 2014;4(3):149–66. doi:10.15171/bi.2014.008.
  35. Ferreira JA, Peixoto A, Neves M, Gaiteiro C, Reis CA, Assaraf YG, et al. Mechanisms of cisplatin resistance and targeting of cancer stem cells: Adding glycosylation to the equation. *Drug Resist Updat.* 2016;24:34–54. doi:10.1016/j.drug.2015.11.003.
  36. Sun T, Wang Y, Wang Y, Xu J, Zhao X, Vangveravong S, et al. Using Sv119-Gold Nanocage Conjugates to Eradicate Cancer Stem Cells through a Combination of Photothermal and Chemo Therapies. *Adv Healthc Mater.* 2014;3(8):1283–91. doi:10.1002/adhm.201400026.
  37. Park J, Park J, Pei Y, Xu J, Yeo Y. Pharmacokinetics and Biodistribution of Recently-Developed siRNA Nanomedicines. *Adv Drug Deliv Rev.* 2016;104:93–109. doi:10.1016/j.addr.2015.12.004.
  38. Sun S, Shang E, Ju A, Li Y, Wu Q, Li Q, et al. Tumor-Targeted Hyaluronic Acid-MPEG Modified Nanostructured Lipid Carriers for Cantharidin Delivery: An in Vivo and in Vitro Study. *Fitoterapia.* 2021;155:105033. doi:10.1016/j.fitote.2021.105033.
  39. Bhojani MS, Van Dort M, Rehemtulla A, Ross BD. Targeted Imaging and Therapy of Brain Cancer Using Theranostic Nanoparticles. *Mol Pharm.* 2010;7(6):1921–9. doi:10.1021/mp100298r.
  40. Nordmeier S, Ke W, Afonin KA, Portnoy V. Exosome mediated delivery of functional nucleic acid nanoparticles (NANPs). *Nanomedicine.* 2020;30:102285. doi:10.1016/j.nano.2020.102285.
  41. Lee J, Jo DG, Park D, Chung HY, Mattson MP. Adaptive Cellular Stress Pathways as Therapeutic Targets of Dietary Phytochemicals: Focus on the Nervous System. *Pharmacol Rev.* 2014;66(3):815–68. doi:10.1124/pr.113.007757.
  42. Sandoval MA, Sloat BR, Lansakara P, Kumar DSP, Rodriguez A, Kiguchi BL, et al. EGFR-Targeted Stearoyl Gemcitabine Nanoparticles Show Enhanced Anti-Tumor Activity. *J Controlled Release.* 2012;157(2):287–96. doi:10.1016/j.jconrel.2011.08.015.
  43. Singh P, Destito G, Schneemann A, Manchester M. Canine Parvovirus-like Particles, a Novel Nanomaterial for Tumor Targeting. *J Nanobiotechnol.* 2006;doi:10.1186/1477-3155-4-2.
  44. Isaacson KJ, Jensen MM, Subrahmanyam NB, Ghandehari H. Matrix-Metalloproteinases as Targets for Controlled Delivery in Cancer: An Analysis of Upregulation and Expression. *J Controlled Release.* 2017;259:62–75. doi:10.1016/j.jconrel.2017.01.034.
  45. Cui P, Wang S. Application of Microfluidic Chip Technology in Pharmaceutical Analysis: A Review. *J Pharm Anal.* 2019;9(4):238–47.
  46. Wu PH, Onodera Y, Ichikawa Y, Rankin EB, Giaccia AJ, Watanabe Y, et al. Targeting Integrins with RGD-Conjugated Gold Nanoparticles in Radiotherapy Decreases the Invasive Activity of Breast Cancer Cells. *Int J Nanomedicine.* 2017;12:5069–85. doi:10.2147/IJN.S137833.
  47. Park J, Choi Y, Chang H, Um W, Ryu JH, Kwon IC, et al. Alliance with EPR Effect: Combined Strategies to Improve the EPR Effect in the Tumor Microenvironment. *Theranostics.* 2019;9(26):8073–90. doi:10.7150/thno.37198.
  48. Chen S, Boda SK, Batra SK, Li X, Xie J. Emerging Roles of Electrospun Nanofibers in Cancer Research. *Adv Healthc Mater.* 2018;7(6):e1701024. doi:10.1002/adhm.201701024.
  49. Lin G, Zhang H, Huang L. Smart Polymeric Nanoparticles for Cancer Gene Delivery. *Mol Pharm.* 2015;12(2):314–21. doi:Pharmaceutics.
  50. Khoshnejad M, Parhiz H, Shuvaev VV, Dmochowski IJ, Muzykantov VR. Ferritin-Based Drug Delivery Systems: Hybrid Nanocarriers for Vascular Immunotargeting. *J Controlled Release.* 2018;282:13–24. doi:10.1016/j.jconrel.2018.02.042.
  51. Barar J, Rafi MA, Pourseif MM, Omid Y. Blood-Brain Barrier Transport Mechanisms and Targeted Therapy of Brain Diseases. *Bioimpacts.* 2016;6(4):225–48. Available from: <https://doi.org/10.15171/bi.2016.30>. doi:10.15171/bi.2016.30.
  52. Huang J, Liu F, Han X, Zhang L, Hu Z, Jiang Q, et al. Nanosensitizers for Highly Efficient Sonodynamic Cancer Therapeutics. *Theranostics.* 2018;8(22):6178–94. doi:10.7150/thno.29569.
  53. Sanna V, Pala N, Dessì G, Manconi P, Mariani A, Dedola S, et al. Single-Step Green Synthesis and Characterization of Gold-Conjugated Polyphenol Nanoparticles with Antioxidant and Biological Activities. *Int J Nanomedicine.* 2014;9(1):4935–51. doi:10.2147/IJN.S70648.
  54. Gilabert-Oriol R, Weng A, Mallinckrodt BV, Melzig MF, Fuchs H, Thakur M, et al. Immunotoxins Constructed with Ribosome-Inactivating Proteins and Their Enhancers: A Lethal Cocktail with Tumor Specific Efficacy. *Curr Pharm Design.* 2014;20(42):6584–643. doi:10.2174/1381612820666140826153913.
  55. Liu D, Auguste DT. Cancer Targeted Therapeutics: From Molecules to Drug Delivery Vehicles. *Journal of Controlled Release* 2015;219:632–643.
  56. Battogtokh G, Cho YY, Lee JY, Lee HS, Kang HC. Mitochondrial-Targeting Anticancer Agent Conjugates and Nanocarrier Systems for Cancer Treatment. *Front Pharmacol.* 2018;9. doi:10.3389/fphar.2018.00922.
  57. Toporkiewicz M, Meissner J, Matuszewicz L, Czogalla A, Sikorski AF. Toward a Magic or Imaginary Bullet? Ligands for Drug Targeting to Cancer Cells: Principles, Hopes, and Challenges. *Int J Nanomedicine.* 2015;10:1399–414. doi:10.2147/IJN.S74514.
  58. Gurka MK, Pender D, Chuong P, Fouts BL, Sobelov A, Menally MW, et al. Identification of Pancreatic Tumors in Vivo with


- Ligand-Targeted, PH Responsive Mesoporous Silica Nanoparticles by Multispectral Optoacoustic Tomography. *J Controlled Release*. 2016;231:60–7. doi:10.1016/j.jconrel.2015.12.055.
59. Liu J, Liu J, Xu H, Zhang Y, Chu L, Liu Q, et al. Novel Tumor-Targeting, Self-Assembling Peptide Nanofiber as a Carrier for Effective Curcumin Delivery. *Int J Nanomedicine*. 2013;9(1):197–207. doi:10.2147/IJN.S55875.
  60. Pandya DN, Hantgan R, Budzevich MM, Kock ND, Morse DL, Batista I, et al. Preliminary Therapy Evaluation of 225Ac-DOTA-c (RGDyK) Demonstrates That Cerenkov Radiation Derived from 225Ac Daughter Decay Can Be Detected by Optical Imaging for in Vivo Tumor Visualization. *Theranostics*. 2016;6(5):698–709. doi:10.7150/thno.14338.
  61. Numata K, Hamasaki J, Subramanian B, Kaplan DL. Gene Delivery Mediated by Recombinant Silk Proteins Containing Cationic and Cell Binding Motifs. *J Controlled Release*. 2010;146(1):136–43.
  62. Porciani D, Tedeschi L, Marchetti L, Citti L, Piazza V, Beltram F, et al. Aptamer-Mediated Codelivery of Doxorubicin and NF- $\kappa$ B Decoy Enhances Chemosensitivity of Pancreatic Tumor Cells. *Mol Ther - Nucleic Acids*. 2015;4(4):e235. doi:10.1038/mtna.2015.9.
  63. Despanie J, Dhandhukia JP, Hamm-Alvarez SF, Mackay JA. Elastin-like Polypeptides: Therapeutic Applications for an Emerging Class of Nanomedicines. *Journal of Controlled Release* 2016;240:93–108.
  64. Thakuri PS, Liu C, Luker GD, Tavana H. Biomaterials-Based Approaches to Tumor Spheroid and Organoid Modeling. *Adv Healthcare Mater*. 2018;7(6):e1700980. doi:10.1002/adhm.201700980.
  65. Lu J, Zhao W, Huang Y, Liu H, Marquez R, Gibbs RB, et al. Targeted Delivery of Doxorubicin by Folic Acid-Decorated Dual Functional Nanocarrier. *Molecular Pharmaceutics* 2015;11(11):4164–4178.
  66. Adijanto J, Naash MI. Nanoparticle-Based Technologies for Retinal Gene Therapy. *Eur J Pharm Biopharmaceutics*. 2015;95:353–67. doi:10.1016/j.ejpb.2014.12.028.
  67. Abdalla MO, Karna P, Sajja HK, Mao H, Yates C, Turner T, et al. Enhanced Noscipine Delivery Using UPAR-Targeted Optical-MR Imaging Trackable Nanoparticles for Prostate Cancer Therapy. *J Controlled Release*. 2011;149(3):314–22.
  68. Tseng SH, Chou MY, Chu IM. Cetuximab-Conjugated Iron Oxide Nanoparticles for Cancer Imaging and Therapy. *Int J Nanomedicine*. 2015;10:3663–85. doi:10.2147/IJN.S80134.
  69. Zhang Y, Chan JW, Moretti A, Uhrich KE. Designing Polymers with Sugar-Based Advantages for Bioactive Delivery Applications. *J Controlled Release*. 2015;219:355–68. doi:10.1016/j.jconrel.2015.09.053.
  70. Ray P, Cheek MA, Sharaf ML, Li N, Ellington AD, Sullenger BA, et al. Aptamer-Mediated Delivery of Chemotherapy to Pancreatic Cancer Cells. *Nucleic Acid Therapeutics*. 2012;22(5):295–305. doi:10.1089/nat.2012.0353.

## Author biography

**Navni Sharma**, Research Scholar

**Vimal Arora**, Professor  <https://orcid.org/0000-0001-9520-138X>

**Gaurav Joshi**, Assistant Professor  <https://orcid.org/0000-0002-1033-0199>

**Bhupendra Gopalbhai Prajapati**, Professor  <https://orcid.org/0000-0001-8242-4541>

**Akshay Parihar**, Assistant Professor  <https://orcid.org/0000-0002-9597-2800>

**Cite this article:** Sharma N, Arora V, Joshi G, Prajapati BG, Parihar A. Role of nanoparticles in pancreatic drug delivery: Including a bibliography on Targeted drug delivery. *IP Int J Comprehensive Adv Pharmacol* 2023;8(2):112-117.