Disclosures

- Dr Al Palaniappan and Dr Noushin Brealey are both full-time employees of GSK, holding shares in the company.

- The views and opinions expressed in this presentation are those of the speakers and do not reflect the views or positions of GSK.
Objectives

Drivers of healthcare costs and pharmaceutical research

Current route of drug development

COVID-19 vaccination development

Accelerating drug development and how to innovate?

Questions?
Increasing Healthcare Costs Globally

What is Healthcare?
- Organised provision of medical care
- Prevention of disease
- Diagnosis and treatment of disease, illness and injury
- Treatments for long-term recovery

Global Expenditure
- Doubled from 2000 to US $8.5 trillion in 2019 (who.int)

Indian Expenditure
- US $45 billion in 2015-2016
- US $72 billion by 2020 (NITI Aayog Report March 2021)
Why are healthcare costs increasing globally?

**Increasing global population**

**Increasing demand for healthcare**

- 1950, average global life expectancy was 47 years
- 2019, average global life expectancy was 73 years (United Nations 2022)

**Greater spending power**

**Growing proportion of global society has greater spending power**

**Greater availability of healthcare treatments**

- Scientific breakthroughs and increase in approvals of novel treatments
- 50 FDA novel drug approvals in 2021 (FDA 2021)
## Global Pharmaceutical R&D spend

<table>
<thead>
<tr>
<th>Global Research &amp; Development (R&amp;D) spend by Pharmaceutical Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td>2012</td>
</tr>
<tr>
<td>2021</td>
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</table>

## Drivers for increasing R&D spend

- Increasing demand for novel innovations to treat clinical unmet need
- Time-limited patent life with sales erosion through generic/biosimilar substitution
- Increased understanding of biology and novel targets and new delivery modalities

## Drug development costs and timescale

- Cost to bring new drug to market estimated at US $1.3 billion (JAMA 2022)
- Median time to market is 11.80 years (BMJ Open 2021)
- 90% of clinical programmes fail
The usual route to drug development

Discovery & Development and Pre-Clinical

3-6 years

Target Identification and Validation
- Identifying the function of a possible therapeutic target and its role in disease
- Linking disease with target biomarkers
- In vitro and in vivo work

Lead Optimisation and Candidate Selection
- High throughput screening
- Selection of candidate molecule for development

Pre-Clinical Animal Studies
- Toxicology
- Pharmacology
- Drug-Drug Interactions

Pre-Clinical Animal Studies
- Safety
- Pharmacokinetics

Phase 1 studies
- Proof of Concept
- Dose ranging
- Safety

Phase 2 studies
- Efficacy
- Safety

Phase 3 studies
- Regulatory Filings
  - FDA
  - CHMP
  - PMDA
  - Global

Clinical Studies

Months
- n= 10s

1-4 years
- n= 100s

2-4 years
- n= 1000s

Months to a year+

Median time to market 11.80 years (BMJ Open 2021)
COVID-19 vaccines developed in under a year, without compromising safety

SARS-CoV-2 identified in December 2019

2nd December 2020, MHRA granted first emergency-use authorisation for a COVID-19 vaccine (Pfizer and BioNTech)

Tests on more than 43,000 people showed that Pfizer vaccine was 95% effective at preventing disease (Nature 2020)

8th December 2020, Margaret Keenan (81 years) became the first person in the world to be given the Pfizer COVID-19 vaccine as part of a mass vaccination programme (BBC 2020)

By October 2022, more than 12.7 billion doses of COVID-19 delivered globally (Bloomberg 2022)
How was this achieved?

<table>
<thead>
<tr>
<th>Worldwide collaboration</th>
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<tbody>
<tr>
<td>• Scientists and researchers sharing knowledge</td>
</tr>
<tr>
<td>• Government and private sectors providing source of funding and underpinning the financial risk</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Advances in genomic sequencing</th>
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<tbody>
<tr>
<td>• By January 2020, SARS-CoV-2 viral genome sequenced</td>
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</table>

<table>
<thead>
<tr>
<th>Strategic investment</th>
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<tbody>
<tr>
<td>• Multiple companies and vaccine platforms, increasing the probability of success</td>
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</table>

<table>
<thead>
<tr>
<th>Clinical trial design</th>
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</thead>
<tbody>
<tr>
<td>• Rigorous standards for efficacy and safety maintained</td>
</tr>
<tr>
<td>• Speeding up development, by combining phases of drug development e.g. phase 2/3</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Working closely with regulators</th>
</tr>
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<tbody>
<tr>
<td>• Rapid review of clinical trial design</td>
</tr>
<tr>
<td>• Inline review of emerging efficacy and safety data</td>
</tr>
<tr>
<td>• Post emergency-use authorisation safety monitoring</td>
</tr>
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</table>
Accelerating drug development to reach patients faster

- Faster to market
- Increasing the number of new medicines available to patients
- Less attrition and higher probability of success
- Reduction of overall cycle times across all development
- Reduction in development costs
- Better insights and decision making early
- The opportunity

Increasing the number of new medicines available to patients
How to innovate and accelerate?

Using genetic and proteomic data

- Genetically validated targets are at least twice as likely to successfully become medicines
- Proteomics
  - Investigating proteins of interest to better understand disease-related mechanisms and identify biomarkers of disease
  - Paving the way for personalised medicine

Clinical trial design

- Multi-part protocols,
  - Incorporating key sub-studies to support rapid progression, e.g. food effect, drug-drug interaction cohorts
  - Incorporation of challenge models in phase 1 to de-risk early
  - Combining phases 1, 2 and 3
  - Simpler study designs

Adaptive trial designs

- Ongoing data review to change the study design
  - Smaller studies which can be expanded/stopped early
  - Concentrating on specific sub-populations or dose range
How to innovate and accelerate?

**Digital innovation**
- Aiding recruitment and enrolment
- Identifying potential study sites
- Optimising clinical trial design
- Optimising the patient experience
  - Digital monitoring and wearable devices, with real time data capture and review
  - Decentralised visits and use of telemedicine
  - Reducing the burdens for study sites
  - Collection of data directly from electronic health care records

**Real world data**
- Allowing researchers to go beyond data gathered in traditional randomised controlled trial
- Historical or contemporaneous control data to supplement or be used in lieu of comparator arms (*Yap 2021*)
  - Rare disease or small target population
  - Significant clinical unmet need
  - Highly predictable disease progression
  - Large expected size effect

**Improving and using available regulatory frameworks**
- FDA’s fast track, breakthrough therapy, accelerated approval and priority review (*FDA 2022*)
- Can MHRA be nimbler and more efficient post-Brexit?
<table>
<thead>
<tr>
<th>Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isomorphic Labs</td>
<td>Using AI and machine learning methods to accelerate and improve the drug</td>
</tr>
<tr>
<td></td>
<td>discovery process</td>
</tr>
<tr>
<td>BenevolentAI</td>
<td>Using AI to explore interconnected disease networks to better understand</td>
</tr>
<tr>
<td></td>
<td>complexities of biology and derive novel insights</td>
</tr>
<tr>
<td>VERISIMLife</td>
<td>Using machine learning to predict the clinical outcome of new assets before</td>
</tr>
<tr>
<td></td>
<td>they enter clinical trials</td>
</tr>
<tr>
<td>trials.ai</td>
<td>Mining massive amounts of trial-related documents to aid clinical trial</td>
</tr>
<tr>
<td></td>
<td>design</td>
</tr>
<tr>
<td>deeplens</td>
<td>Connecting trial sponsors to community oncology practices at scale for patient</td>
</tr>
<tr>
<td></td>
<td>recruitment</td>
</tr>
<tr>
<td>Clinical One</td>
<td>Platform to unify clinical data from all sources, and harmonises with patients’</td>
</tr>
<tr>
<td></td>
<td>Electronic Health Care Records</td>
</tr>
<tr>
<td></td>
<td>Collecting data after trial has ended, enabling longer term impact of</td>
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<tr>
<td></td>
<td>treatments, collection of real-world data</td>
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</table>
A lot more investment is needed
Top 10 largest databases in the world

(Compare Business Products 2022)

1. Library of Congress
• 130 million items ranging from cook books to colonial newspapers to US government proceedings

2. Central Intelligence Agency (CIA)
• Little known about the overall size

3. Amazon
• World’s biggest retail store
• Keeps extensive records on its 59 million active customers

4. YouTube
• More than 100 million clips watched per day
• Accounts for >60% of all online videos watched

5. ChoicePoint
• Background financial check service
• Contains information about American population – addresses, phone number, driving records...

6. Sprint
• World’s largest telecommunication company
• Offers mobile services – keeping track of all calls placed on their network

7. Google
• 91 million searches per day
• Accounts for close to 50% internet search activity

8. AT&T
• United States’ oldest telecommunications company
• Contains 1.9 trillion calling records

• Atomic energy research, high energy physics experiment, simulations of the early universe and more

10. World Data Centre for Climate
• Data for and from climate research are collected, stored and disseminated
• Information on climate research and anticipated climatic trends
Could this be the future?
Thank you!