PDA Parenteral Drug Association

Training and Research Institute

All About Prefilled-Syringe Systems

Christa Jansen-Otten, Klaus Ullherr, Bernd Zeiss

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Agenda –
DAY 1

Welcome and Introduction

Overview and Introduction into the Pre-filled Syringe Market

- Overview & trends
- Stakeholders
- User's perspective
- Syringe system overview

Pre-fillable Syringe

- Glass and COP/COC syringes
- Barrel forming and needle mounting
- Washing with WfI
- Siliconization
- Nest and tub, bags
- Sterilization
- Syringe specification: Example
- Regulatory guidelines and technical standards: EU/US/ISO/...

Plunger Stoppers, Needle Shields, Tip Caps

- Materials
- Physical and chemical properties
- Supporting documents
- Design and functionality
- Processing
- Regulatory guidelines and standards

Fill and Finish

- Bag opening
- Tub opening
- Filling
- Stoppering

Hands-on session

- 3 groups, 20 min per station

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All about Pre-Filled Syringe Systems

From Initial Development to Final Fill Finish

Overview and Introduction into the Pre-filled Syringe Market

Christa Jansen-Otten, Bernd Zeiss

23-24 October 2025

Vienna, Austria

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Overview and Trends

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What type of containers are used for injectables?

Prefilled Syringes

- Elastomeric Components:
- Plungers, Tip Caps and [Rigid] Needle Shields

Cartridges

- Elastomeric Components:
- Plungers and Lined Seals

Vials

- Elastomeric Components:
- Lyophilization or Serum Stoppers, and Seals

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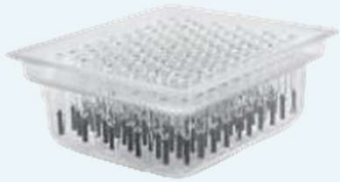
Syringe Market Overview

Global Syringe Market

- **Prefillable Syringes** (most polypropylene) Diluents and flush syringes (WFI)
- **Disposable Syringes** (most polypropylene) Drug is transferred from primary container (vial)
- **Prefilled Syringes (PFS)** Drug is stored in the syringe and administered
  - **COC / COP PFS**
  - **Glass PFS**



COC = Cyclic Olefin Copolymer COP = Cyclic Olefin Polymer

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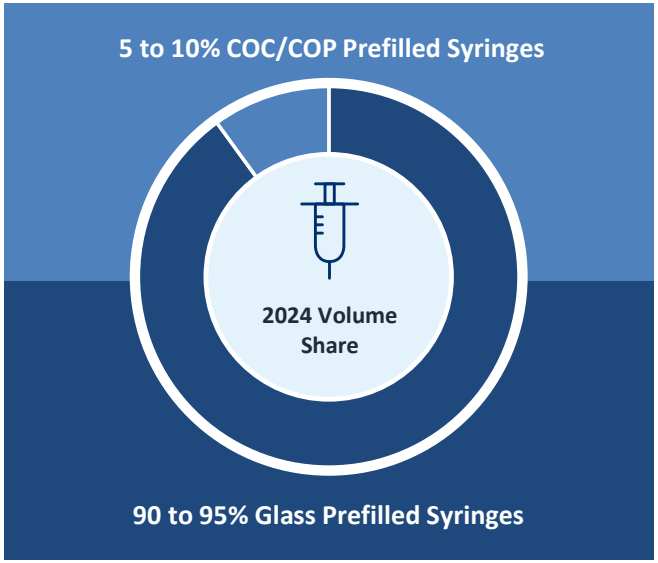
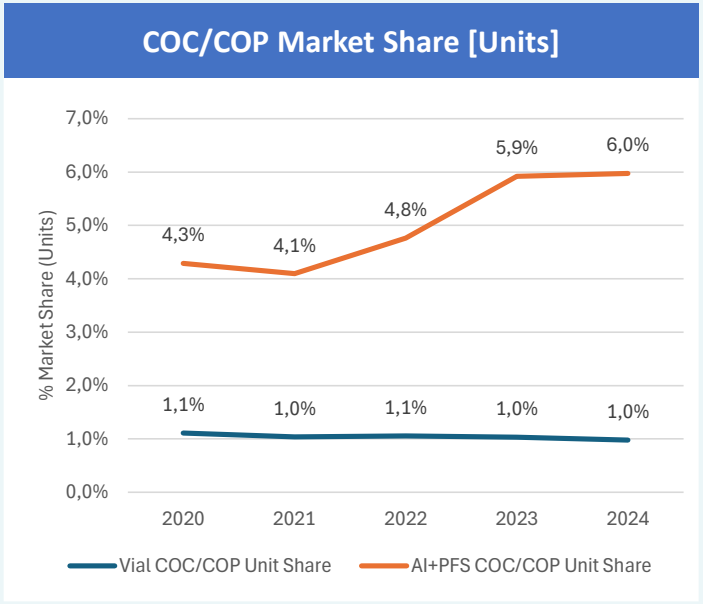
PFS Polymer vs. Glass – Market Estimates

- The market share of polymer containers (PFS, vials, cartridges) is increasing
- The global PFS volume is estimated to be ~ 5Bn* units currently.
- The global PFS market was valued at US$ 13.6 Bn in 2021 and is anticipated to reach more than US$ 35.7 Bn by end of 2031 [CAGR** 10.1%].





Based on market experience, internal knowledge and IQVIA data
AI: Auto Injector

*Bn: Billion
**CAGR: Compound Annual Growth Rate

*Prefilled Syringes Market | Global Analysis Report 2031 (transparencymarketresearch.com)

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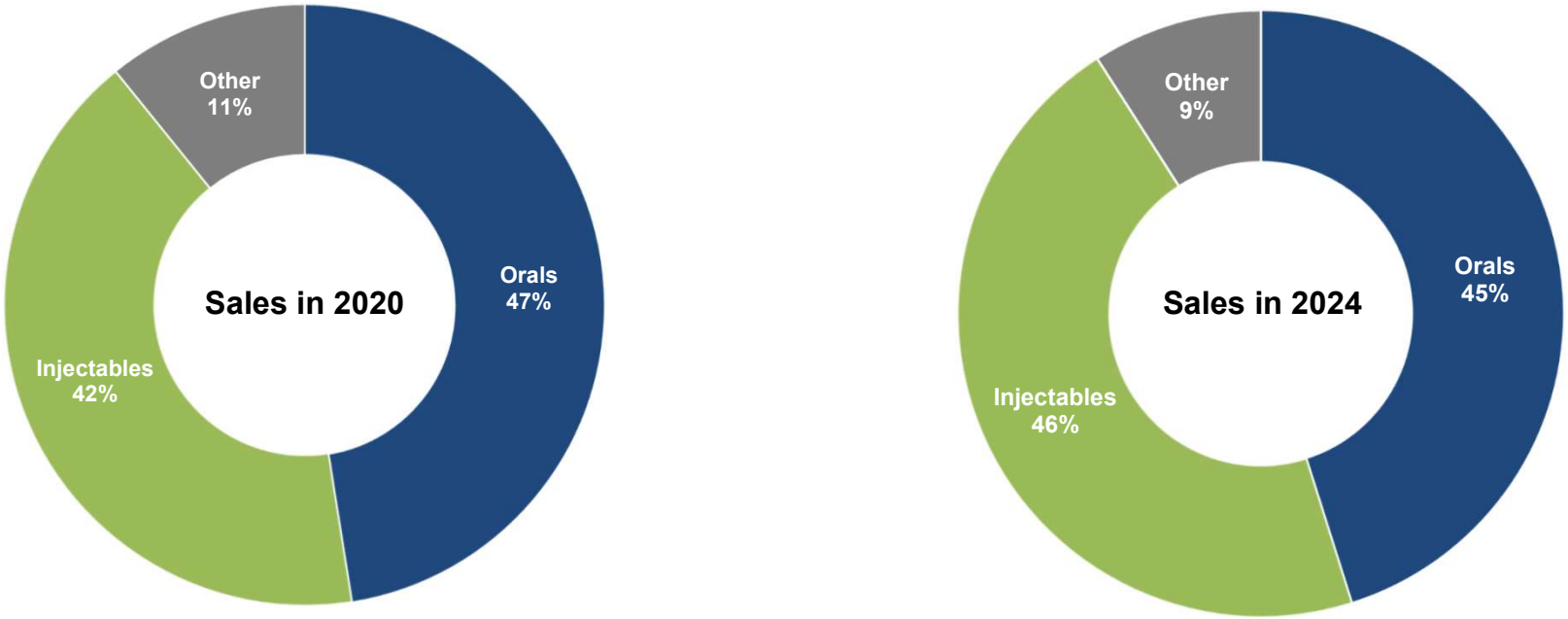
Share of Injectables has increased through 2024

Global Market Share% by Route of Administration



Source: IQVIA 2024 Global Audited Sales

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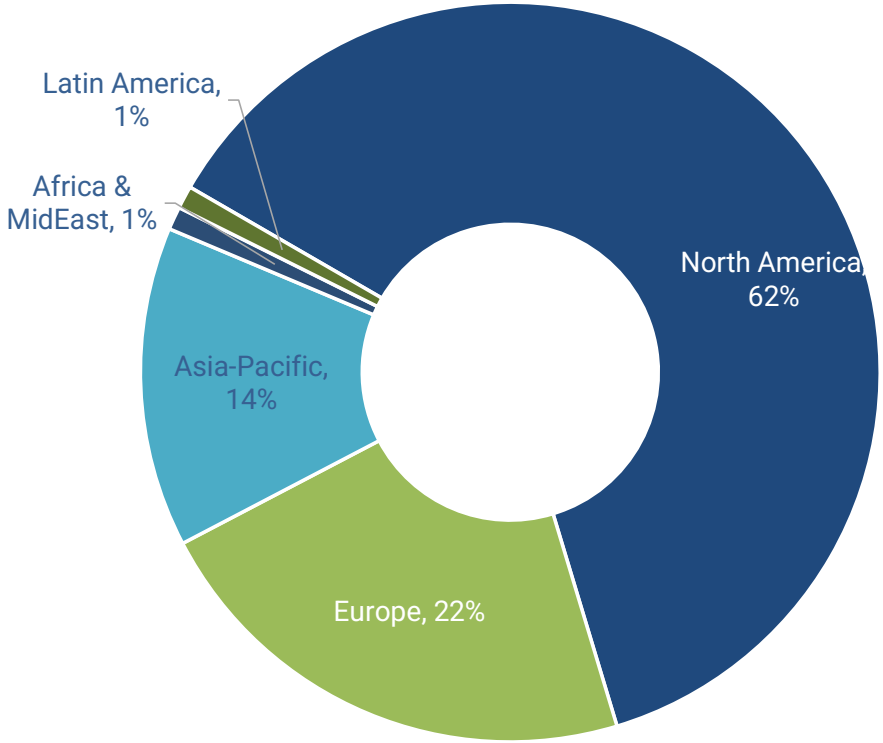
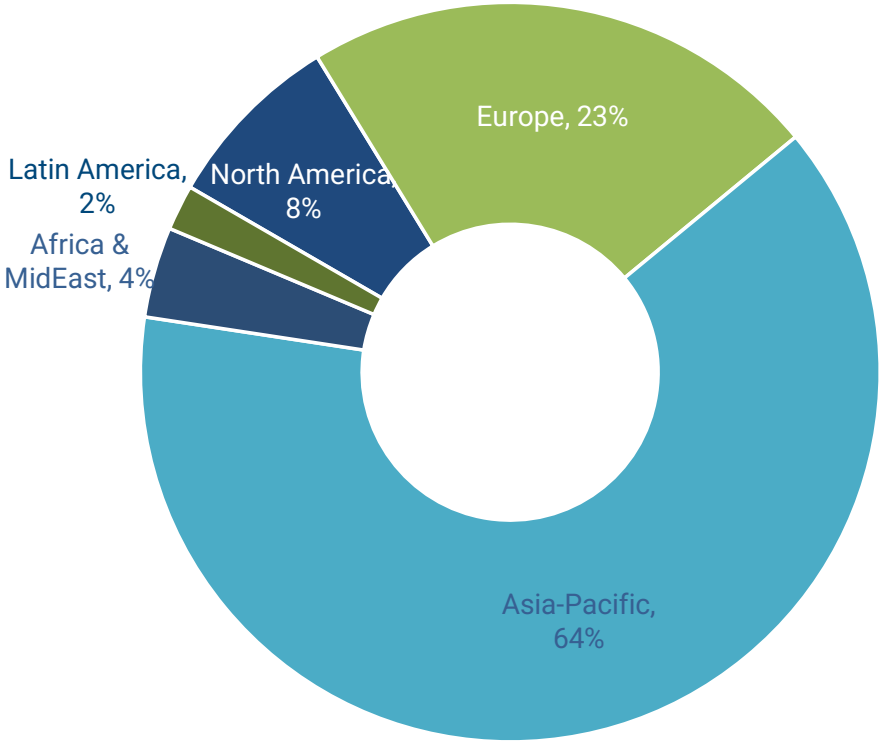
Injectable Value Share By Region, 2024



Regions	2020 - 24 CAGR
Global	10%
North America	13%
Europe	10%
Asia-Pacific	0%
Africa & MidEast	13%
Latin America	16%

Source: IQVIA 2024 Global Audited Sales

Injectable Volume Share By Region, 2024



Regions	2020 - 24 CAGR
Global	3%
North America	3%
Europe	-1%
Asia-Pacific	4%
Africa & MidEast	2%
Latin America	3%

Source: IQVIA 2024 Global Audited Sales

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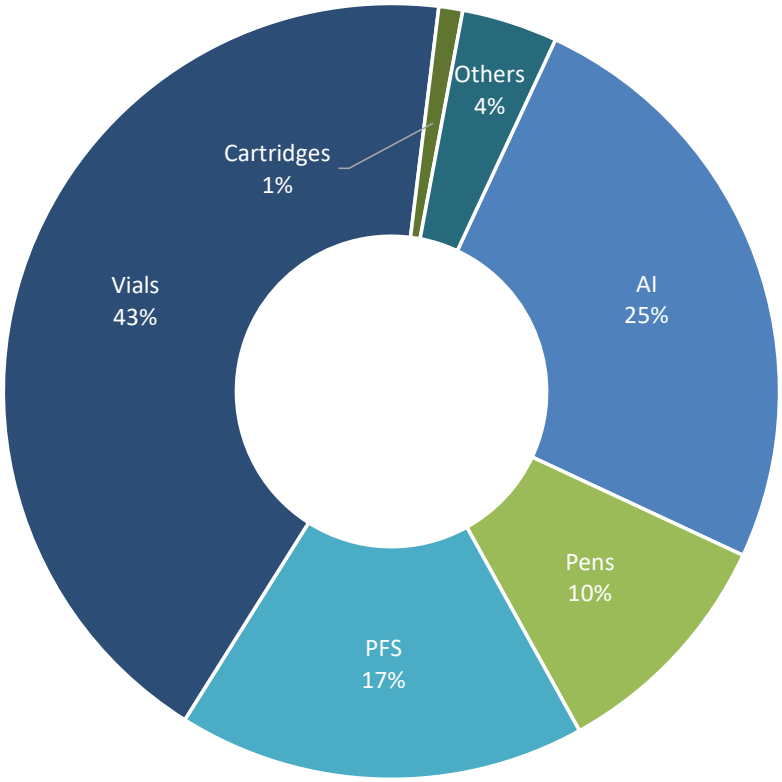
Global Injectable Value Share By Format, 2024



Formats	2020 - 24 CAGR
Auto Injectors	27%
Pens	10%
PFS	8%
Vials	6%
Cartridges	-2%
Other injectables	0%
Grand Total	10%

Source: IQVIA 2024 Global Audited Sales

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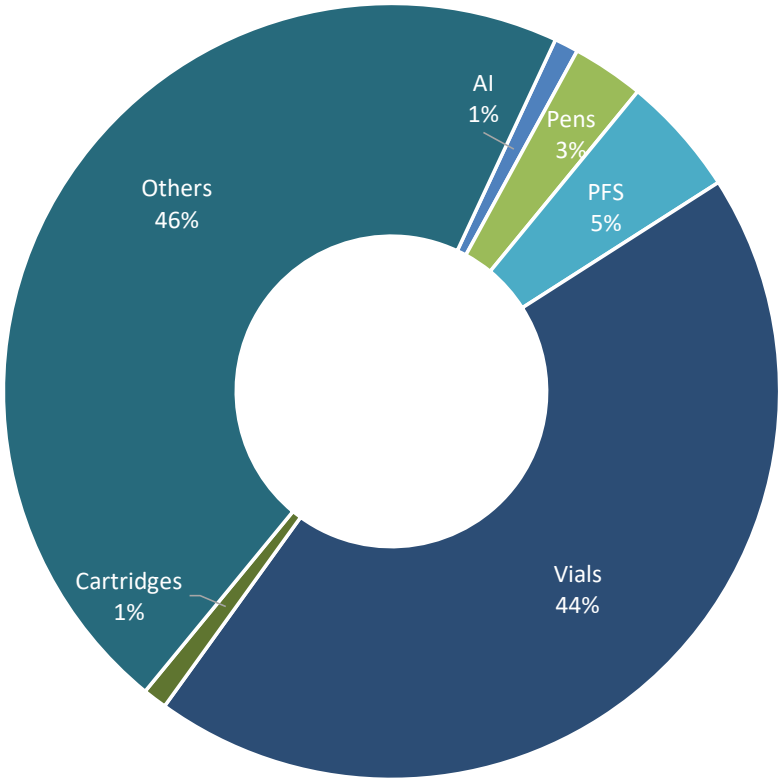
Global Injectable Volume Share By Format, 2024



Formats	2020 - 24 CAGR
Auto Injectors	26%
Pens	2%
PFS	0%
Vials	3%
Cartridges	0%
Other injectables	3%
Grand Total	3%

Source: IQVIA 2024 Global Audited Sales

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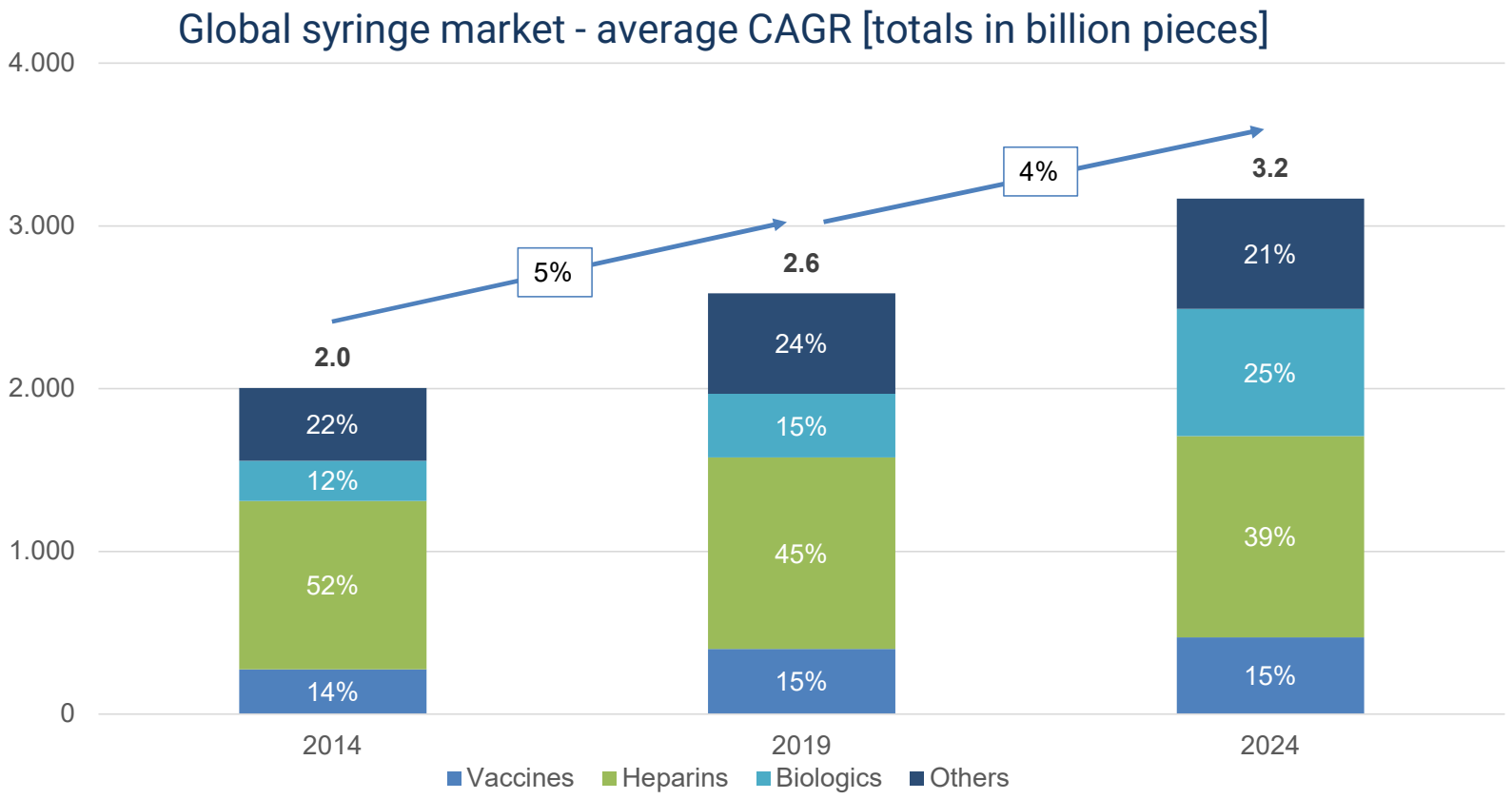
Global syringe market - average CAGR



Source: IQVIA 2024 Global Audited Sales

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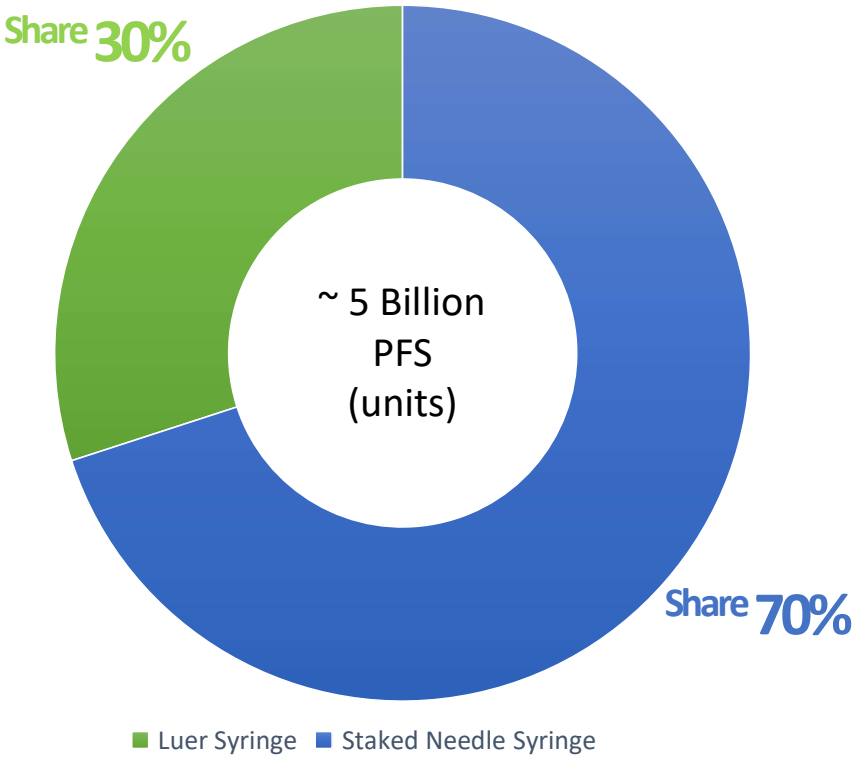
Global Prefilled Syringe Market & Trends

- Global prefilled syringe market growing at 10.8% (estimate) annually*
- Most staked needle syringe applications use rigid needle shields; All newly developed drugs in staked needle format prefer rigid needle shields
- Valued for minimizing drug waste and making self-administration easier*
- Commonly packaged drugs in prefilled syringes include biologics like GLP-1s, vaccines, heparin, erythropoietin products, and interferons*

Luer Syringe

Staked Needle Syringe

Luer (Slip or Lock) vs Staked Needle



Data Source: Multiple sources including 2023 IQVIA & estimations based on PFS supplier inputs

*MarketsandMarkets, Prefilled Syringes Market Report, July 2024.

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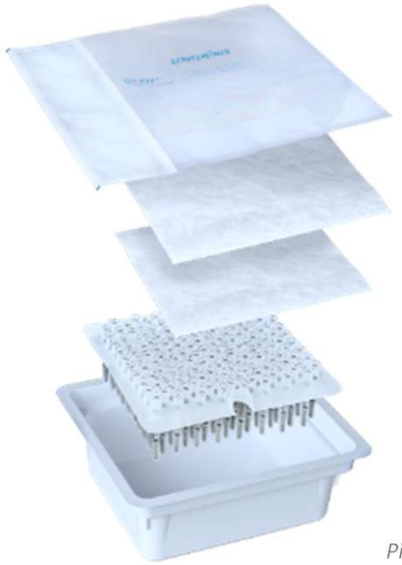
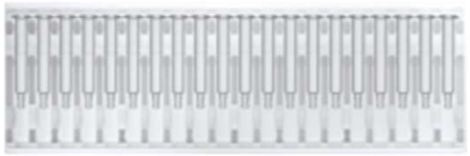
Global Prefilled Syringe Market: Ready-to-Use vs Bulk Syringes

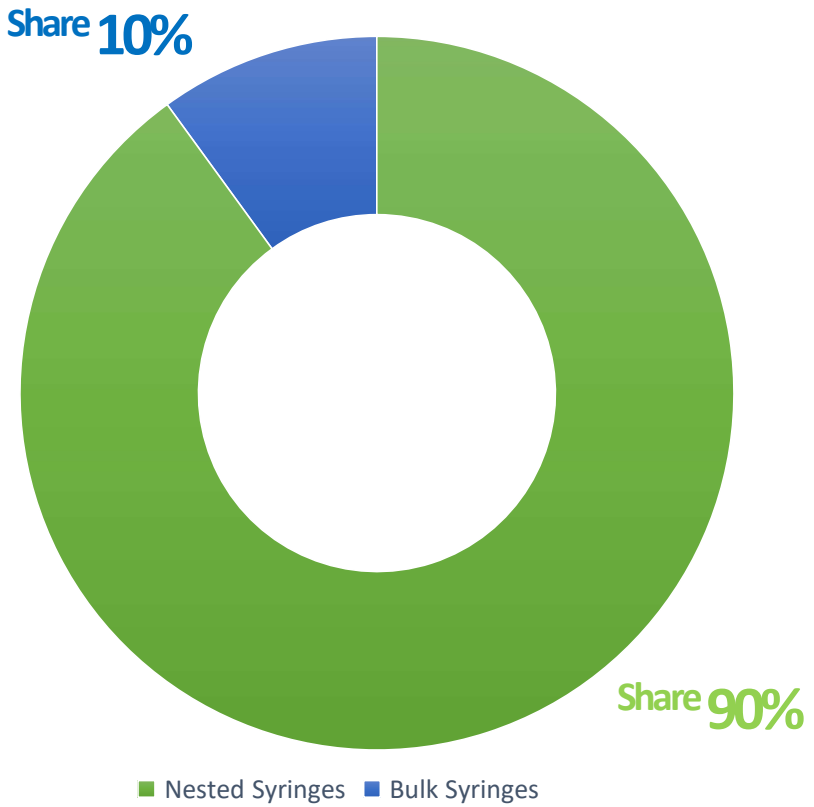
- Ready-to-Use nested glass syringes in tubs



Pictures property of Gerresheimer

- Bulk glass syringes on rondo trays





Data Source: Industry knowledge from conversations with glass suppliers

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Global Prefilled Syringe Market by Application

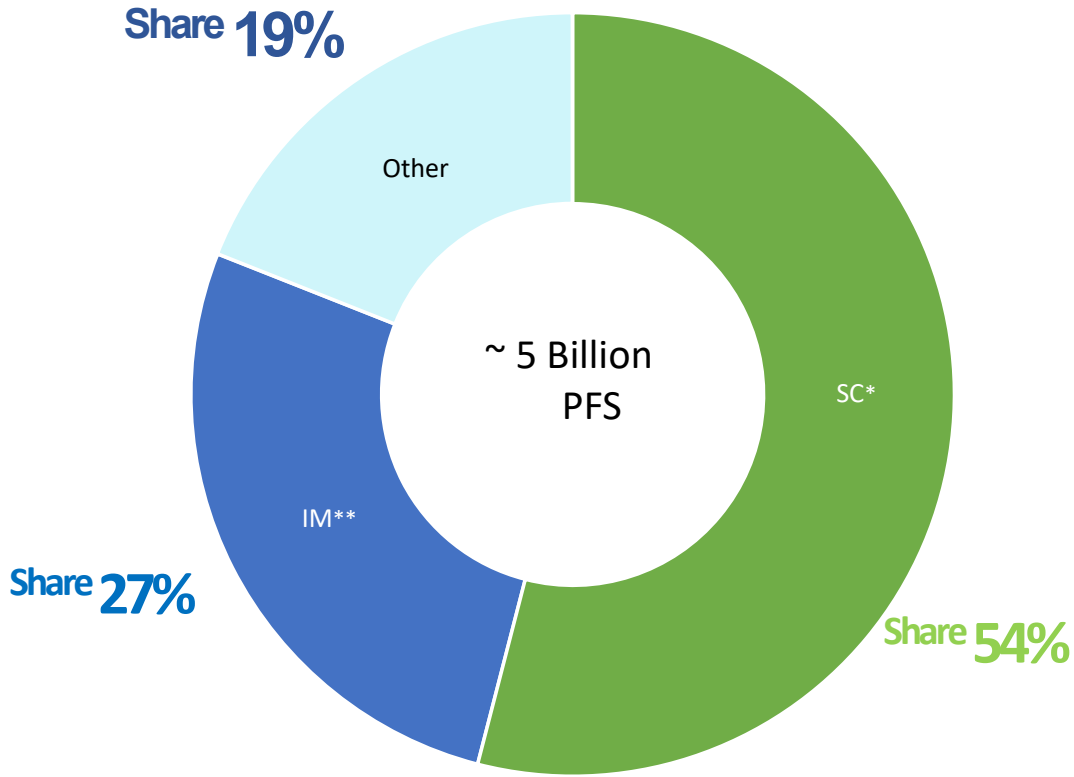
- Subcutaneous Injection = SC

  Typically uses ½'' needle size & represents in more than 50% of the prefilled syringe market

- Intramuscular Injection = IM

  Uses needle sizes 5/8'', 1'' or longer generally & represents 27 % of the market

Trends in self-administration & home use are driving growth in the SC market while vaccines are driving growth in the IM market



Data Source: Multiple sources including 2023 IQVIA & PharmaCircle; "Other" includes, but is not limited to: intravitreal, intradermal, and intravenous

*SC: subcutaneous injection
**IM: intramuscular injection

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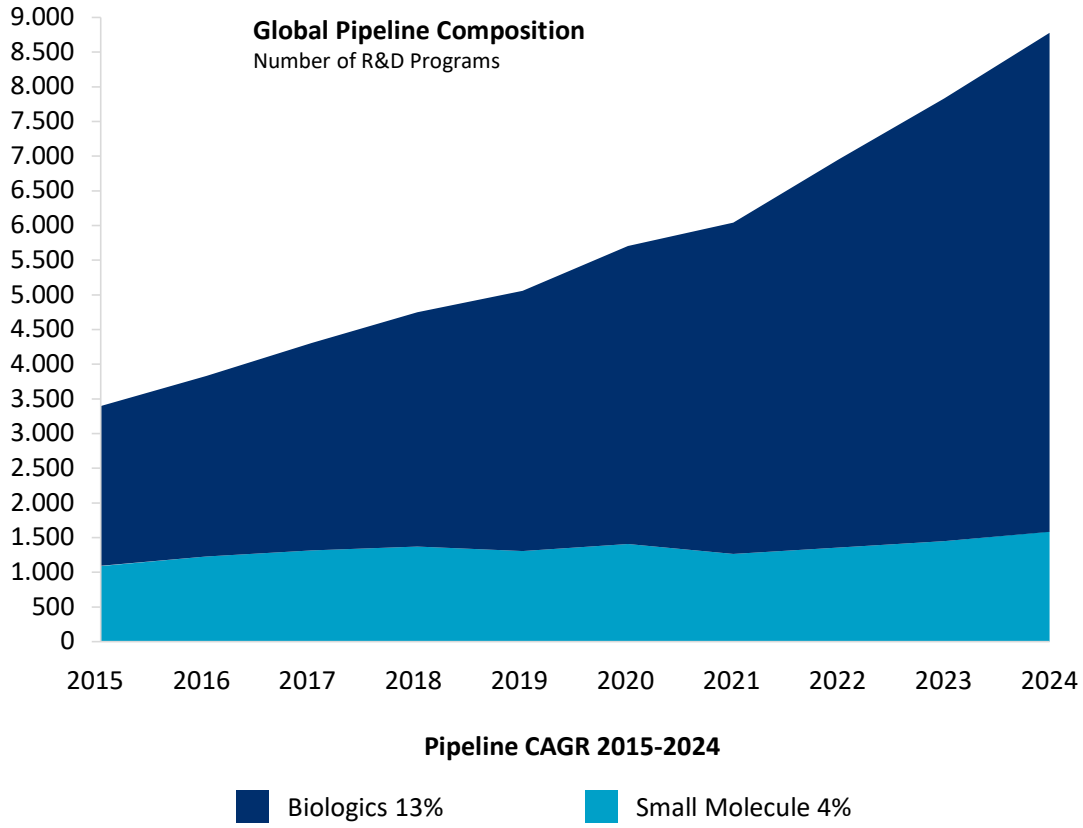
Growing Share of Biologic Drugs



~80% **of global pipeline is biologics**

Biologics R&D growth is outpacing small molecule.

More biosimilars are entering the market

Based on Phamacircle Pipeline Dynamics. Format Injection, Phase 1 to Registration

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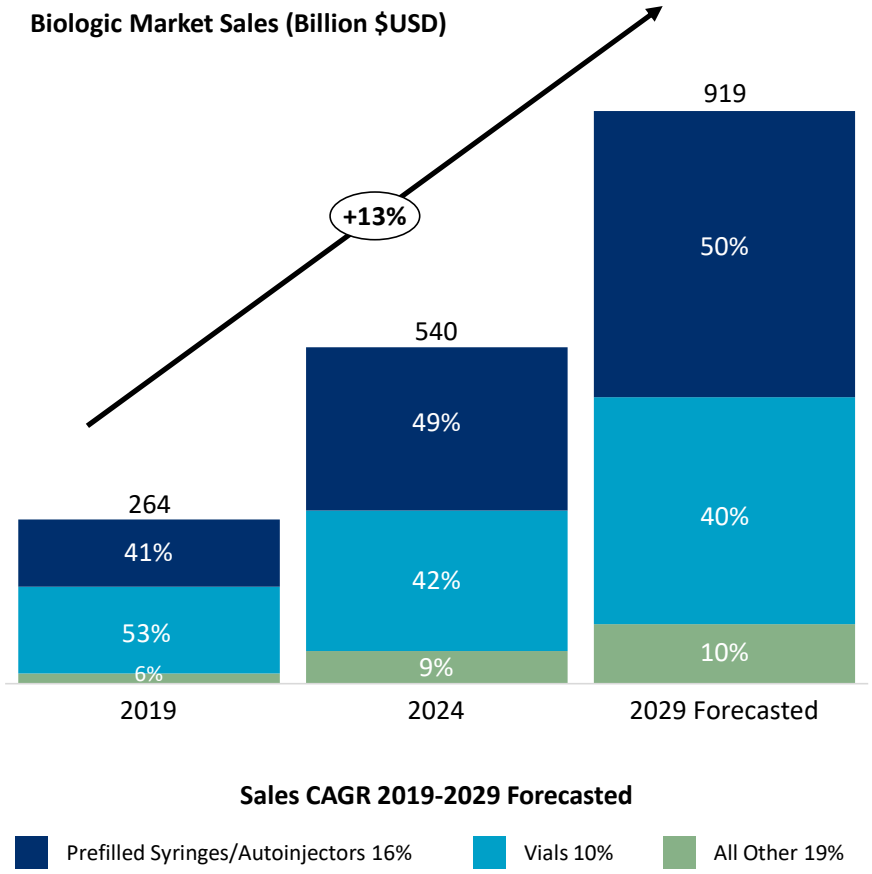
Market Driving Value Growth and Shifting Towards Self-Administered Devices



Prefilled syringes and autoinjectors comprise nearly 50% of the biologics market value

Increasing demand for self administered devices

- Lifecycle management strategies
- Shift from hospital to home
- Increase focus on patient safety

West Global Injectable Demand Model, MIDAS IQVIA data . PFS includes autoinjector formats

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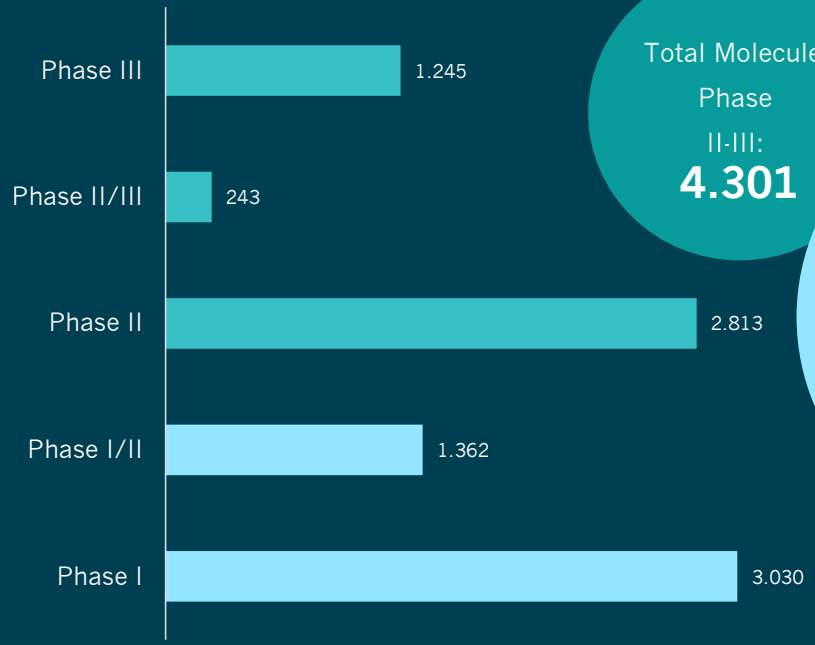
Clinical trials I

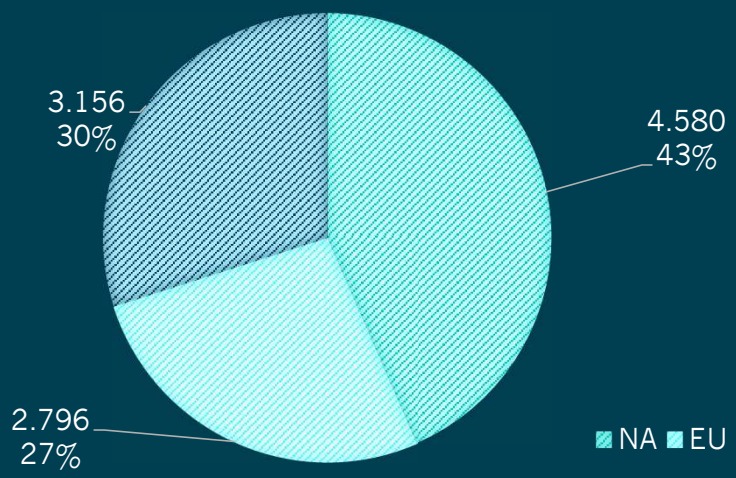
MOLECULES IN DEVELOPMENT



Total Molecules Phase II-III: **4.301**

Total Molecules Phase I-III: **8.693**

REGIONAL SPLIT CLINICAL TRIALS



IQVIA 2025

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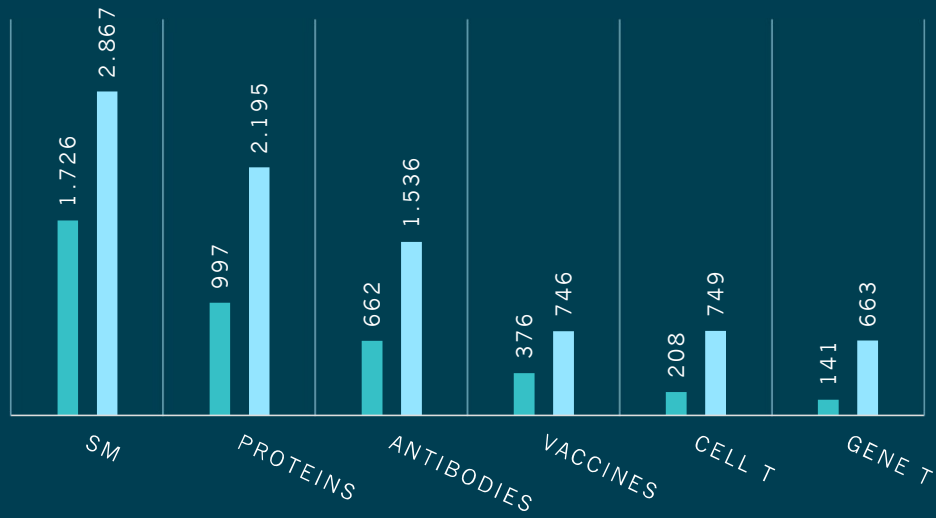
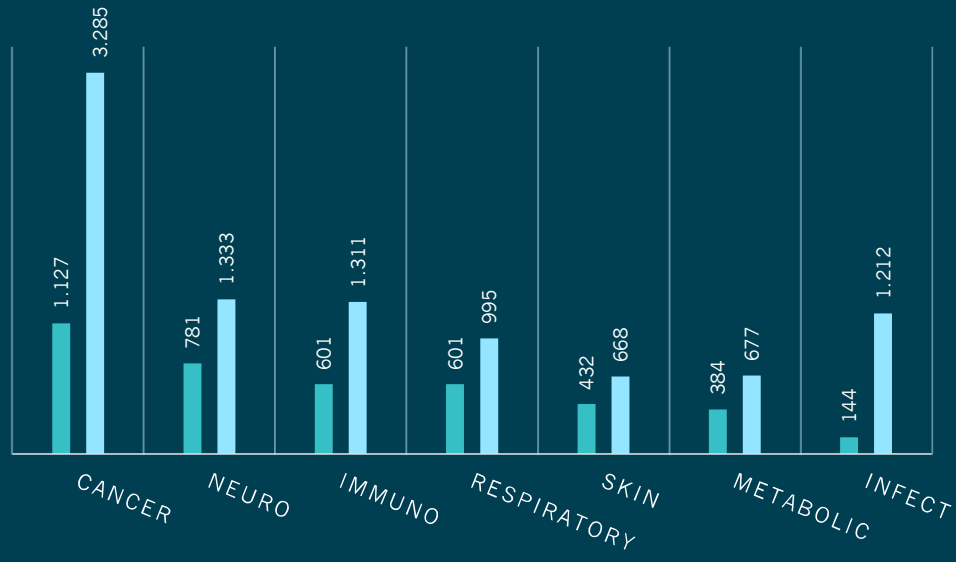
Clinical trials II

MOLECULES BY DRUG CLASS



MOLECULES BY TARGET INDICATIONS



IQVIA 2025

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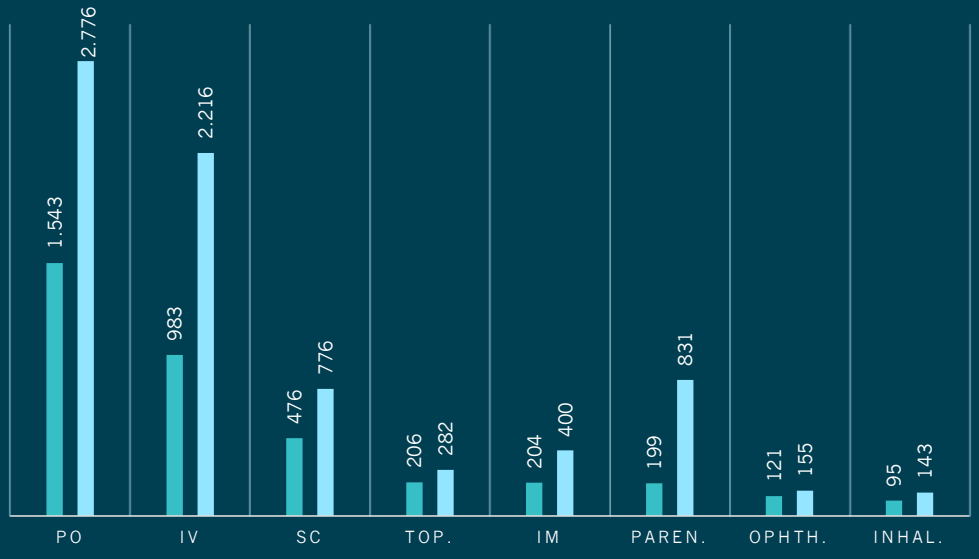
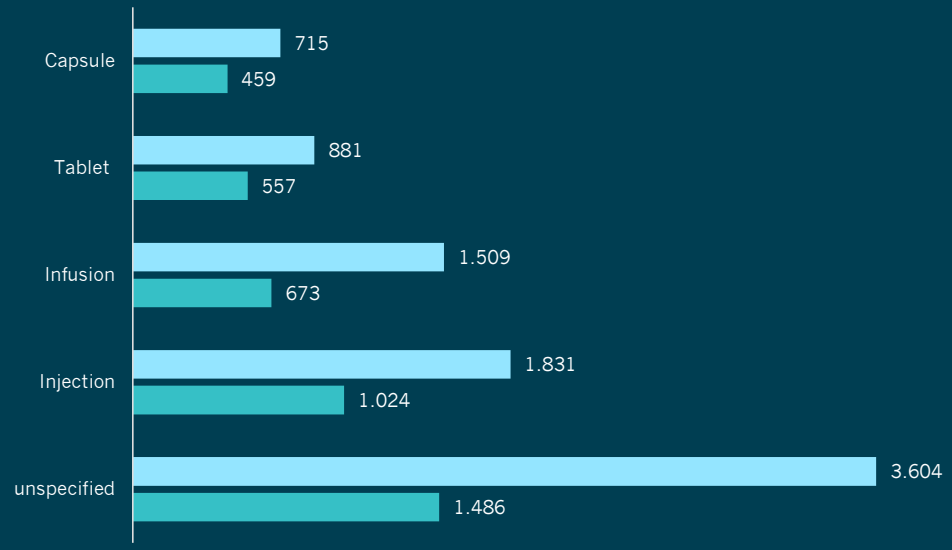
Clinical trials III

MOLECULES PER ROUTE OF ADMINISTRATION



MOLECULES PER FORMULATION



IQVIA 2025

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Bringing a New Drug to Market is Complex and Costly

Increasing costs

It can cost

$2.6 billion

to bring a new drug to market[1]

Drug development takes a long time

It takes an average of

over 10 years

from first patent filing to market[2]

Drug development is increasingly risky

Only 10%

of drugs entering clinical testing receive regulatory approval[3]

Impact of Delays

$1.1 million

lost sales for each day a drug's development and launch is delayed[1]

[1] Based on data from Tufts Center for the Study of Drug Development
[2] Emerging Biopharma's Contribution to Innovation, June 2022, IQVIA.
[3] Biotechnology Innovation Organization: Clinical Development Success Rates

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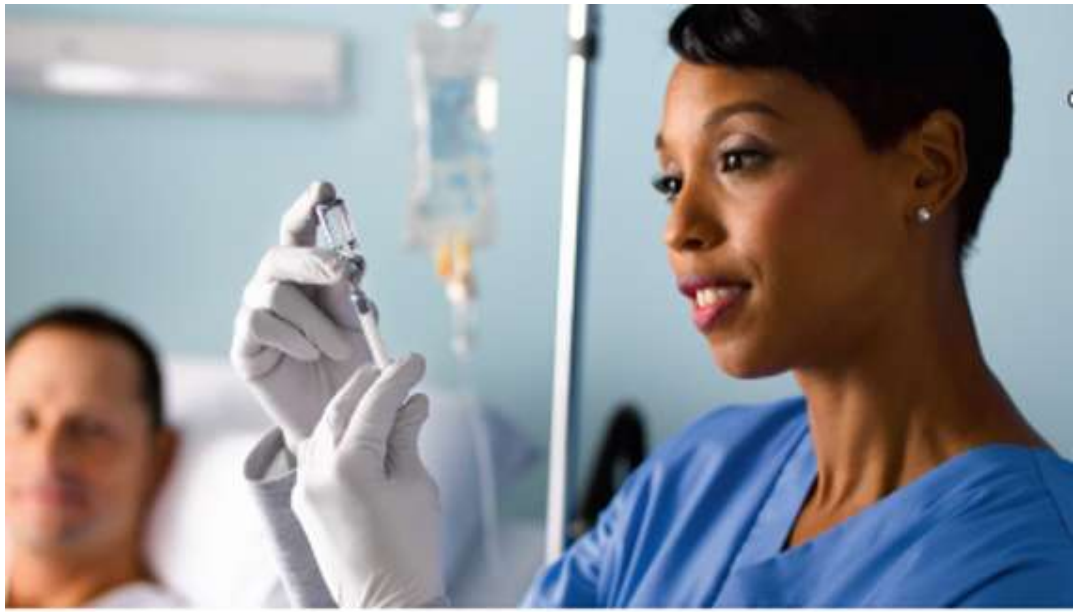
Healthcare Industry is Evolving – some trends related to PFS

Trend from IV to subcutaneous: SC Monoclonal Antibodies approvals > IV since 2017 (8% vs. 6%) driven by lifecycle management, biosimilar adoption and hospital to at-home care trend

Large volume delivery for PFS: driven by home care injection of high viscose drug, a consequence of the above trend for IV to subcutaneous

GLP-1 obesity/diabetes: market explosion syringes and cartridges chosen as primary containers.

Innovations in ophthalmic drug delivery: increased challenges and drive the innovations in ophthalmic drug delivery



Biologics Driving Pipeline Growth: >2400 companies with Biologics pipeline programs , increasingly complex treatments such as personalized medicine and cell and gene therapies

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Our Healthcare Industry is Evolving – some trends related to PFS cont.

Advancements in silicone free prefilled syringe solutions to protect complex and sensitive biologics from silicone-induced protein aggregation and particle formation

Alternatives to EtO* sterilization: raised over the years multiple times, effects like residuals of EtO and ECH* and not environmentally friendly

Advancements in manufacturing including fully robotic manufacturing and assembly lines

CCI and stability of PFS for extreme cold storage driven by mRNA vaccines and other new therapies

*EtO: ethylenoxid
**ECH: ethylene chlohydrine

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Our Healthcare Industry is Evolving – some trends related to PFS cont.

Trend to self-administration / combination products: 49% of injectables in market can be self-administered, led by PFS, Auto Injector

Innovation & collaboration: importance of choosing the right partner to develop new products to solve problems

Increased focus on sustainability: Sustainable packaging, social responsibility efforts, and environmental actions

Advancements on Radio Frequency Identification (RFID) added to PFS: enabling unit-level traceability and data analytics for manufacturing and disease management.

Regulatory complexity is increasing new EU GMP Annex 1 requiring more stringent sterile manufacturing process for injectable drugs and Article 117 Medical device regulation and ISO standards 11608

Digital health and smart devices are playing a pivotal role in the digitalization of health. Utilizing data collected from delivery devices and connected platforms holds significant promise for enhancing patient engagement and placing the end user at the center of focus

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Stakeholders & Main Syringe Markets

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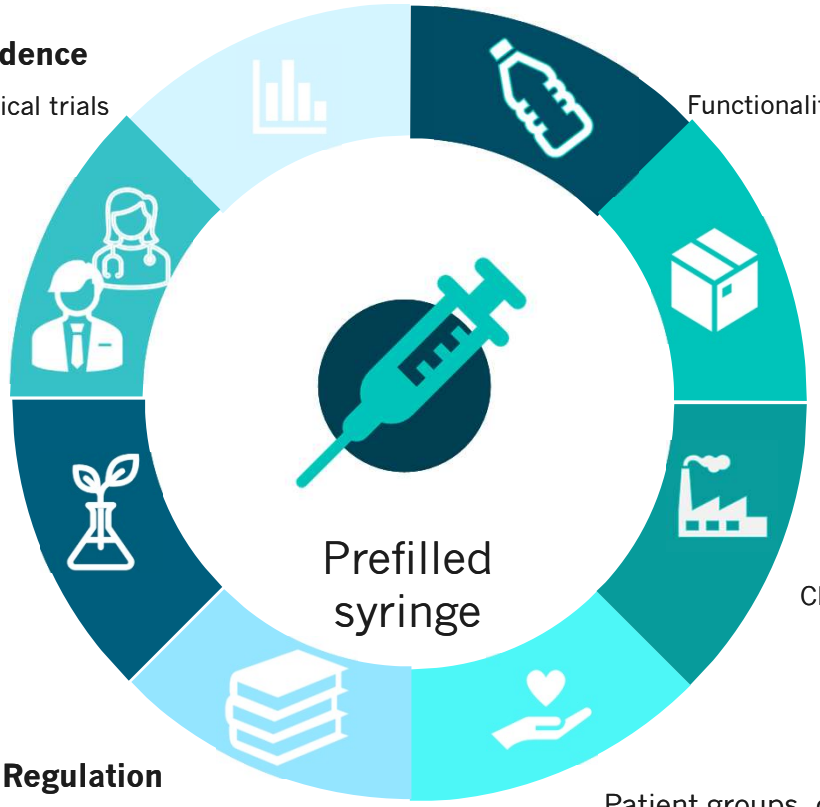
Interfaces and Stakeholders
to get to a final drug product in a PFS



Clinical evidence

Data from clinical trials

End User

Patient or HCP user studies, safety

Drug formulation

Stability, leachables, concentration

Regulation

Europe MDR, Combination Product USA

Primary Packaging

Functionality, biocomp, extractables

2ndary packaging

Anticounterfeiting, blisters, sterilization

Fill and Finish

CMO or internal, quality

Marketing

Patient groups, competition

Syringeability – syringe system

Physical functionality
Chemical/pharmaceutical interactions
Particles
Device integration

Quality - components

Constant quality
Breakage…
Closure integrity
Tested components

Processability

Filling & Finish
Sterility
Annex 1 compliance

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Diverse Syringes for Diverging Needs

Application/ requirement	Heparins - anticoagulants	Vaccines – mainly flu vaccines	Biologics – very diverse group	Aesthetics – beauty and lifestyle	Diabetes/ Obesity
Route of administration	Subcutaneous injection, 1/2” needle	Intramuscular injection, 5/8” needle	Mostly subcutaneous injection, 1/2” needle	Subcutaneous injection, diverse needles SC, ID	Subcutaneous injection, 1/2” needle
Syringe format	0.5 mL and 1 mL long with staked-in needle	1 mL short → trend towards Luer Lock	1 mL long 2.25 mL (and higher) (<<0.5 ml – ophthalmics)	Luer Lock 1 mL Long	1 mL long with staked-in needle
End user	Health care prof. Patient	Health care prof.	Health care prof. Patient	Health care prof.	Patient
Batch size	High volume	High volume	Small batch sizes	Mid batch size	High volume
Device application	Safety device integration	Back Stop Disposable needle	Often Autoinjector use	Possible	Autoinjector
Very high focus on	Processability & speed	Processability & speed	Sensitive drugs, often small fill lines	Appearance	Processability
Price sensitiveness	high	medium	low to medium	medium	medium
Remarks	Few players, mass market	Few players, mass market	Device integration	Hyaluronic acid not oxygen sensitive	Hormones, few players so far; syringes, also Cartridge based devices

Other ROAs: intravenous, buccal, nasal, subdermal, intradermal, topical, intrethecal...

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Advantages of PFS

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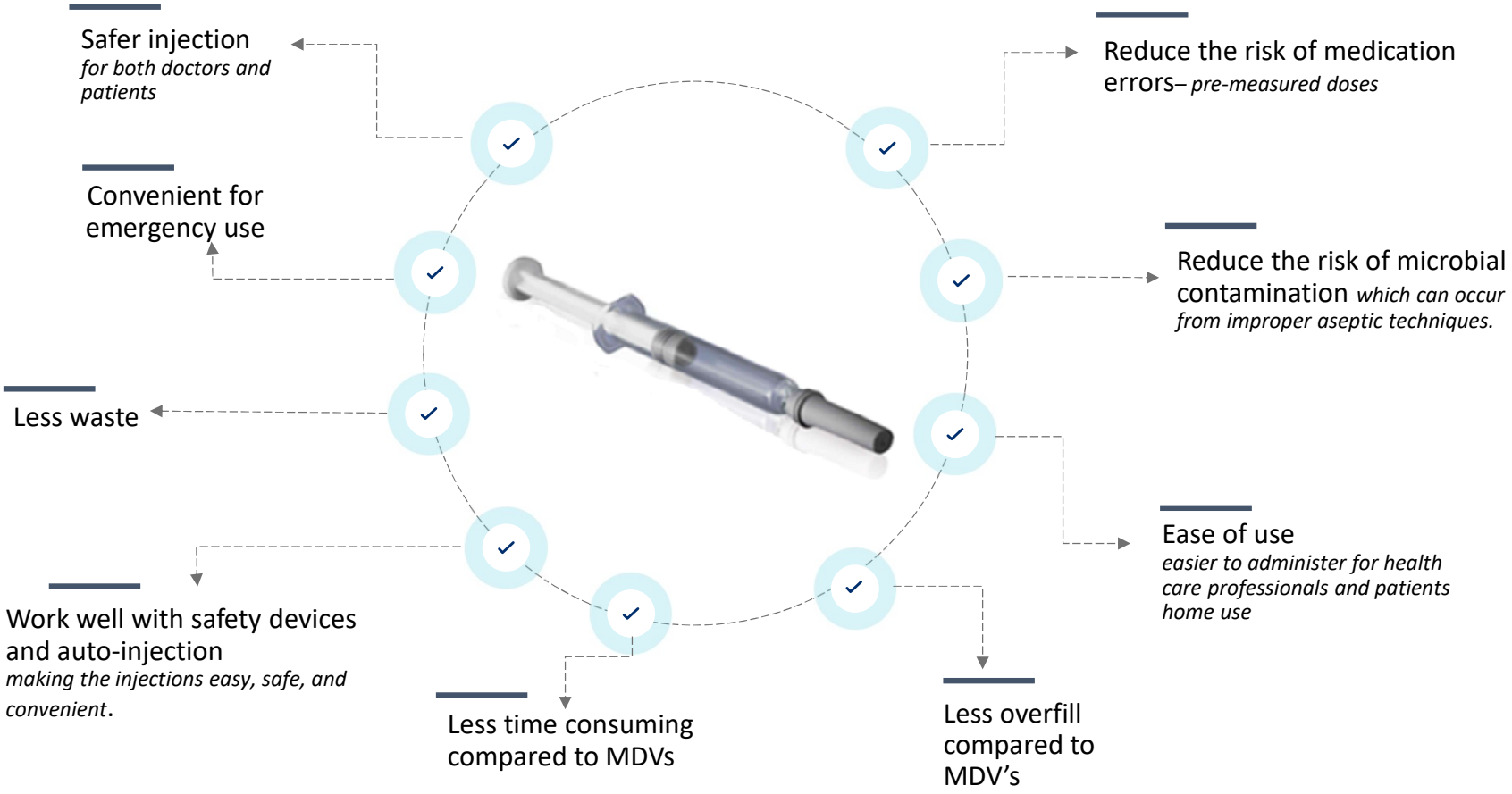
Multi Dose Vials [MDV's] vs Prefilled Syringes: Some Advantages



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Decision making – does a syringe make sense?

Prefilled glass syringe	Advantage	Filled glass vial, closed	Advantage
Total cost for container			
Low overfilling, low residual volume	+	High overfilling, high residual volume	−
Higher costs for packaging materials	−	Lower costs for packaging materials	+
User-friendliness			
Single dose	+	Single or multiple dose	+/−
Few steps through to injection	+	Many steps in injection preparation	−
Low risk of incorrect dosing	+	Higher risk of error for correct dosing	−
No other components needed (needle syringe) at point-of-care, exception: push-on cannula for Luer syringes	+	Disposable components necessary at the point of care: Plastic single-use syringe, Cannula for filling, Injection cannula	−
Contact materials			
Contact with the drug during storage: Glass, Elastomer stopper, Elastomer cap, Tungsten (extractables), Silicone oil (glide agent), Needle adhesive, Stainless steel	−	Contact with the drug during storage: Glass, Elastomer stopper	+
Special applications			
Highly viscosity drugs, low volume	+	Highly viscosity drugs	−
Lyophilization, reconstitution complex	−	Lyophilization, reconstitution simple	+
Autoinjector, simplicity, home use	+	Training necessary, especially for the uninitiated	−
Overall advantage	7 | 3		3 | 6

Zeiß, Bernd: Silikonölfreie vorgefüllte Spritzensysteme Pharm. Ind. 84, Nr. 8, 1021–1029 (2022).ECV • Editio Cantor Verlag, Aulendorf (Germany

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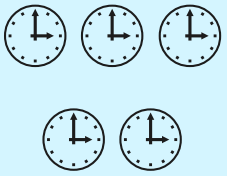
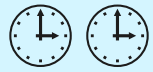
Holistic view on advantages of Prefilled syringes

	Infusion – vial (or bottle, bag)	Prefilled Syringe	Safety syringe (PFS)	Auto-injector – syringe inside	Wearable – vial or cartridge inside
Main use	Hospital	Home use, doctor, hospital	Hospital, home use	Home use	Home use
Home use	rare	yes	yes	convenient	convenient
Injection time	Infusion 	10 s (sc) 	10 s (sc) 	10 s (sc) 	minutes 
Cost of device	$	$$	$$$	$$$$	$$$$$
Cost for health system	$$$$$	$	$$	$$$	$$$$
Example	Cancer treatment	Vaccine, Ophthalmics	Anticoagulants - Heparins	Chronic/ autoimmune diseases	Autoimmune disease/ specialties

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Glass-Plastic Comparison

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Glass Dominates Most Therapy Areas, but COC/COP preferred in Advanced Therapies

COC/COP	Market Section	Glass
+	Small Molecules	+ + +
+	Traditional Biologics (Cancer, Auto-immune)	+ + +
+ +	Pharma Cosmetic Segment (Dermal Fillers, Hyaluron, Liquid Botox)	+
+ + +	Advanced Therapies [e.g., cell and gene therapies, RNA]	+

Most of the market is in glass and will continue so, but COC/COP is the preferred containment solution for sensitive molecules, highest quality specifications and where challenging storage conditions e.g., cold temperature, are required

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Decision making – Glass or COP?

	Advantage of glass	Advantage of COP	Remarks
Risk of breakage during filling	+ −	+ −	Line clearance after glass breakage during filling is expensive but rare
Risk of breakage at the point of care	+ −	+ −	Possible, but rare with small volume syringes. Breaking force minimized in advance during development
Luerlock integrated	−	+	Slipping of the thread and detachment impossible with COP
Tungsten	−	+	Alternative pin materials available today, no tungsten in COP injection molding
Adhesive	−	+	COP syringe free of adhesive
Silicone oil	+ −	+ −	COP syringes silicone oil free, long available
Gas and especially oxygen barrier	+	−	Glass unsurpassed
Extractables	+	−	Low for glass and known, inorganic
pH shift	−	+	No pH shift with COP
Experience	+	−	Experience with glass in the pharmaceutical industry is extensive, also for filling lines
Costs	+	−	COP more expensive than glass
Design freedom	−	+	Injection molding allows diverse designs
Tool	+	−	Free molding needs no special, expensive injection molding tools
Tolerances	−	+	Glass with wider tolerances through free molding
Scratch resistance	+	−	Plastic sensitive, however scratches do not affect the breaking force
Sterilization of the packaging material	+ −	+ −	Glass: EtO** COP: gamma, steam
Terminal sterilization	+ −	+ −	Glass: steam, EtO, other methods COP: steam, gamma, other methods
Overall advantage	6 | 6	6 | 6	

OP = Cyclic Olefin Polymer
**EtO = Ethylene Oxide

Zeiß, Bernd: Silikonölfreie vorgefüllte Spritzensysteme Pharm. Ind. 84, Nr. 8, 1021–1029 (2022).ECV • Editio Cantor Verlag, Aulendorf (Germany)

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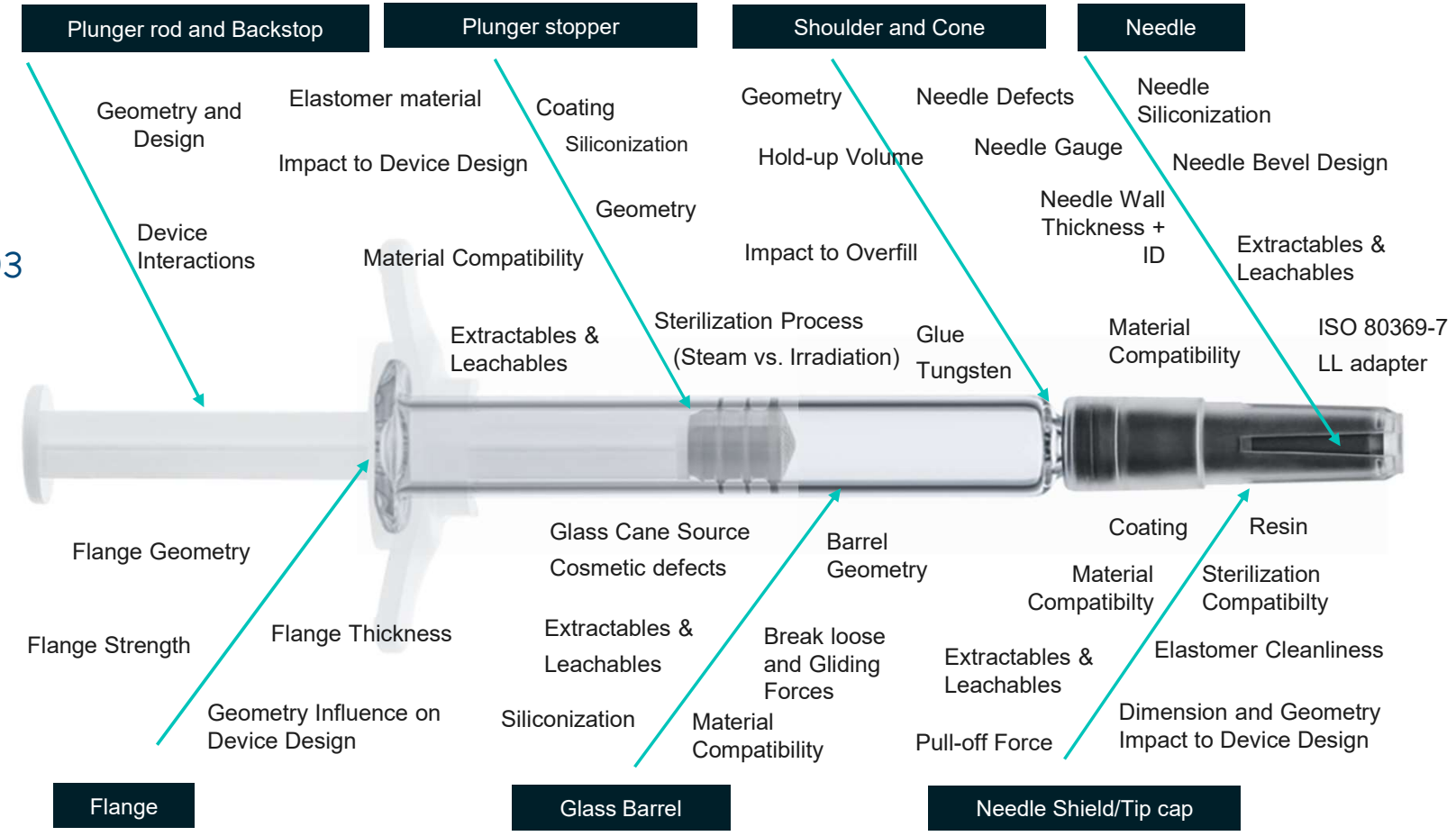
Syringe System Overview

Finished Drug product

Material, Funcionality, Drug contact

- ISO 11040-8
- BioComp - ISO 10993
- Sterilisation
- Sterility
- Stability
- Fill& Finish
- Shipping/Vibration Studies



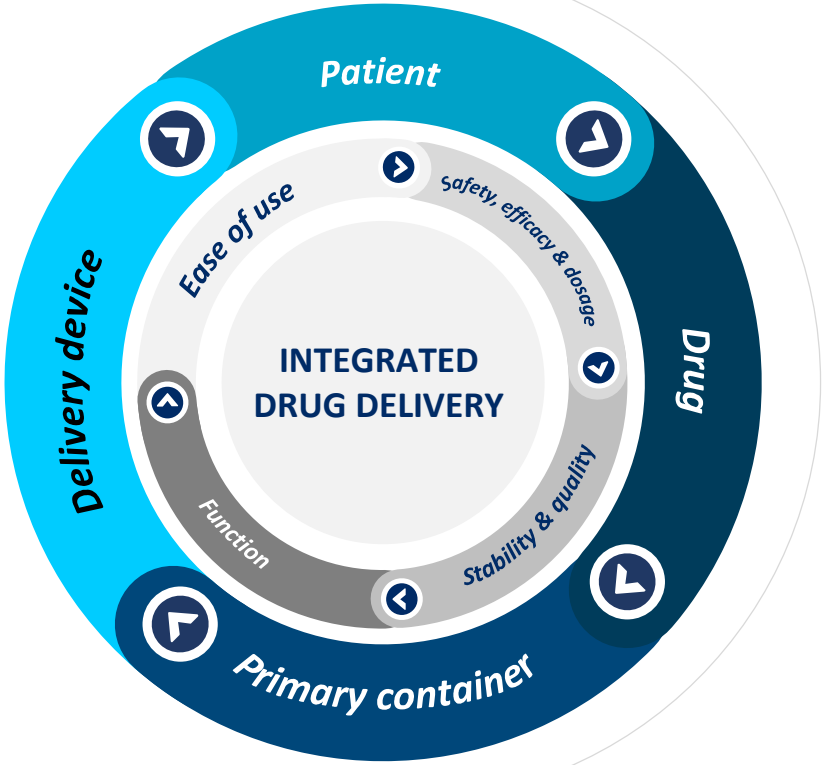
Adapted from David A. Post, Sherwin Shang, Shweta A. Raina,and William Szechinski. Development of Biopharmaceutical Drug-Device Products. PFS characterization and Interaction with Biologic Formulations. AAPS Advances in the Pharmaceutical Sciences Series 35, 2019 - 831 ff

Primary Containment & Patient Experience

Container closure systems are the heart of drug quality and combination products. They offer:

- Stability
- Protection
- Integration with delivery device
- Safety
- Quality

Critical to the Patient Experience



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Summary

Growing double digit market for PFS

Polymer syringes market is increasing but don´t mix with disposable syringes

Biological drive pharmaceutical value growth and biologics need PFS (in e.g. autoinjectors)

Our Healthcare Industry is Evolving – a lot of trends related to PFS

GLP 1 agonists as rather new big market

Many parameters to check if a PFS makes sense

Advantages of PFS over vials

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Thank you very much for your attention!

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