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Original article

## Current status and vision of local pharmaceutical industries in Saudi Arabia: The focus on nanomedicines



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### ABSTRACT

**Background:** Pharmaceutical nanomedicine products are expected to impact the global pharmaceutical market and healthcare system significantly. Since 2000, the Food and Drug Administration (FDA) and European Medicines Agency (EMA) have approved over 80 nanomedicine products for marketing; an additional double that number is currently being tested in clinical trials. The nanomedicine market is expected to reach USD 350.8 billion by 2025 from USD 138.8 billion in 2016. This demonstrates the importance of nanotechnology to the delivery of pharmaceuticals. The main benefits of employing nanotechnology to distribute therapeutic agents include reducing the undesired toxicity from non-specific distribution and increasing patient adherence, which can indirectly minimize the burden on the country's healthcare system. Such products are expected to gain a significant economic impact on Saudi Arabia's pharmaceutical drugs market once they get developed locally.

**Method:** A descriptive and cross-sectional study, including a web-based questionnaire and a complete categorization of pharmaceutical products formed by the national industries in Saudi Arabia, was utilized to investigate the current and future direction of pharmaceutical manufacturing exploiting nanotechnology in the Kingdom.

**Results:** The survey showed an apparent lack of willingness within the national pharmaceutical industries, as the majority ( $\approx 86\%$ ) of the leading Saudi companies cannot enable nanotechnology-based medicines in their manufacturing. However, more than 93% of the national pharmaceutical industries, upon the basis of the responses, agreed that the development of pharmaceutical products with nanotechnology is an important step toward solving various complications associated with conventional forms of the available medicine.

**Conclusion:** National pharmaceutical industries in Saudi Arabia will need to get closer to manufacturing nanomedicines by partnering with international pioneer companies. In addition, empowering the local research and development (R&D) centers in nano delivery systems could facilitate translating their

**Abbreviations:** CVS, cardiovascular; CNS, central nervous system; CAGR, Compound annual growth rate; EMA, European Medicines Agency; FDA, Food and Drug Administration; GDP, gross domestic product; GCC, Gulf Cooperation Council; MENA, Middle East and North Africa; OTC, over-the-counter; R&D, research and development; SFDA, Saudi Food and Drug Authority.

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R&D outcomes into novel advanced and commercialized products. This could imitate the direction of the global pharmaceutical market and share its revenue which will positively reflect on the Kingdom's economy.

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## 1. Introduction

The pharmaceutical industries in the Gulf Cooperation Council (GCC) countries started their efforts to improve the pharmaceutical market in the region about 25 years ago (Alsaddique 2017). The key concept was to reduce the cost of drugs that rose rapidly. However, the GCC countries still import 90% of their drug needs from major international companies (Alsaddique 2017). In Saudi Arabia, the medical sector is the third subsidized sector, following the military and educational sectors, with funding of over USD 46 billion in 2019 (International Trade Administration 2019). The pharmaceutical market is worth USD 8.3 billion. Forecasts applied by the Pharmaceuticals Export Promotion Council of India (pharmexcil 2020) showed that the Saudi pharmaceutical market would reach USD 10.89 billion by 2024 with a compound annual growth rate (CAGR) of 5.4%. This made the pharmaceutical market in Saudi Arabia the largest in the region, attracting several international pharmaceutical companies to localize their drug manufacturing technologies as part of the Kingdom's long-term development plan - Vision 2030.

Saudi Arabia has successfully promoted local pharmaceutical manufacturing development during the last decade to become the leading manufacturer and innovator in the MENA region by accelerating the transition of pharmaceuticals into products with higher complexity. The Kingdom's market is expected to grow at a 5% rate each year until 2025 to reach USD 10 billion. The contribution of Saudi Arabia to the MENA region is expected to increase and get 30% by 2025 (IQVIA 2019). Most pharmaceutical companies started as importers and distributors of drugs, and some have developed into pharmaceutical industries. Locally manufactured products cover only a small amount (i.e. 30%) of the current market demand (Tawfik et al., 2022), with a primary focus on producing generics, which means there is a growth potential, but this will require a significant capital investment. Saudi Arabia's pharmaceutical drugs market is expected to exhibit a CAGR of 7.3% during the forecast period (2020–2027), owing to increasing launches and approval of drugs. Among drug types, the branded drugs segment is expected to hold a major revenue share in 2027, owing to increasing launches of branded medicines in the local market, which is expected to accelerate the Saudi Arabia pharmaceutical drugs market growth soon (Coherent Market Insights 2021). For instance, in December 2015, SAJA Pharmaceuticals announced that it signed a contract with Novartis AG to launch SAJA, the first anti-diabetic drug (Jalra<sup>®</sup> and JalraM<sup>®</sup>), as a second brand of Novartis AG blockbuster (Galvus<sup>®</sup> and Galvus met<sup>®</sup>). However, increasing the production of pharmaceutical products locally by foreign players will also put more competitive pressure on smaller local companies that can fight to compete on their costs with international competitors. Global manufacturers are now focused on developing and launching advanced pharmaceutical drugs such as nanomedicines to improve therapeutic effects and patient convenience, which are expected to gain a significant economic impact that could reflect positively on one country's Gross domestic product (GDP).

The estimated cost of healthcare worldwide in 2017 was USD 7.8 trillion (World Health Organization 2019). Between 2017 and 2022, it was anticipated to expand at a pace of 5.4% per year. Saudi Arabia is considered the leading spender on healthcare in the Middle East, with nearly USD 37 billion in spending across the Ministry of Health and the private and semi-government sectors (Aitken et al., 2019). The average cost of healthcare worldwide (excluding the US) is USD 677 per person; however, in Saudi Arabia, it is more than USD 1,120 per person, which is 66% more than the average cost worldwide.

The global healthcare system is already starting to feel the effects of implementing nanotechnology in pharmaceutical products. Pharmaceutical applications and products based on nanotechnology, approved in the 80 s, have significantly increased (Farjadian et al., 2019). Over 80 nanomedicine products have been approved by the FDA and EMA and sold for over 20 years (Halwani 2022). This demonstrates the relevance of nanotechnology to the delivery of pharmaceuticals. Several nano pharmaceutical products were developed to alter the efficacy, safety, physicochemical, and pharmacokinetic/pharmacodynamic properties of the original medications; thereby increasing their effectiveness and decreasing their side effects (Choi and Han 2019).

Many fields of study and applications benefit significantly from nanotechnology and nanosciences. The term "nanotechnology" refers to the manufacture and application of materials, apparatus, and systems in the nanoscale, an intermediate range between atoms and the molecular scale with the vital prerequisite that at least one dimension is in the nanometer length (Jain 2008). Since several nanotechnology concepts have been created and several nanotechnology-based medications are currently on the market, the impact of nanotechnology on healthcare is already being seen. In various parts of the world, the public and private sectors are increasing their investments in nanotechnology (Thassu et al., 2007).

The size of the pharmaceutical market in Saudi Arabia has grown massively in the past few years; however, most national pharmaceutical industries still focus on manufacturing generics. In contrast, the major worldwide manufacturers focus on developing and launching advanced pharmaceutical drugs such as nanomedicines. This effort of developing new advanced medicines could gain a significant economic impact on both the pharmaceutical drugs market and the overall healthcare system. Consequently, the number of medications based on nanotechnology is increasing annually, as nanotechnology allows therapeutic agents to reach the targeted site and avoid their associated side effects and unfavorable pharmacokinetics parameters (Havel et al., 2016), which could increase a drug's total bioavailability and benefits over the conventional dosage forms.

Therefore, this study will investigate the sharing of nanomedicine products in the Saudi pharmaceutical market and understand more about the impact of nanomedicines, if any, on the national pharmaceutical industries. In addition, the accessibility of advanced drug manufacturing technologies in the healthcare system and the plans of localizing such technologies within the local

pharmaceutical industries will be assessed. Finally, this study will evaluate the current status and observe the future visionary directions of the Saudi pharmaceutical manufacturing capacity toward exploiting new drug manufacturing technologies, particularly nanotechnology.

## 2. Method

A descriptive cross-sectional study was conducted to assess the current and futuristic views on pharmaceutical manufacturing in Saudi Arabia and its potential impacts on the national economy. Thus, a web-based questionnaire was developed to be filled out by the national pharmaceutical industries. The survey consisted of three parts: general information about the industry includes pharmaceutical product manufacturing, marketing, and new biopharmaceuticals, awareness and willingness of the industry in nanomedicines includes planning for initiative and availability of application and research department, and the future and perspective of the industry to adopt the manufacturing of advanced pharmaceutical products. The validity of the survey was conducted using the face validity method, which is based on the judgment of two academics in the field of industrial pharmacy. Furthermore, the data's internal validity was evaluated using the Pearson correlation coefficient ( $r$ ), which indicates a good internal validity range from 0.8622 to 0.9985 (correlation is significant at level 0.05), as shown in the [supplementary materials](#) section. The survey period was four weeks (January 2022) and was distributed electronically to a key person in all national pharmaceutical industries in Saudi Arabia (a total of 17) using their mailing list. Systematic searches were also conducted for relevant research literature and report about the Saudi pharmaceutical market.

We also identified all pharmaceutical products made by the national pharmaceutical industries, available in the market and approved by Saudi Food and Drug Authority (SFDA). This study used national pharmaceutical industries' websites and the SFDA database to extract all medications available in the Saudi market ([Saudi Food and Drug Authority, 2023](#)). The pharmaceutical drugs were then analyzed to assess the key local pharmaceutical players in the Saudi market. The unit analysis was pharmaceutical products approved by SFDA during the study period (June 2021 to October 2022). This analysis was then categorized and examined the products according to the drug type (generic VS branded drugs), whether it uses nanomedicine or not; its therapeutic application; i.e. cardiovascular (CVS), musculoskeletal, oncology, anti-infective, metabolic disorder, hematology, central nervous system (CNS), ophthalmology, gastrointestinal, respiratory, and dermatology; and the route of administration (oral, topical or injectable).

Data were analyzed with SPSS version 16.0 (SPSS Inc., Chicago, USA). Descriptive analysis was performed for all variables in the study and presented as numbers and percentages. Pearson correlation was done using Prism 9 Version 9.5.1 (528).

## 3. Results

To assess the current status and future direction of pharmaceutical manufacturing in Saudi Arabia using nanotechnology, a descriptive survey focusing on the national pharmaceutical industries was distributed to 17 national pharmaceutical industries. Two of these local pharmaceutical industries did not respond, and they were excluded from this study. The oldest industry was established in 1940, and the newest one in 2017. Those industries are manufacturing 1536 pharmaceutical products in the Saudi market. 67% of the national pharmaceutical products are based in the capital of the Kingdom of Saudi Arabia (Riyadh), while 27% and 6% of these industries are based in Jeddah and Dammam, respectively. Hence,

this survey scans the country's capital and the main two economic city hub where all the respondent industries locate. Most of the respondents and data acquired from this survey were from decision-maker positions (e.g., Regulatory Affairs Managers and R&D directors), reflecting authentic and validated information.

Most national pharmaceutical industries (87%) focus more on manufacturing drugs (generic and branded). In comparison, drug repackaging of branded and generic medicines represents 53% and 40% of the entire national industries, respectively ([Fig. 1](#)). The results showed that only two companies could manufacture biological drugs ([Fig. 1](#)). It should be noted that all participating national pharmaceutical industries are eligible to export their pharmaceutical products. It also exhibited that oral pharmaceutical products are the dominant dosage form manufactured by all national pharmaceutical industries ([Fig. 2](#)).

In contrast, 59% of these industries manufacture topical pharmaceutical products, followed by parenteral products (53%), as shown in [Fig. 2](#). Only one national pharmaceutical industry manufactures ophthalmic pharmaceutical products. According to the study analysis of the locally manufactured pharmaceutical products, most of the products were generic in comparison to branded products manufactured in Saudi Arabia. 54% of the national pharmaceutical industries provide up to 5 branded pharmaceutical products, and 27% manufacture more than 10 branded drugs ([Fig. 3](#)). Less than 14% of the national pharmaceutical industries do not provide branded products ([Fig. 3](#)).

More than 82% of the national pharmaceutical industries do not manufacture biological products, while less than 14% manufacture not more than 10 biological products in the Saudi market. More than 80% of the national pharmaceutical industries do not manufacture biosimilar products, while 20% of the sectors manufacture between 1 and 5 biosimilar products in the Saudi market. None of the Saudi pharmaceutical manufacturing companies produces or repackage nanotechnology-based medicines ([Fig. 1](#)).

Although most of the entire national pharmaceutical industries (73%) that participated in the survey are aware of nanomedicines ([Fig. 4](#)), they still need to produce or show initiatives to implement nanotechnology-based medicines in their manufacturing. The rest of the industries must be aware of nanomedicines ([Fig. 4](#)). In addition, only 13% of the local sectors comprehend and grasp the knowledge of knowing and following up with the number of nanomedicines available in the global market ([Fig. 5](#)). Upon the basis of the previous response, 93% of the national pharmaceutical industries participating in this survey agreed that the development of pharmaceutical products with nanotechnology is an important step toward solving various complications associated with conventional forms of available drugs ([Fig. 6](#)). This highlights the inadequate insights into nanotechnology and the need for a serious entry into the pharmaceutical nanomedicines' era.

80% of the national pharmaceutical industries agreed that challenges might arise upon developing nanomedicines. Some of the obstacles declared by these pharmaceutical industries are lack of experience in processing and preparing pharmaceutical nano-based formulations; lack of knowledge, talents (manpower), capability, facility, and experts; high cost of developments and scaling up; and unclear approval regulations by SFDA. Accordingly, the considerable investment will be required to make such products available in the market.

As a result, part of this study covered the pharmaceutical products manufactured by the domestic pharmaceutical industries. Most of these manufacturers (82%) neither produce nor repackage any nanomedicine product ([Fig. 1](#)). Only one industry announced that they distribute one product of nanomedicines, which is over-the-counter (OTC). Two pharmaceutical industries plan to include nanotechnology in their production lines, with one of both industries has completed the plan ([Fig. 7](#)). Interestingly, these two

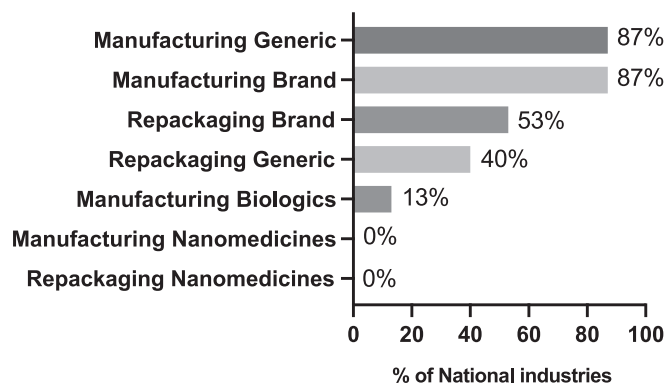


Fig. 1. General view of the role of national pharmaceutical manufacturing in Saudi Arabia.

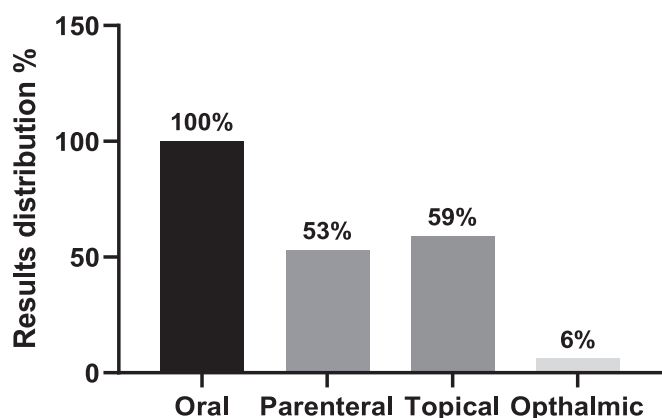


Fig. 2. The manufacturing distribution of pharmaceutical dosage formulations among national pharmaceutical industries.

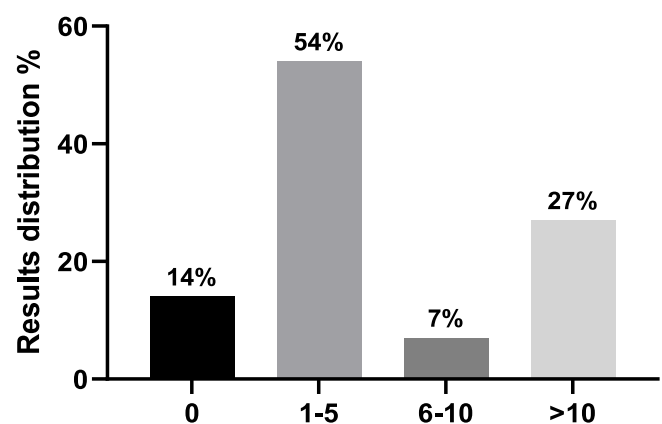


Fig. 3. Number of branded pharmaceutical products among national pharmaceutical industries.

pharmaceutical industries expect to manufacture nanomedicines in the market within 2 years, and they can already produce such products.

On the other hand, more than half (53%) of the national pharmaceutical industries plan to exclude pharmaceutical nanotechnology from their production lines. Still, they are interested in applying it soon (Fig. 7). Six industries expect to provide nanomedicines in the market within 6 years, while two industries expect to produce such products in a timeframe of more than 6 years. The rest of the pharmaceutical industries, representing

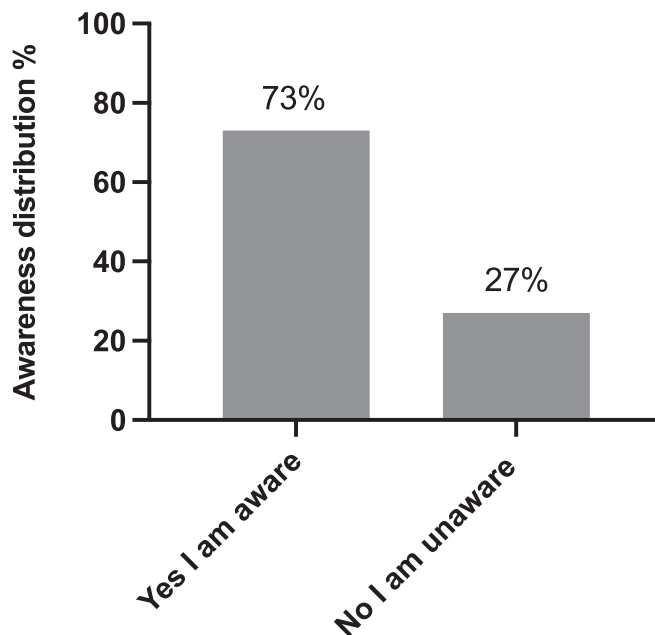


Fig. 4. National pharmaceutical manufacturers' awareness of nanomedicine products in the global market.

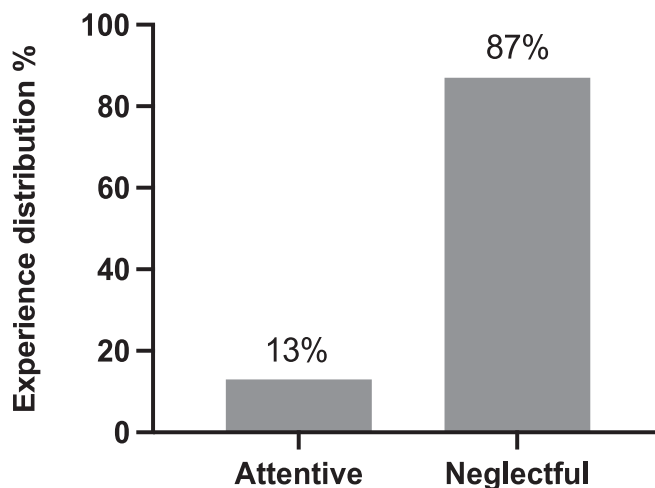


Fig. 5. National pharmaceutical manufacturers' experiences with nanomedicine products in the global market.

33% of the national industries, clearly stated that it is not the ideal time to consider nanotechnology in their production lines (Fig. 7). This could be a direct outcome of a need for in-depth knowledge of nanomedicines and their expertise in their manufacturing capabilities. In general, the survey showed an apparent lack of willingness within the national pharmaceutical industries, as the majority (86%) of the leading Saudi companies need the current capacity to enable nanotechnology-based medicines in their manufacturing.

An essential part of this survey covered the availability and the status of the R&D in the industry, in addition to whether or not it can facilitate the development of nanomedicines. The results showed that 13 national pharmaceutical industries have an active R&D department developing their pharmaceutical products available in the market. Eight of such industries rely on outsourced R&D services, while the remaining six have their local R&D department. Moreover, 7 of the 13 national pharmaceutical industries have collaborated with different Scientific Research Centers to

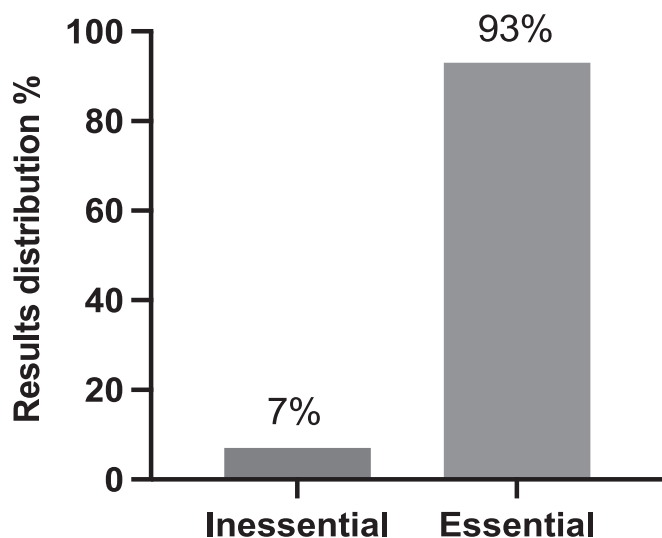


Fig. 6. Essentiality of employing nanotechnology in the development of pharmaceuticals.

develop their products, while the other five industries do not have any collaboration.

The highest number of pharmaceutical products provided by national pharmaceutical industries were contributed to the following top five therapeutic areas: anti-infective (17%) followed by CVS (12%), CNS (10%), alimentary tract, and metabolism (9%) and dermatology (8%). Fig. 8 provides details information about the distribution of pharmaceutical products by therapeutic area. Each of these therapeutic classes has been categorized into different subclasses according to the availability of pharmaceutical products produced by national pharmaceutical industries in the Saudi market to investigate the high market demand in each class (Table 1). For example, the anti-infective class, which represents the largest therapeutic class in the Saudi market by representing 17% of the total pharmaceutical products, was further subclassified into antibiotic, antifungal, antivirals and antiparasitic. Antibiotic represents the highest number of anti-infective products in the market (70%), while antifungal and antiviral represent 19% and 10% of the total anti-infective products, respectively (Fig. 9-b).

The CVS class is the second largest therapeutic class after the anti-infective class, representing 12% of the total pharmaceutical products, showing the Saudi market's high demand for this therapeutic class (Table 1). The CVS class was also subcategorized into

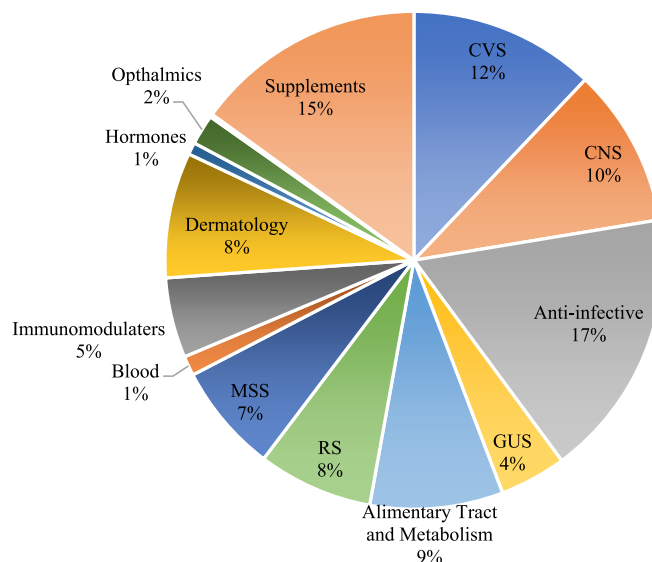


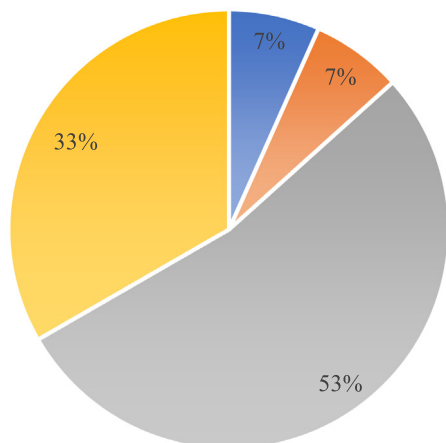
Fig. 8. Therapeutics distribution of pharmaceutical products in the Saudi market produced by national industries.

antihypertensive (76%), antihypotensive (1%), antiplatelet (11%) and antihyperlipidemic (12%) (Fig. 9-a). The CNS, alimentary tract and metabolism, and dermatology therapeutic classes here are also categorized into different subclasses, as shown in Fig. 9-c, 9-d, and 9-e. These findings can open up more investigation about the pharmaceutical products that should be developed in the near future.

Different dosage forms were manufactured by the national industries, with the oral dosage form accounting for 56%, followed by injectable (30%), topical (9%), ophthalmic (2%) and other dosage forms (3%) (Fig. 10).

#### 4. Discussion

A significant frequency of lifestyle diseases exists in Saudi Arabia, ranking among the highest in the world. Over 23% of adults above 20 years old suffer from hypertension, 18.5% of the population has diabetes, and 35% are obese (Colliers International 2019). 84% of deaths in Saudi Arabia were caused by non-communicable diseases, according to the WHO. Currently, the leading cause of mortality in Saudi Arabia is cancer, urogenital, blood, and



- we have a plan and it is completed.
- we have a plan but it is not completed
- we don't have a plan but we are excited to have one
- we don't have a plan and it is not the time to think about it

Fig. 7. Range of Saudi pharmaceutical manufacturers' acceptability to initiatives of nanotechnology implementation.



**Table 1**

Top five therapeutic areas of pharmaceutical products provided by national industries: subclassification and distribution.

Therapeutics Class	N	%	Treatments	N	%			
Anti-infective	178	17%	Antibiotics	124	70%			
			Antifungals	35	19%			
			Antivirals	18	10%			
CVS	123	12%	Antiparasitics	1	1%			
			Antihypertensives	93	76%			
			Antihypotensives	1	1%			
			Antiplatelets	14	11%			
			Antilipidemics	15	12%			
CNS	105	10%	Sedatives	4	4%			
			Anesthetics	11	10%			
			Antidepressants	20	19%			
			Anti-epileptics	27	26%			
			Antipsychotics	29	28%			
			Alzheimer	8	8%			
			Migraine	2	2%			
			Anti-vertigo	4	4%			
			Antidiabetics	35	40%			
			PPIs	21	24%			
			Laxatives	5	6%			
			IBS	5	6%			
			Antiemetics	17	19%			
Alimentary Tract and Metabolism	88	9%	Antacids	5	6%			
			Cosmotics	6	7%			
			Anti-inflammatory	65	78%			
			Acne	7	8%			
			Wounds	1	1%			
			Corn & Calluses	4	5%			
			Dermatology	83	8%			

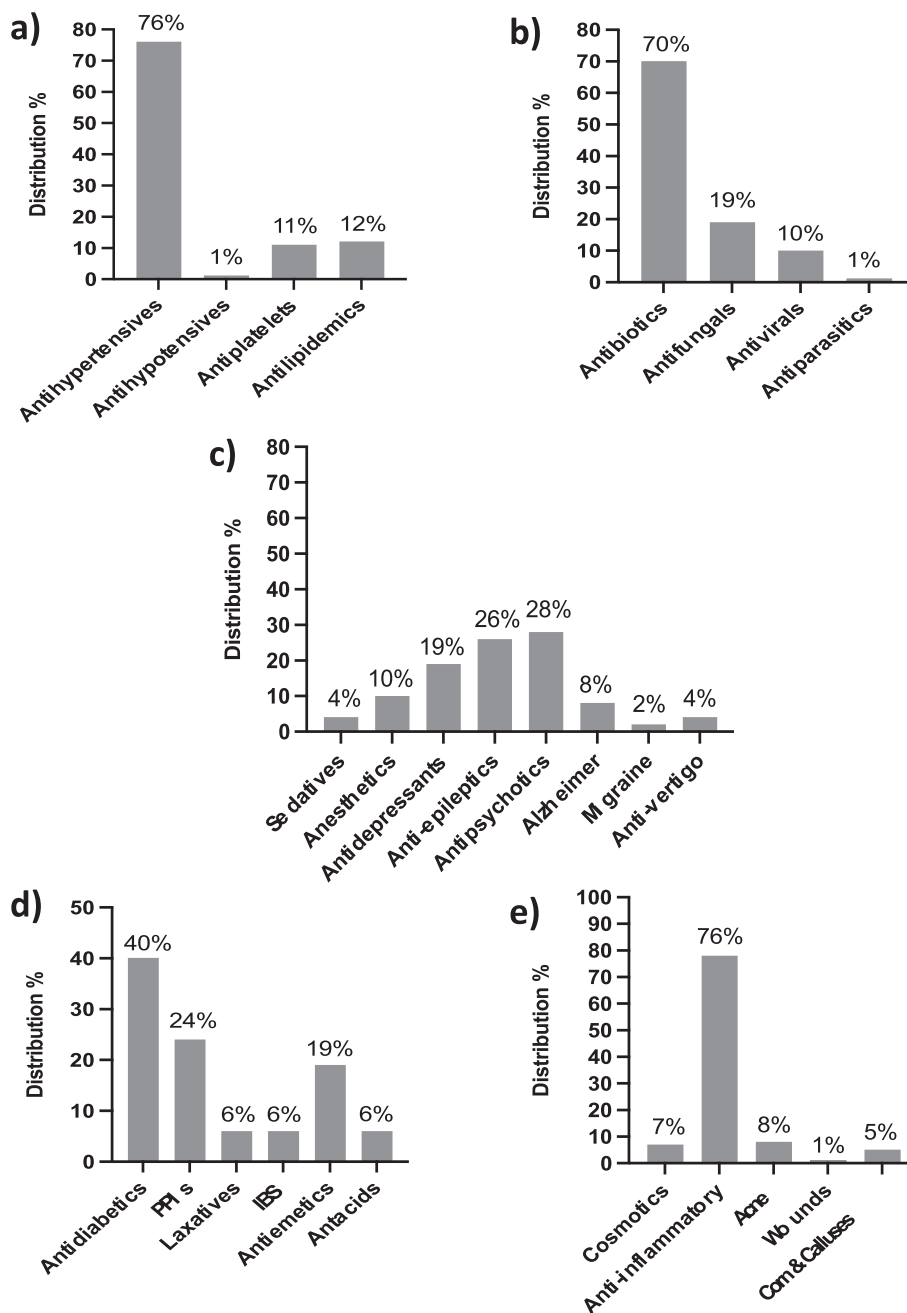
endocrine system disorders, cardiovascular diseases, and diabetes (World Health Organization 2022). The prevalence of many disorders, especially chronic conditions, impacts how often people use medications. A significant challenge to the Kingdom's healthcare system is the growth of chronic diseases and the rise in several lifestyle disorders, which place an additional burden on healthcare spending and drug expenses. The most public funding in the healthcare industry is going into innovative projects like raising health span, lowering obesity and diabetes rates, early and rapid diagnosis of infectious diseases, and localizing advanced pharmaceutical manufacturing technologies.

Saudi Arabia has a modest domestic manufacturing sector. Most pharmaceutical products in the Saudi market are imported from developed countries, including the United Kingdom, the United States, Switzerland, Germany, and France. Several multinational corporations in the field of pharmaceutical products, including Novartis, Pfizer, Bayer, Bristol-Myers Squibb, Roche, and Eli Lilly; nevertheless, only GlaxoSmithKline and Sanofi have local industry capabilities. As part of Vision 2030, the Saudi government has identified localizing the pharmaceutical industry as a top objective. Today, just 30% of medications are produced locally. Additionally, using cutting-edge technologies, such as nanotechnology, to create pharmaceutical items locally in cooperation with pharmaceutical research institutes will reduce the strain on the Kingdom's healthcare system (pharmexcil 2020).

In 2016, the global market size of nanomedicine reached USD 138.8 billion; by 2025, it is expected to reach USD 350.8 billion. Accordingly, the mindset of investment in the pharmaceutical sector in Saudi Arabia needs to include advanced technologies, such as Nano-drug delivery systems. This would strengthen and grow the business in parallel with international pharmaceutical companies and minimize the financial burden on the government regarding drug security. Otherwise, local pharmaceutical industries may have diluted value propositions, with only the fittest surviving the race. Thus, national pharmaceutical industries will need to step forward to mimic the direction of the global market by creating research partnerships with local universities and research centers to develop conventional drug products or to discover new drugs using advanced technologies.

The clinical advantages of the Nano-drug delivery approaches over conventional drugs, such as precise targeting, higher efficacy, and lower toxicity, are frequently offset by the corresponding burden of their high cost. Therefore, the primary justification for creating novel drug delivery systems is the potential financial gain, primarily from making a more efficient way to deliver drugs in general, particularly the new biotherapeutic agents (Farjadian et al., 2019). Worldwide, the development of novel drug delivery systems is continuing and increasing annually, acknowledging the clinical and financial benefits of these new systems. The global market for all innovative medicinal products had an annual value of almost USD 16 billion as of 1997. In 2022, the demand for advanced drug delivery systems rose to USD 275 billion, estimated to reach USD 376.8 billion by 2027. This is consistent with the market predictions from prior years, which assume an annual growth rate of roughly 20% (BCC Research 2022). Any conventional pharmaceutical sector would find this to be an unusual market growth rate favoring the advancements and developments of drug delivery systems. Locally, awareness is well recognized by key personnel of the national pharmaceutical industries, as seen from the current survey's results. The momentum is built (Fig. 6); however, it was noticed that there is null manufacturing or even repackaging of nanomedicine products (Fig. 1). A gap of knowledge (Fig. 4) and experience (Fig. 5) are the two main missing pillars for the continuation of what leaders of local pharmaceutical companies believe in as advantages of nanotechnology and the foundation of ground for the applications of these nanotechnologies in their local production lines. A guiding roadmap is the main demanded point by the local manufacturers to ignite the start of their product development process further and employ advanced technology such as nanotechnology (Fig. 7).

The entire functioning R&D departments within the national pharmaceutical industries are merely running market research and market-based product development. None of these R&D departments aims to enforce basic or applied research nor design or clinically test an innovative novel prototype. In other words, such R&D practices work as a pure revenue-driven development seeking market needs, parallel to the previous data showing unwillingness to enter nanotechnology-based medicine due to



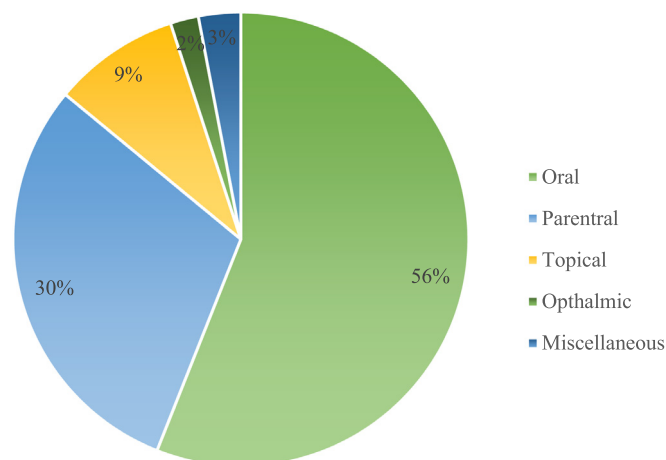
**Fig. 9.** Subclasses distribution of top five therapeutic areas produced by Saudi pharmaceutical industries: anti-infective (a), CVS (b), CNS (c), alimentary tract, and metabolism (d) and dermatology (e).

the lack of knowledge and expertise. However, all participating companies of the national pharmaceutical industries involved in this survey endorsed their acceptance of any professional offer from expertise-houses, practicing specialized academia and pharmaceutical counselling nano-core centers to pave the way for developing their products further by employing advanced technologies.

The Saudi pharmaceutical market needs nanomedicine mainly because of the rising incidence of communicable and non-communicable diseases. The increased healthcare expenditure rates due to the aging population and the increased lifestyle diseases and demand for healthcare put significant pressure on the healthcare system to allocate resources more efficiently. Nanotechnology has become increasingly important as a drug delivery sys-

tem for healthcare to treat several health conditions. This advanced medication has proven superior to the standard of care, improving patient health outcomes, delaying the progression of diseases, and reducing overall morbidity and mortality rates. However, the findings from this study showed that the key national pharmaceutical industry needed more nanomedicine products manufactured locally. This demonstrates an urge for a national plan and a collaboration from all stakeholders involved in the drug manufacturing field to engage the patient perspectives and to shape the efforts and investments toward implementing localizing nanomedicine production in Saudi Arabia.

All products currently manufactured by the national pharmaceutical industries in Saudi Arabia were categorized to emphasize the therapeutic areas that may benefit from nanotechnology. The



**Fig. 10.** Dosage forms distribution of the pharmaceutical products produced by national industries in the Saudi market.

categorization indicated that the top five therapeutic areas produced by Saudi pharmaceutical industries include anti-infective, CVS, CNS, alimentary tract and metabolism, and dermatology. It should be noted that local pharmaceutical medication is essential for drug security and the stability of the healthcare system. The national pharmaceutical industries mainly focus on those top categories, and these areas are known to meet the high patient demand. Still, they are also considered a small percentage of the total market needs. The prevalence of these diseases is very high, and nanomedicines can provide better efficacy by delivering therapeutic agents more specifically to the targeted site of action, reducing the dosing frequencies, and avoiding potential toxic side effects, which will, in turn, going to save the total healthcare costs (Halwani 2022). Advanced pharmaceutical R&D activities in Saudi Arabia are minimal and mainly focus on national universities and research centers. However, local pharmaceutical industries focus on money generation via the production of generic drug products or the repackaging of imported international branded drugs. Therefore, localizing nanomedicine development and production can be the driving force to enhance the value of the drug market in the region and attract more business opportunities in the Kingdom.

Thus, it is critical to building a joint platform to foster such technology to encourage the decision-makers with market opportunities based on the community's benefits by reducing disease prevalence and saving the total healthcare expenditure (Parhizkar et al., 2018). Further collaborations between academia and research centers with the private sector may be critical to fill the gap and accelerate nanomedicine product translation into the market. Providing support to the local industry will facilitate the development of nano-drug products, which will help minimize healthcare expenses and enhance drug security (Germain et al., 2020, Metselaar and Lammers 2020). Furthermore, international companies, which develop nanomedicines, should also be involved in building and shaping the regulatory framework to motivate local industries to create and produce nanomedicine and to encourage the growth of nanomedicine production as a whole (Metselaar and Lammers 2020). The Kingdom is well-positioned as the leading pharmaceutical market in the region and should lead the industry and play a more advanced role in producing pharmaceuticals and biopharmaceuticals (Tawfik et al., 2022).

## 5. Conclusion

National pharmaceutical industries have been growing in the past years, and the number of manufactured generic drug products

has dramatically increased. The development of new and innovative products is still in the infancy phase. Nano pharmaceuticals offer the potential solution to improve and create an innovative therapy for many health problems. This is an evolving area in pharmaceutical science that provides an excellent opportunity for companies to develop new drugs or improve available products. However, there still needs to be more initiative to localize nanomedicine production by the national pharmaceutical industries. It is crucial to motivate companies to invest in this area to keep up with all up-to-date and advanced pharmaceutical technologies in the global drug market. Otherwise, national pharmaceutical industries may have diluted value propositions, with only the fittest surviving the race.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jsps.2023.06.007>.

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