Case Study:
Oracle's Advanced Analytics at UK National Health Service

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UK NHSBSA
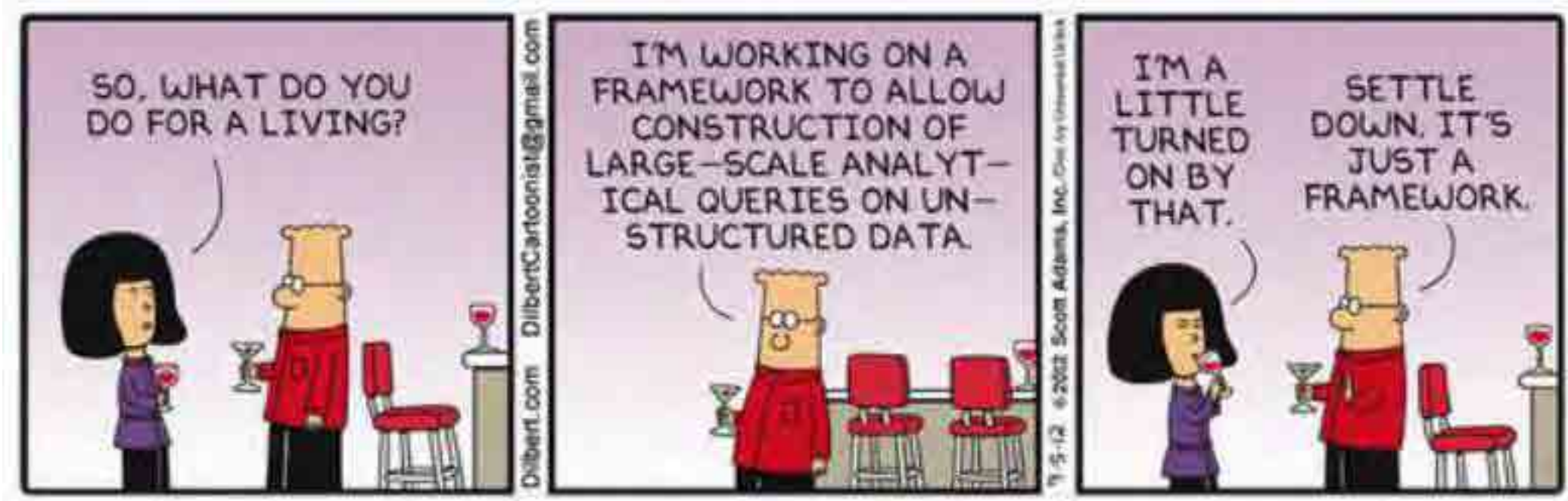
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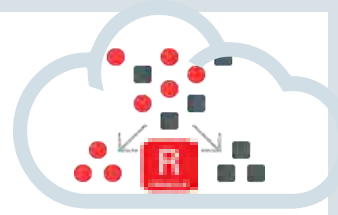
ORACLE
OPEN
WORLD

ORACLE

NHS
Business Services Authority

Dilbert on Big Data

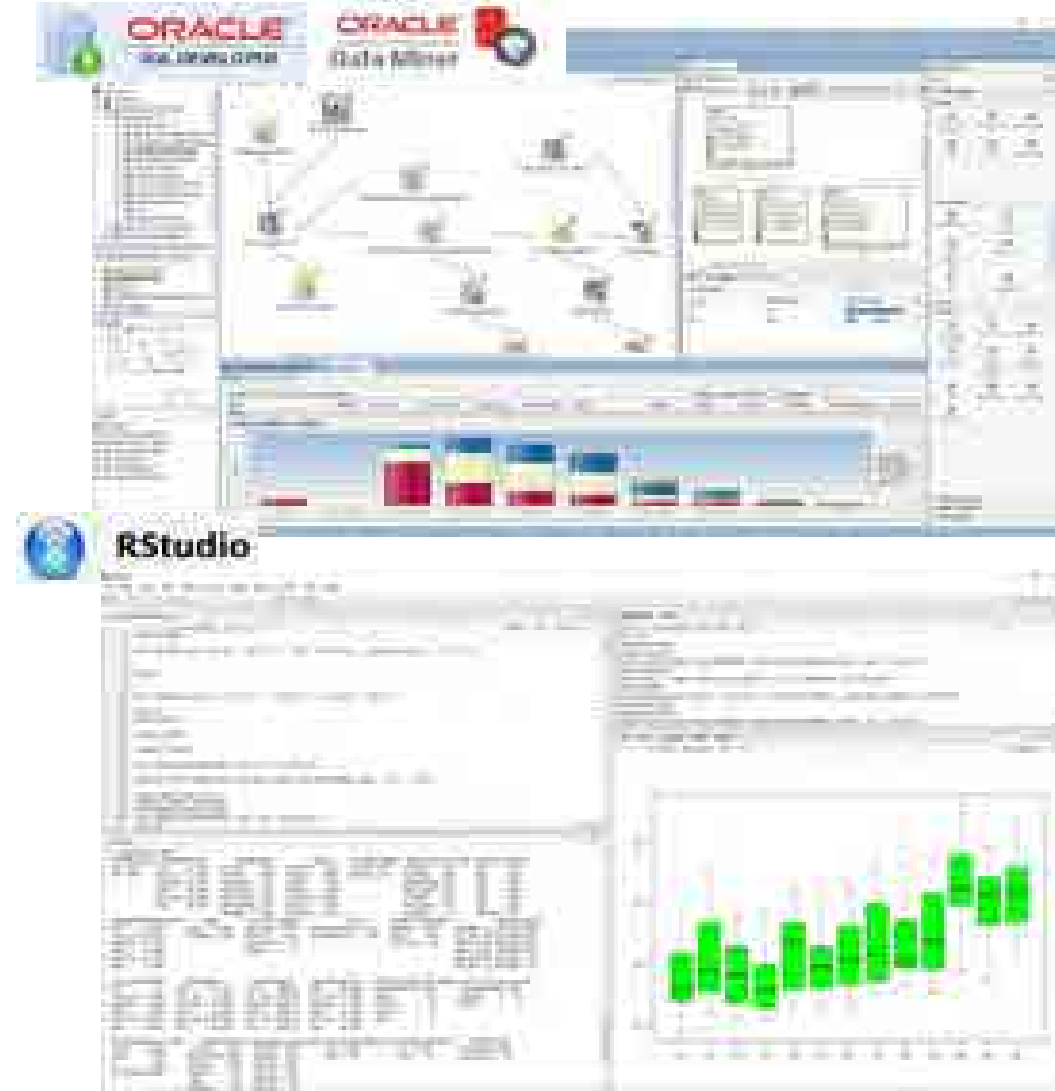# Oracle's Machine Learning/Advanced Analytics
Fastest Way to Deliver Scalable Enterprise-wide Predictive Analytics

Key Features

- Parallel, scalable machine learning algorithms and R integration

- In-Database + Hadoop—Don't move the data

- Data analysts, data scientists & developers

- Drag and drop workflow, R and SQL APIs

- Extends data management into powerful advanced/predictive analytics platform

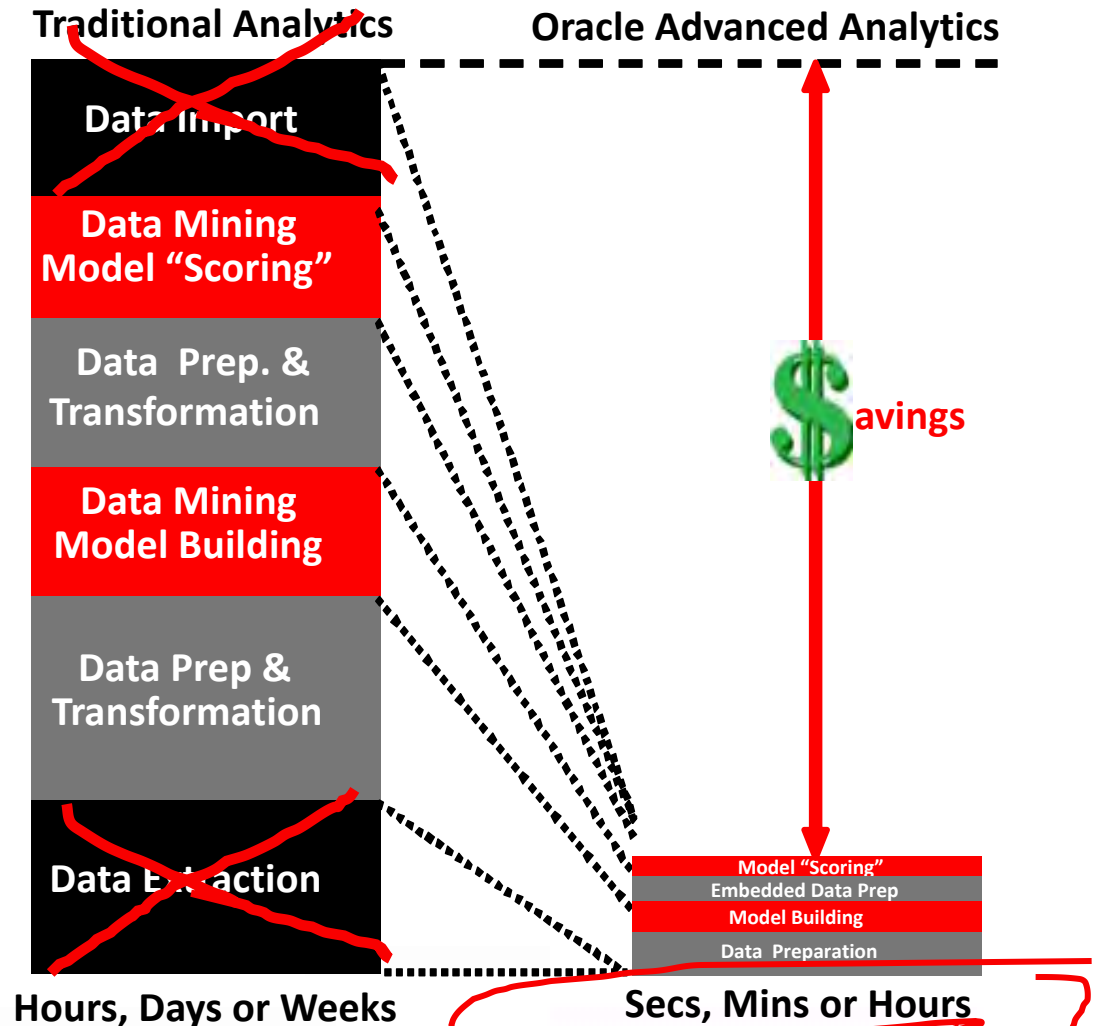- Enables enterprise predictive analytics deployment + applications

Oracle's Machine Learning/Advanced Analytics
Fastest Way to Deliver Enterprise-wide Predictive Analytics
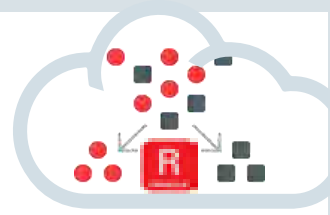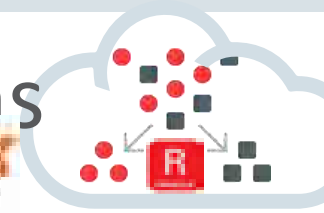
Major Benefits

- Data remains in Database & Hadoop
  - Model building and scoring occur in-database
  - Use R packages with data-parallel invocations
- Leverage investment in Oracle IT
  - Eliminate data duplication
  - Eliminate separate analytical servers
- Deliver enterprise-wide applications
  - GUI for ML/Predictive Analytics & code gen
  - R interface leverages database as HPC engine

Traditional Analytics

- Data Import
- Data Mining Model "Scoring"
- Data Prep. & Transformation
- Data Mining Model Building
- Data Prep & Transformation
- Data Extraction

Hours, Days or Weeks

Oracle Advanced Analytics

$avings

- Model "Scoring"
- Embedded Data Prep
- Model Building
- Data Preparation

Secs, Mins or Hours

Oracle's Machine Learning & Adv. Analytics Algorithms
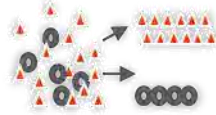
CLASSIFICATION
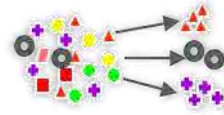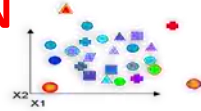– Naïve Bayes
– Logistic Regression (GLM)
– Decision Tree
– Random Forest
– Neural Network
– Support Vector Machine

CLUSTERING
– Hierarchical K-Means
– Hierarchical O-Cluster
– Expectation Maximization (EM)

ANOMALY DETECTION
– One-Class SVM

TIME SERIES
– Holt-Winters, Regular & Irregular, with and w/o trends & seasonal
– Single, Double Exp Smoothing

REGRESSION
– Linear Model
– Generalized Linear Model
– Support Vector Machine (SVM)
– Stepwise Linear regression
– Neural Network
– LASSO

ATTRIBUTE IMPORTANCE
– Minimum Description Length
– Principal Comp Analysis (PCA)
– Unsupervised Pair-wise KL Div
– CUR decomposition for row & AI

ASSOCIATION RULES
– A priori/ market basket

PREDICTIVE QUERIES
– Predict, cluster, detect, features

SQL ANALYTICS
– SQL Windows, SQL Patterns, SQL Aggregates
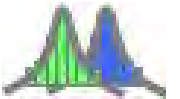
FEATURE EXTRACTION
– Principal Comp Analysis (PCA)
– Non-negative Matrix Factorization
– Singular Value Decomposition (SVD)
– Explicit Semantic Analysis (ESA)

TEXT MINING SUPPORT
– Algorithms support text type
– Tokenization and theme extraction
– Explicit Semantic Analysis (ESA) for document similarity

STATISTICAL FUNCTIONS
– Basic statistics: min, max, median, stdev, t-test, F-test, Pearson's, Chi-Sq, ANOVA, etc.
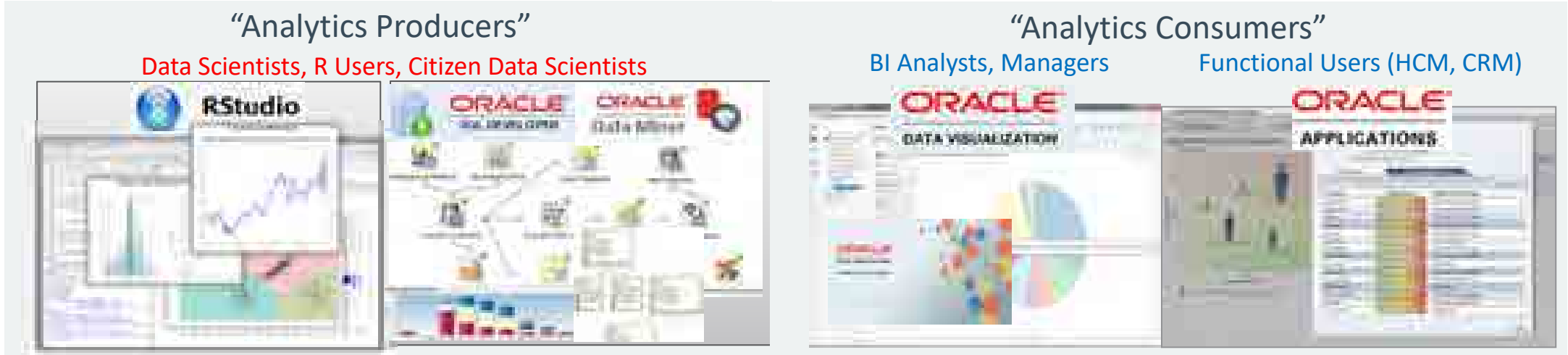
R PACKAGES
– CRAN R Algorithm Packages through Embedded R Execution
– Spark MLlib algorithm integration

EXPORTABLE ML MODELS
– C and Java code for deployment

• OAA (Oracle Data Mining + Oracle R Enterprise) and ORAAH combined
• OAA includes support for Partitioned Models, Transactional, Unstructured, Geo-spatial, Graph data. etc,

Oracle's Machine Learning/Advanced Analytics Platforms
Machine Learning Algorithms Embedded in the Data Management Platforms

"Analytics Producers"
Data Scientists, R Users, Citizen Data Scientists

"Analytics Consumers"
BI Analysts, Managers   Functional Users (HCM, CRM)

ORACLE Data Management + Advanced Analytical Platform

Big Data SQL

ORACLE **Big Data Cloud Service**

"Oracle Machine Learning" Big Data Cloud
ORAAH—Machine Learning Algorithms,
Statistical Functions + R Integration
for Scalable, Parallel, Distributed Execution

ORACLE **Database Cloud**

"Oracle Machine Learning" Database Edition
Machine Learning Algorithms,
Statistical Functions + R Integration
for Scalable, Parallel, Distributed, in-DB Execution

"Why Oracle?

Because that's where the data is!"

— Larry Ellison, Executive
    Chairman and CTO of Oracle Corporation

Oracle Machine Learning
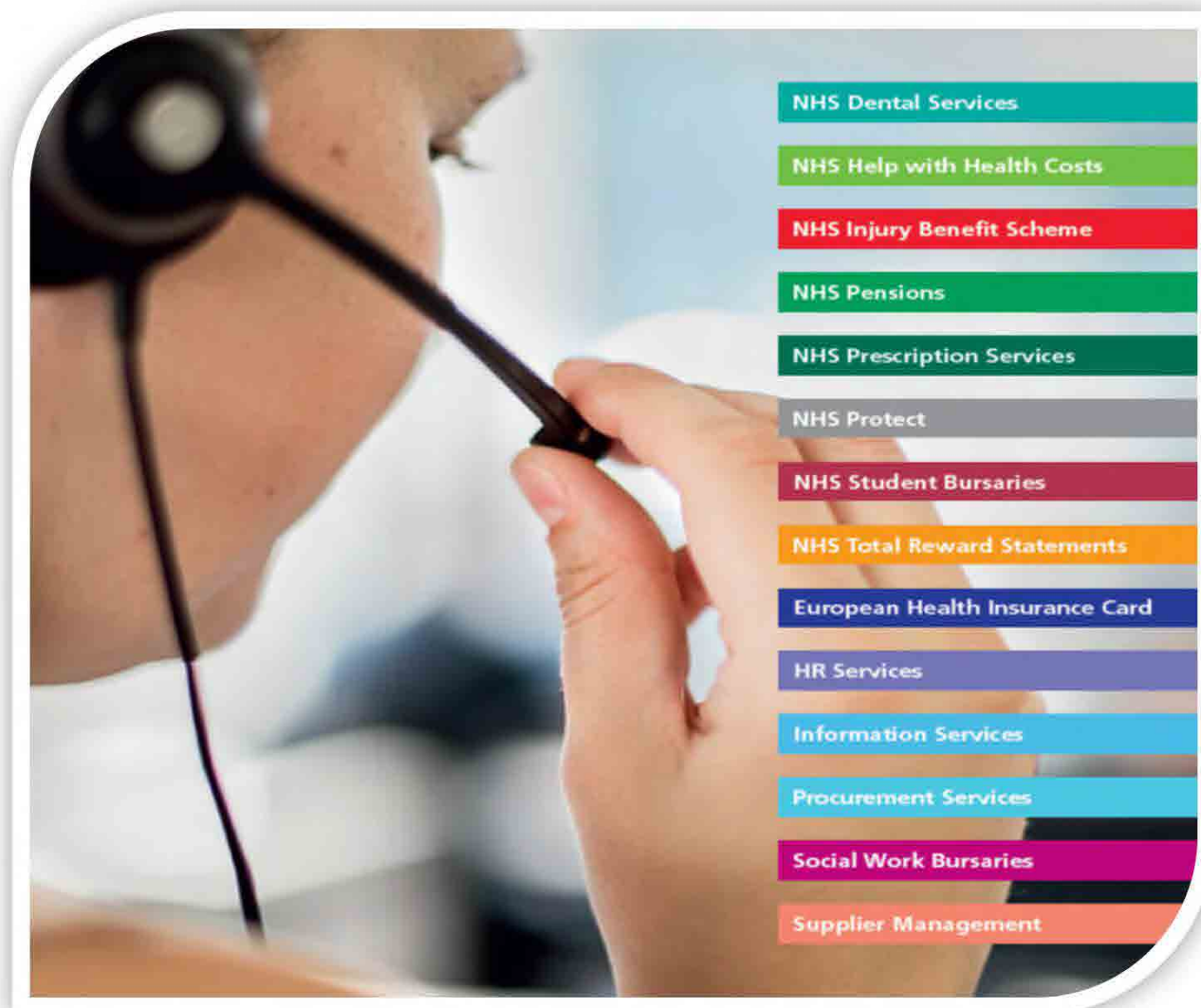Machine Learning Notebook for Oracle Autonomous Database Cloud

Key Features

- Collaborative UI for data scientists
  - Packaged with Oracle Autonomous Database Cloud (V1)
  - Easy access to shared notebooks, templates, permissions, scheduler, etc.
  - SQL ML algorithms API (V1)
  - Supports deployment of ML analytics

NHSBSA Portfolio

- The NHS Business Services Authority is a Special Health Authority and an Arm's Length Body of the Department of Health which provides a range of critical central services to NHS organisations, NHS contractors, patients and the public.

NHS Dental Services

NHS Help with Health Costs

NHS Injury Benefit Scheme

NHS Pensions

NHS Prescription Services

NHS Protect

NHS Student Bursaries

NHS Total Reward Statements

European Health Insurance Card

HR Services

Information Services

Procurement Services

Social Work Bursaries

Supplier Management

NHS Business Services Authority

2016/17 Transactions

1,096,934,672 prescription items processed in 2016/17

7.4 million UK patients received help with their NHS health costs

Over £34 billion the amount of money we handle on behalf of our stakeholders every year

our contact centre handled **4,095,121** calls in 2016/17 and **622,037** emails

5.8 million EHICs provided to UK residents in 2016/17

45,119,982 FP17 dental claim forms processed in 2016/17

£581 million total amount of recurring savings the NHSBSA has delivered so far for the NHS and its patients

The challenge

- NHSBSA asked to collaborate to deliver £1bn of annual recurring savings by March 2018
- Finding and sizing the opportunities to make savings

The answer

- Driving insight from the data we hold in operational systems
- Technology that would enable us put all our data into one environment and analyse it without impacting operations
- Technology that would not turn off the lights if we asked a question of large volumes of data
- A team of people who could look after the data, do the hard sums and then present the findings

In the beginning

- What are the questions we want to answer? Questions that not only demonstrate business value but also test the requirements of the volumes of data.

- What data do we have to answer these questions? Where is it?

- How can we get the data from a transactional system to an environment where we can do some advanced analytics?

- Who is going to own the actions from the insight created?

- How do we engage/educate/involve the rest of the organisation?

Absolute must haves of our new Data Lab

- Security
- Performance
- Hold large amounts of data and process efficiently
- Analysis of the data without not knowing the person
- No issues with the network
- Don't need huge computing power on your desk
- No need for specialist skills such as Hadoop / Spark
- Availability of training – online and classroom
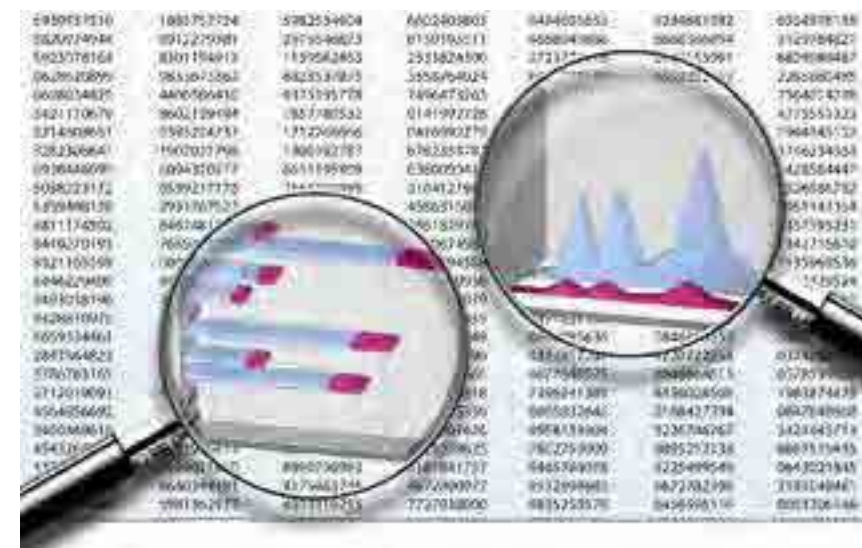
Why Oracle Exadata and Advanced Analytics?

- Engineered in-memory system (algorithms executed within database)
- Existing Oracle database experience within the organisation
- Courses and support available
- Affordability
- Speed to deploy
- Integration with R
- Unstructured data
- Intuitive to use
- Oracle understood our business problem

ANALYSIS & DATA

Our Data Lab

What have we used it for →
- Insight
- Operational Improvements
- Finding Fraud and Error

Lessons we have learned →
- Our structure
- Communications
- Engagement
- Data Governance

Achievements / next steps →
- Created a Data Warehouse
- ePACT2 now 'live'
- eDEN in progress

Identifying Fraud and Error

- Fraud and Error detection on billions of rows of data

- Identifying where behaviour change can be instigated

- Ensuring accurate payment

- Examples:
  - Ghost patients
  - Contractor uplifting payments
  - Claiming for services not conducted
 - Deceased patients receiving medicines

Medicine Use Review profiling

- A MUR is a personal NHS consultation with your pharmacist to help improve your understanding of your medicines and getting the maximum benefit from them.
- You can discuss the drugs you have been prescribed, any problems or side effects you are experiencing or whether there is a more effective way of taking them.
- Pharmacists can claim for up to 400 medicines use reviews per year.

We wanted to:

- Identify unusual behaviour which may require further investigation.
- Provide an overview of patterns of pharmacy contractor behaviour for MURs.
- Help inform the work of the NHSBSA Provider Management Team.

Medicines Use Review (MUR)

Helping patients get the most from their medication
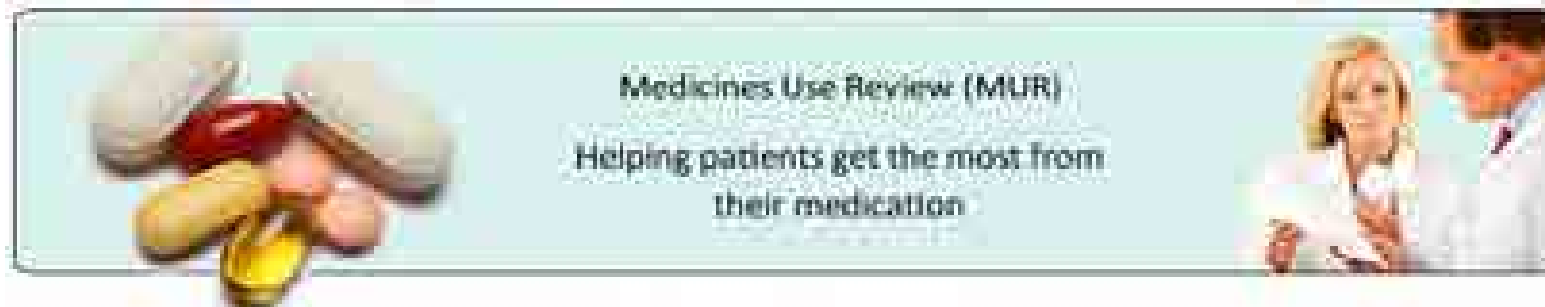
Medicine Use Review profiling 2015/16

What did we find?

- 3.3 million MURs declared in by 11,029 contractors.

- Increasing year on year since 2012.

- Multiples account for 60% of contractors who undertake MURs and around 70% of MURs. The median average number of MURs is 400 for multiples and 223 for independent contractors.

- 16% of contractors declared more than 400 MURs and 3% more than 410 MURs.
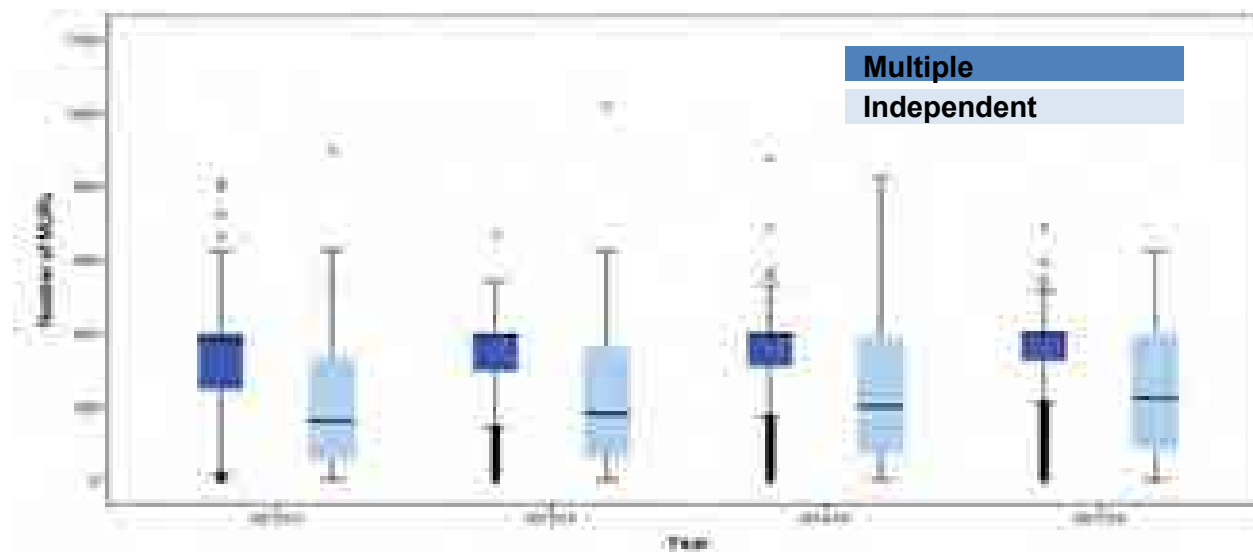
Medicine Use Review profiling
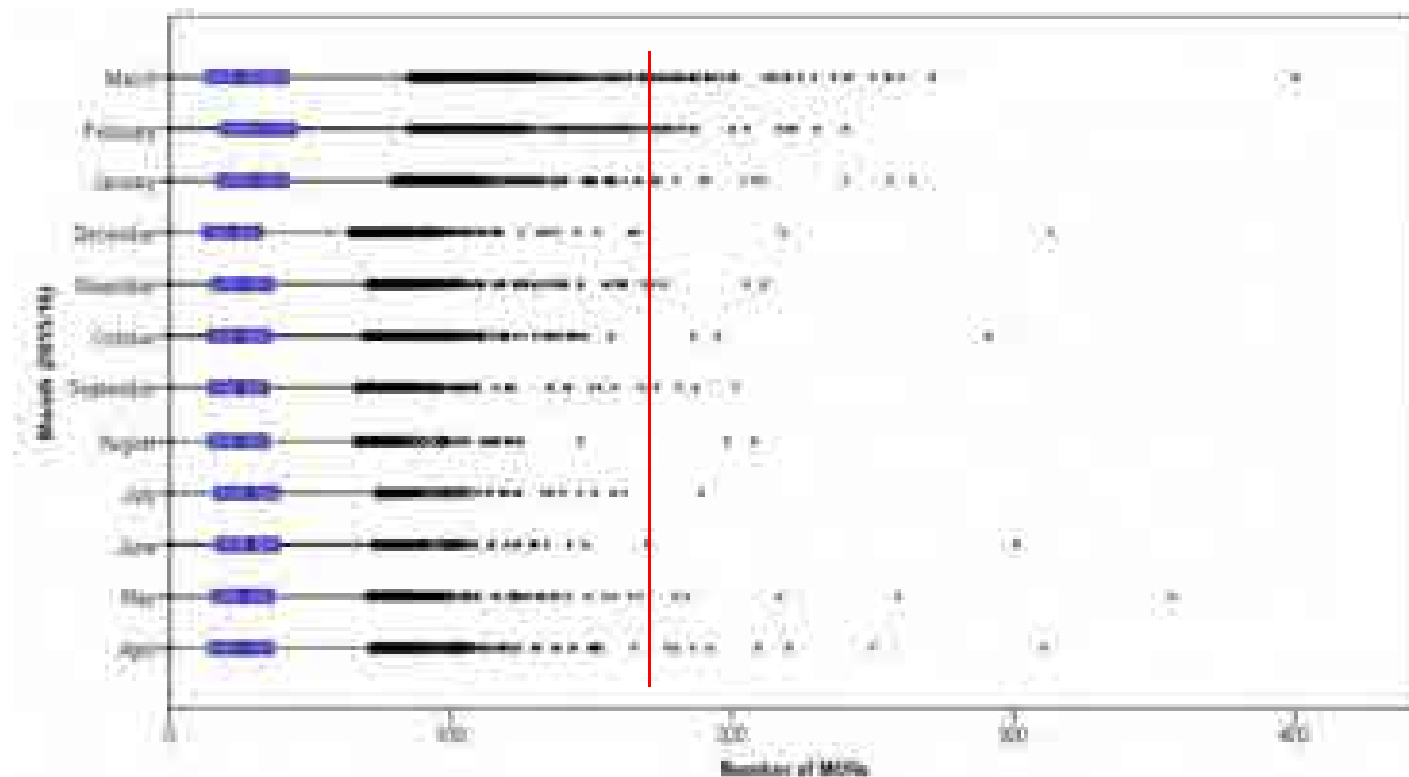
Examples of unusual behaviour:

- High number of MURs in a given month.

Median average	27
Extreme value	108+
Maximum	400

- High ratio of MURs to 100 items

Median average	0.4
Maximum	13.7

- Contractors achieving 400 MURs early
- 28 contractors declared 400 MURs in the first 5 months, 10 of whom also did so in 2014/15

Medicine Use Review profiling

Next steps

- Challenge outlier behaviour. Recover monies if claiming was inappropriate.

- Routine reports on MUR activity – flagging outliers

- Recommend more data collected to gather more insight on £96M per year spent on MURs

Deterrent effect of exemption checking


We wanted to:

- Identify if fewer people are incorrectly claiming exemption.
- Estimate the savings to the NHS resulting from the behaviour change of patients who misclaim exemption.
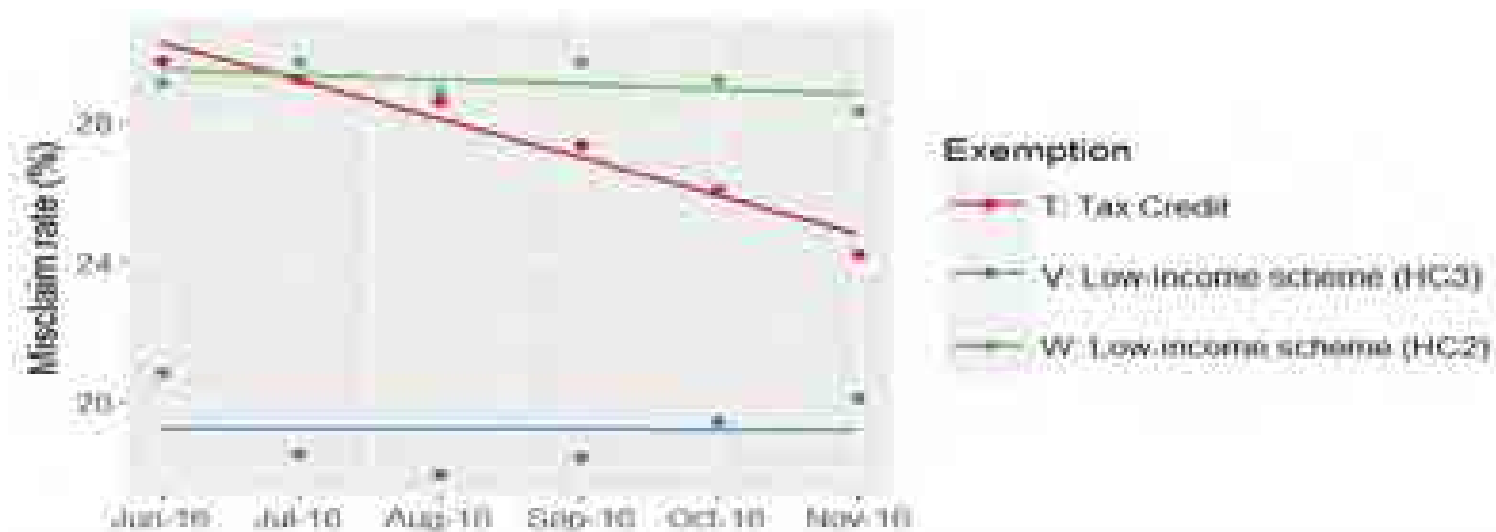
Deterrent effect in exemption checking - BECs

- *Changepoint* modelling showed that the rate of reduction in the misclaim increased statistically significantly in only two of four exemption categories:
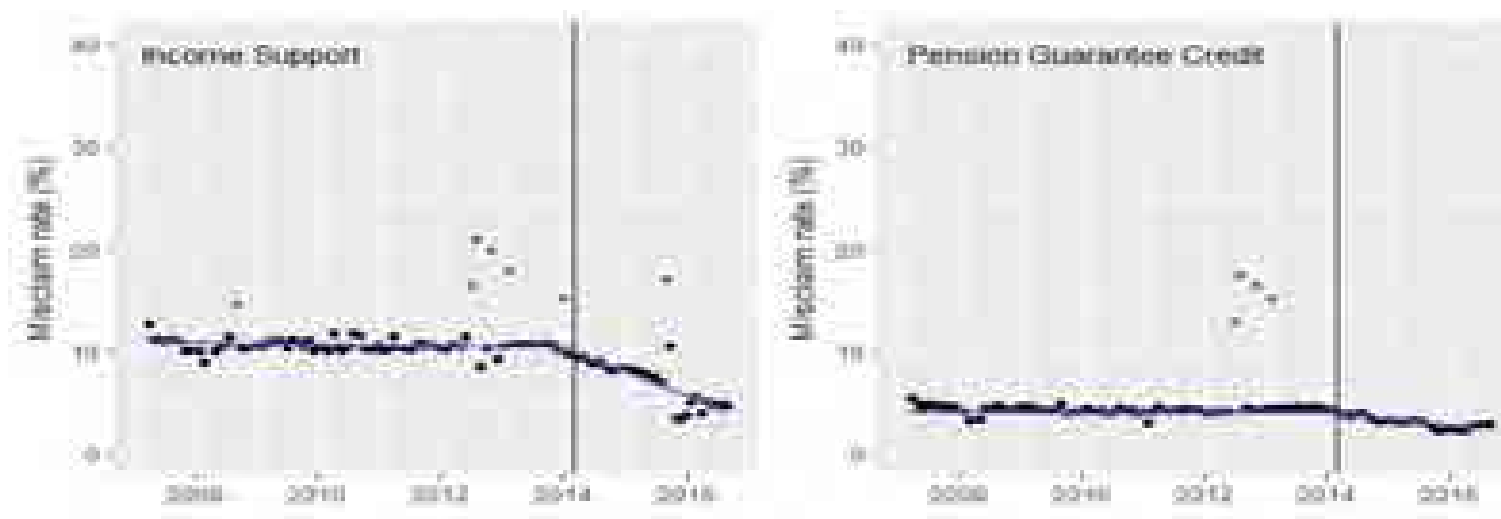
- Total savings in BECs categories were between £2.1 and £1.8 million per financial year between 2014/15 and 2015/16.
- BUT the rates could have declined due to other confounding factors.

Deterrent effect in exemption checking - DECs

- DECs is the youngest scheme, running since June 2016. There were no intervention awareness campaigns in DECs.

- The misclaim rate in DECs-checked categories declined statistically significantly in only one of three exemption categories: Tax Credit.

- The savings were on average, £4.6 million in the 6 months alone since the scheme was launched in June 2016 until November 2016.

Deterrent effect in exemption checking - PECs

- Unlike in BECs, there was no intervention awareness campaigns in PECs.
- PECs has been running for a shorter period of time, since September 2014.
- The misclaim rate in PECs-checked categories declined statistically significantly in only all five exemption categories
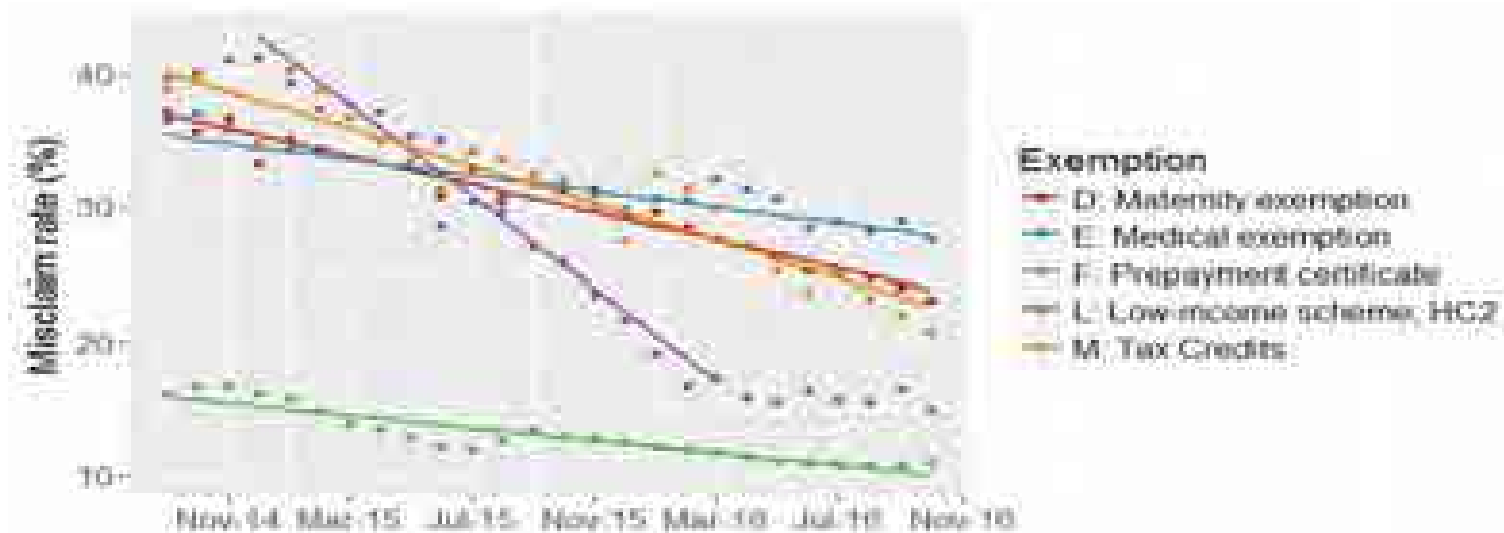
- The savings were, on average, £69.7 million for the 2015 calendar year.

Improving Patient Care

- Identify patient pathways
- Understand the pinch points or areas of concern
- Co-ordinate with domain experts

- Examples
  - Antibiotic resistance
  - Polypharmacy
  - Mental Health Care
  - Care homes

Antimicrobial resistance

- Resistance to antibiotics poses a "major global threat" to public health, says a new report by the World Health Organization (WHO).

- Dr Keiji Fukuda, assistant director-general at WHO, said: "Without urgent, coordinated action by many stakeholders, the world is headed for a post-antibiotic era, in which common infections and minor injuries which have been treatable for decades can once again kill."

- Professor Nigel Brown, president of the UK Society for General Microbiology, said it was vital microbiologists and other researchers worked together to develop new approaches to tackle antimicrobial resistance.

NEWS

Health

Antibiotic resistance now 'global threat', WHO warns
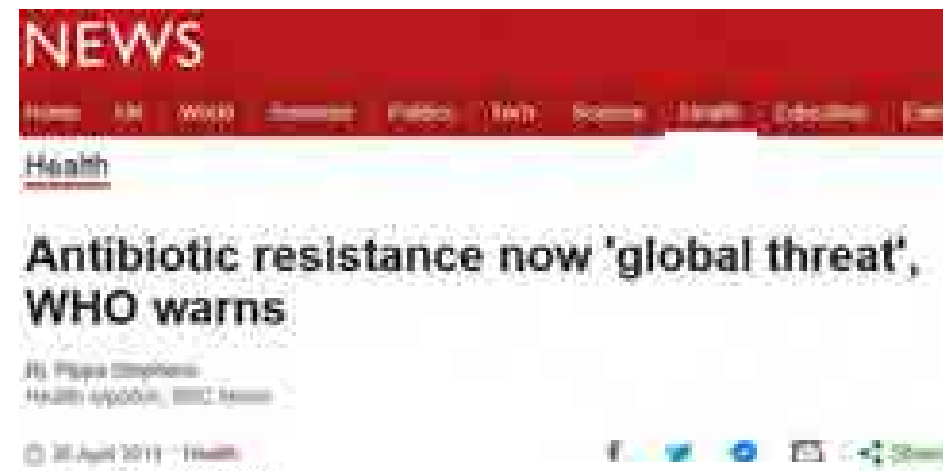
" What we urgently need is a solid global plan of action which provides for the rational use of antibiotics

Dr Jennifer Cohn, Medecins sans Frontiers

Antibiotic prescribing in children

- A gap in understanding regarding the **appropriate** use of antibiotics in children.

- Antibiotic resistance poses a significant threat to public health.

- Reducing the inappropriate use of antibiotics will:
  – delay the development of resistance that leads to patient harm from infections that are harder and more costly to treat
  – protect patients from healthcare acquired infections.

Antibiotic prescribing in children

What we found:

- Children aged 14 years and under received 14% of all antibiotic items prescribed and 88% of oral liquid antibiotics prescribed.

- Over half of oral liquid antibiotics prescribed to children are to under 5's.

- Penicillins account for the around three-quarters of oral liquid antibiotics prescribed to children, with Amoxicillin being the most commonly prescribed of these.

- A metric has been produced based on patient list sizes, which permits comparison of the oral liquid antibiotics prescribing rate to children across CCGs, practices etc.

- In the analysis the proportion ranges between 1% and 90% with an average of 17%.

Antibiotic prescribing in children

What next?

- Consideration of the appropriateness of the metric.
  - Availability of age data
  - Appropriateness of patient list size

- When a metric is established, identify the potential cost savings if all practices were to reduce prescribing to an agreed level.

Dental antibiotic prescribing

- As we have shown, GPs have recently been targeted for their antibiotic prescribing but dentists have not and the level of information available for dentists is not as granular as the GP prescribing data.

- Potential benefits of providing this data include:
    - influencing dentists' professional practice and improving adherence to guidance
    - savings for the NHS from stopping unnecessary prescribing
    - supporting Public Health England to reduce antimicrobial resistance from the overuse of antibiotics.

- Findings will be shared with the Antimicrobial Resistance dental sub-group at Public Health England and the Chief Dental Officer to discuss next steps.
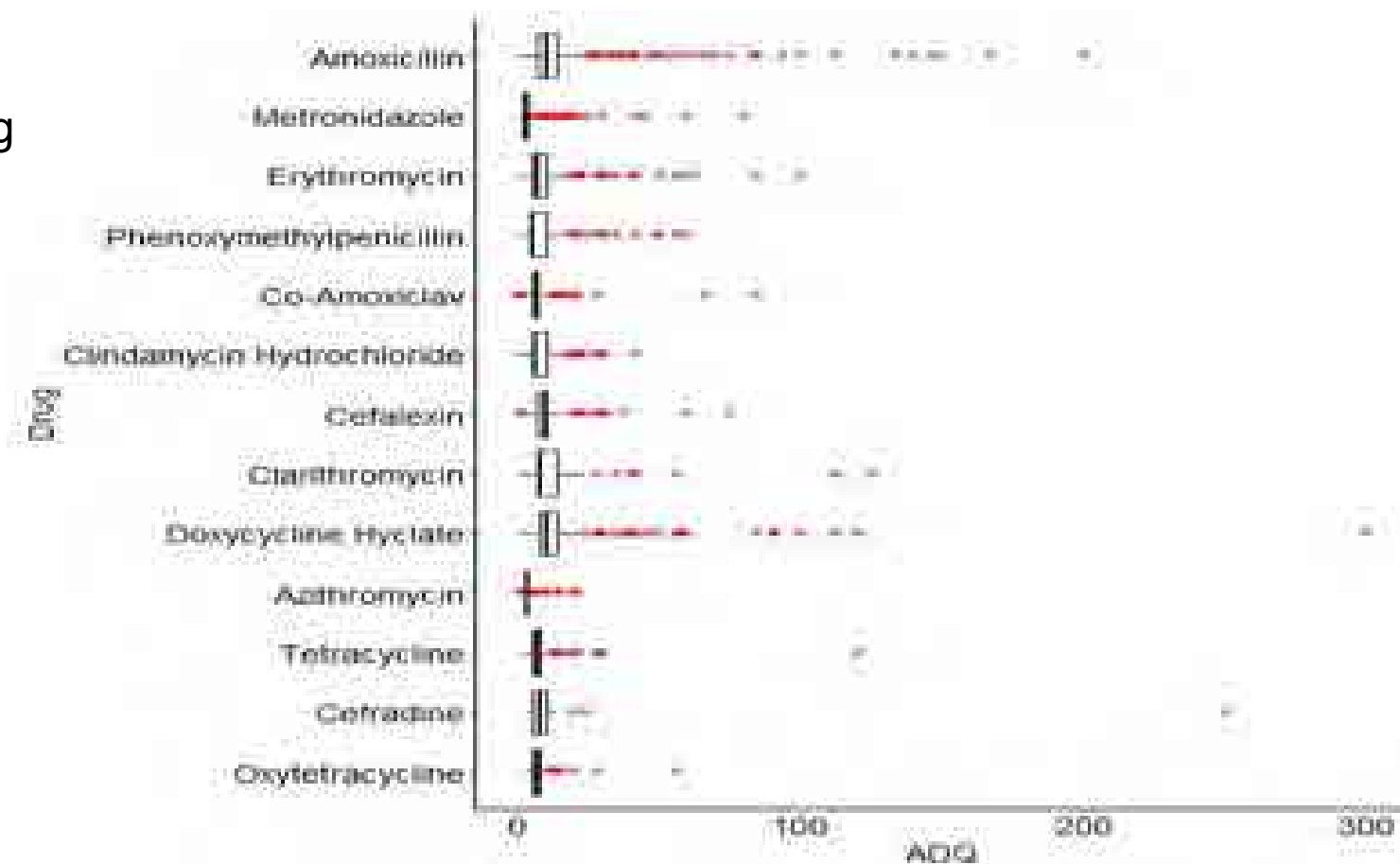
Dental antibiotic prescribing

We found:

- There were 1.7 million antibacterial items prescribed by dentists between April and September 2015.

- Accounts for two-thirds of all dental prescribing and 9% of all antibacterial prescribing over the period.

- Amoxicillin 500mg is the most commonly prescribed by far, accounting for 47% of all antibacterial items prescribed by dentists.

Dental antibiotic prescribing

- There are instances where high quantities of antibacterial drugs are being prescribed and where drugs are being prescribed in higher than recommended doses.

- In other cases, there is evidence to suggest that hand written prescriptions and lack of clarity regarding the quantity being prescribed, is leading to error in the quantity reimbursed.

CCGs who have met/not met target for antibiotic prescribing

- Recent estimates show that antibiotic prescribing has reduced by over **7%** following the impact of our work
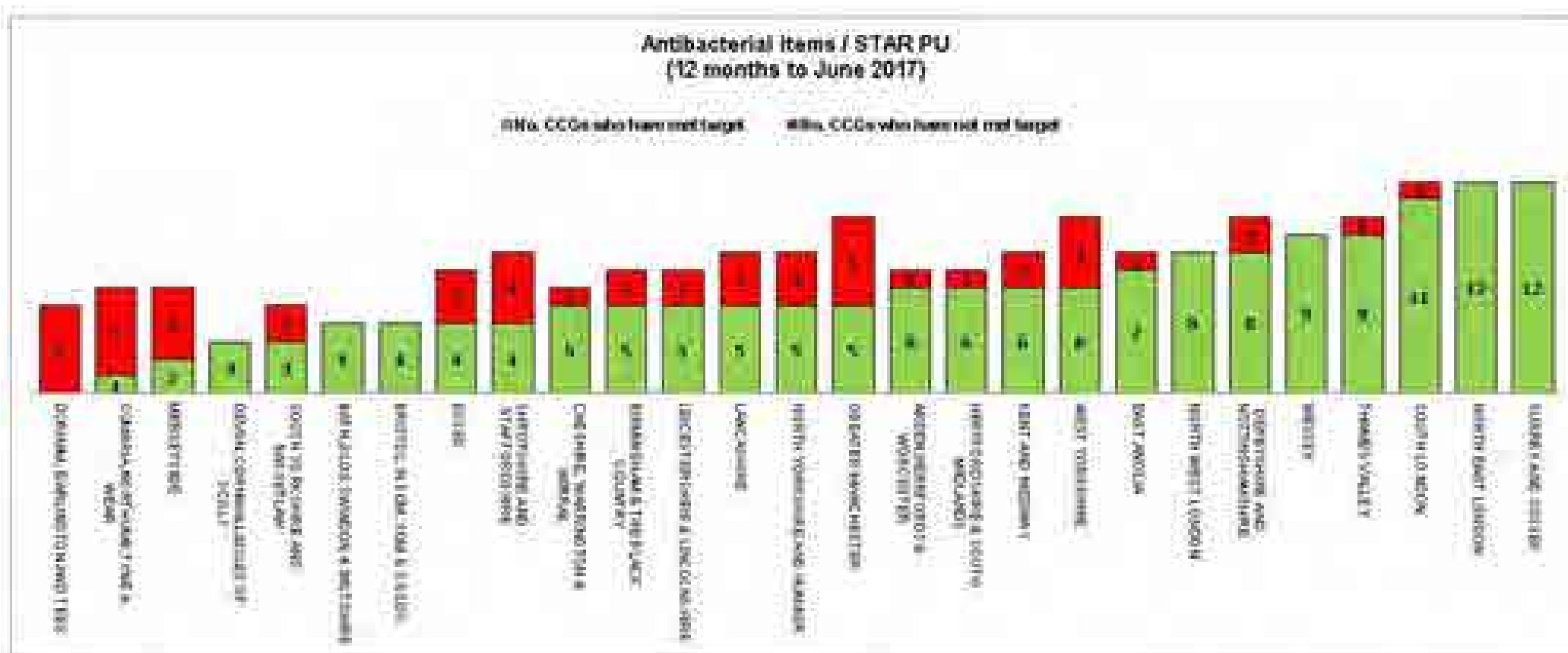
PolyPharmacy through the Cloud

We wanted to provide:

- insight into prescribing of multiple medicines for individual patients in primary care (PolyPharmacy).
- potential metrics to show the variation of Polypharmacy across England to help CCGs and others to target their work plans to address PolyPharmacy.

We wanted to show:

- Reducing the inappropriate use of multiple medicinal items by an individual will reduce:
  - the risk of harmful interaction of drugs on individual patients
  - spend of ineffective or harmful prescribing
  - hospital admissions for adverse reactions to medicines that could be avoided

We developed:

- a data warehouse to hold all our data in one place
- a PolyPharmacy dashboard using OBIEE

ePACT 2 delivered through BICs

Feedback #ePACT2

Off out to practice in a bit to talk about this year's #AMS task for GPs. Printed some of the #ePACT2 dashboard to illustrate. Very cool

Oh wow, #ePACT2 is seriously powerful. Whole quarter's data for 3 CCGs and doesn't blink. Presentation level too

Love #ePACT2, brilliant system, it makes compiling and manipulating data so much easier.

#ePACT2 is definitely going to be a game changer. Especially the #polypharmacy dashboard. Very cool stuff

NHSBSA CEO @NHSBSA_CEO · 12 Sep
Great to be nominated in enhancing care by sharing data and information category #ePact2

HSJ Awards @HSJ_Awards
The shortlist for the 2017 #HSJAwards in partnership with @dePoelHC has been announced - find out who's on it: bit.ly/2gV3d62

As Gartner says…..

- Getting started with advanced analytics is as much about changing mind-sets and culture as it is about acquiring tools and skills, according to Gartner, Inc.

- Failure to make these changes can be fatal to success.

- Gartner predicts that, through 2017, **60 percent** of big data projects will fail to go beyond piloting and experimentation, and will be abandoned.

- "Many business intelligence (BI) and analytics leaders are unsure how to get started with advanced analytics, and many organizations feel they must make a significant investment in new tools and skills," said Lisa Kart, research director at Gartner.

- So what have we learned?

Gartner

What have we learned?

- Data governance
- Track your recommendations
- Keep a portfolio of your work
- Be relevant and visible to your organisation
- Brainstorm all the things you are going to do before you produce the business case
- Do the easy stuff first
- Be prepared for recruitment to take a long time
- Employ statisticians as well as data scientists
- Use Universities to deliver your statistics and coding training

Since we started in 2014

- We have identified potential savings of:
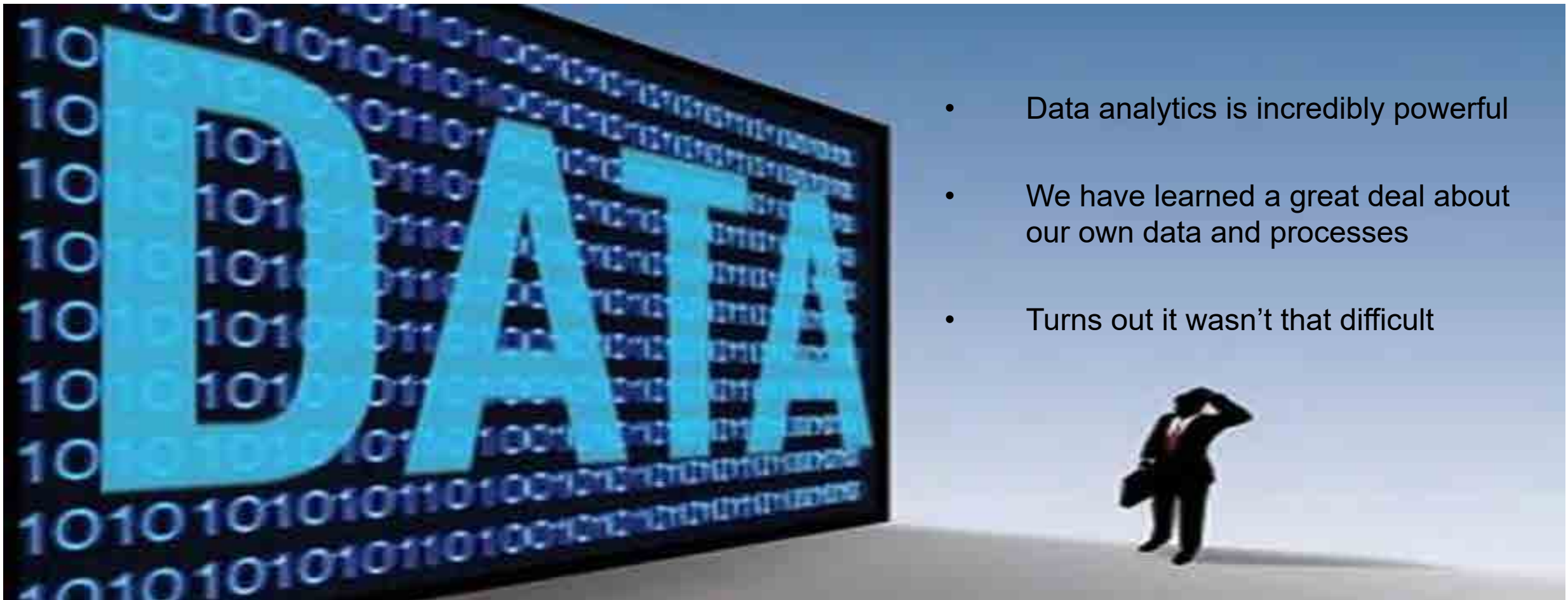
£835 million   **OR**   **$1,134 million**

In conclusion

- Data analytics is incredibly powerful

- We have learned a great deal about our own data and processes

- Turns out it wasn't that difficult