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

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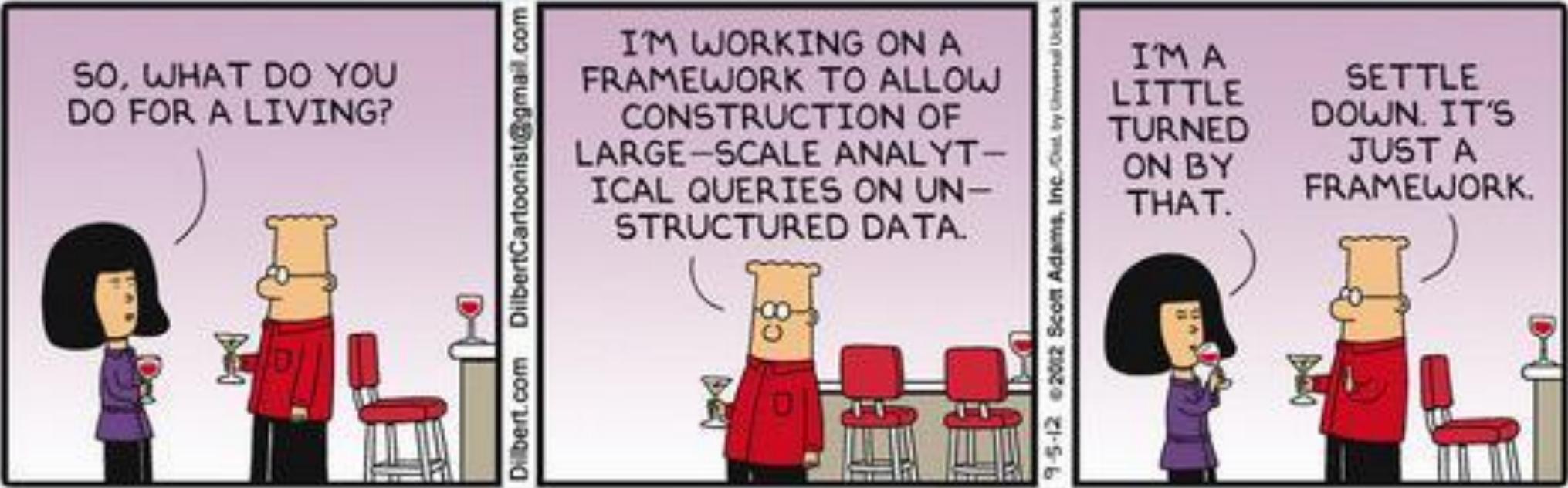
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**NHS**

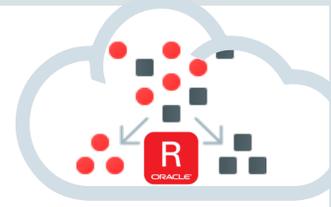
Business Services Authority

# 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



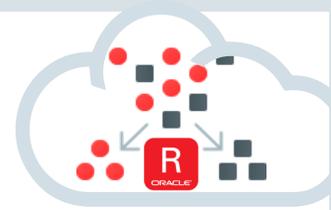
The screenshot shows the Oracle SQL Developer Data Miner interface. It features a central workflow canvas with nodes for 'Supervised Feature Selection', 'Model Building', and 'Likely Buyers'. A 'Performance Overview' window on the right displays metrics for various models, including 'Model 11' with a score of 0.97. A 'Reports' window at the bottom shows a bar chart titled 'AGE BY MARITAL STATUS' with categories for 'MARRIED', 'SINGLE', 'DIVORCED', and 'SEPARATED'.

The screenshot shows the RStudio interface. The top pane contains R code for connecting to an Oracle database and running a query. The bottom-left pane shows the R console output, including a summary of the 'CLAIMS' data frame. The bottom-right pane displays a box plot visualization of the data.



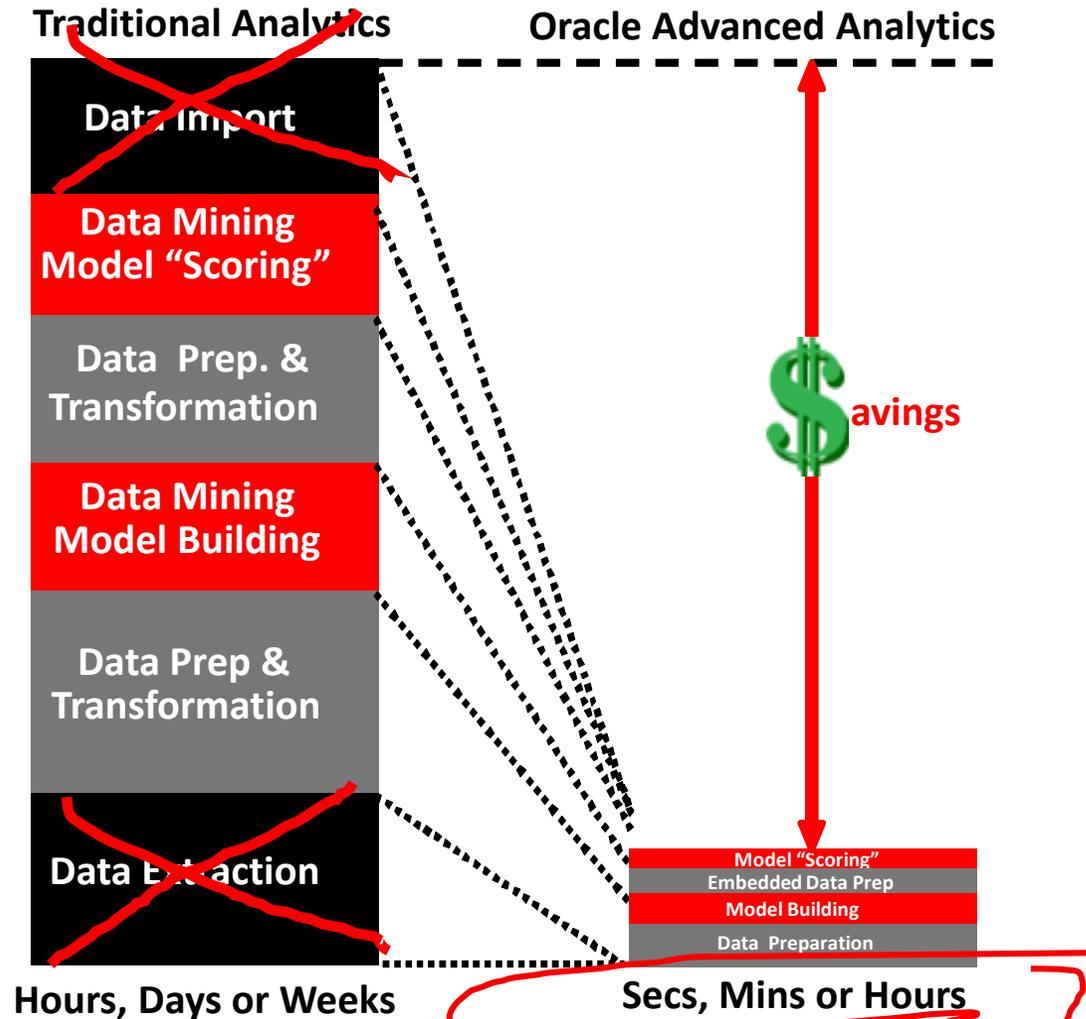
# Oracle's Machine Learning/Advanced Analytics

Fastest Way to Deliver Enterprise-wide Predictive Analytics

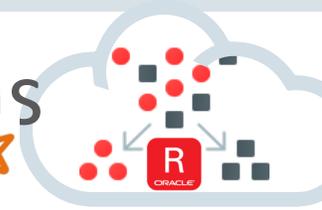


## Major Benefits

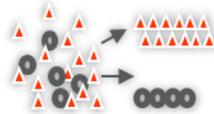
- Data remains in Database & Hadoop
  - Model building and scoring occur in-database
  - Use R packages with data-parallel invocations
- Leverage investment in Oracle IT
  - Eliminate data duplication
  - Eliminate separate analytical servers
- Deliver enterprise-wide applications
  - GUI for ML/Predictive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



# Oracle's Machine Learning & Adv. Analytics Algorithms

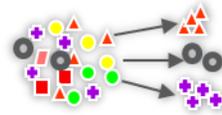


## CLASSIFICATION



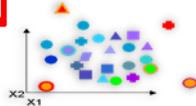
- Naïve Bayes
- Logistic Regression (GLM)
- Decision Tree
- Random Forest
- Neural Network
- Support Vector Machine

## CLUSTERING



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

## ANOMALY DETECTION



- One-Class SVM

## TIME SERIES

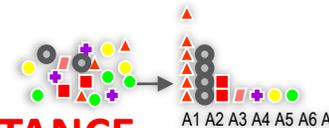
- Holt-Winters, Regular & Irregular, with and w/o trends & seasonal
- Single, Double Exp Smoothing

## REGRESSION



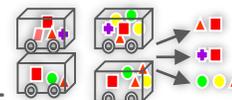
- Linear Model
- Generalized Linear Model
- Support Vector Machine (SVM)
- Stepwise Linear regression
- Neural Network
- LASSO

## 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

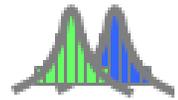
- Principal Comp Analysis (PCA)
- Non-negative Matrix Factorization
- Singular Value Decomposition (SVD)
- Explicit Semantic Analysis (ESA)

## 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



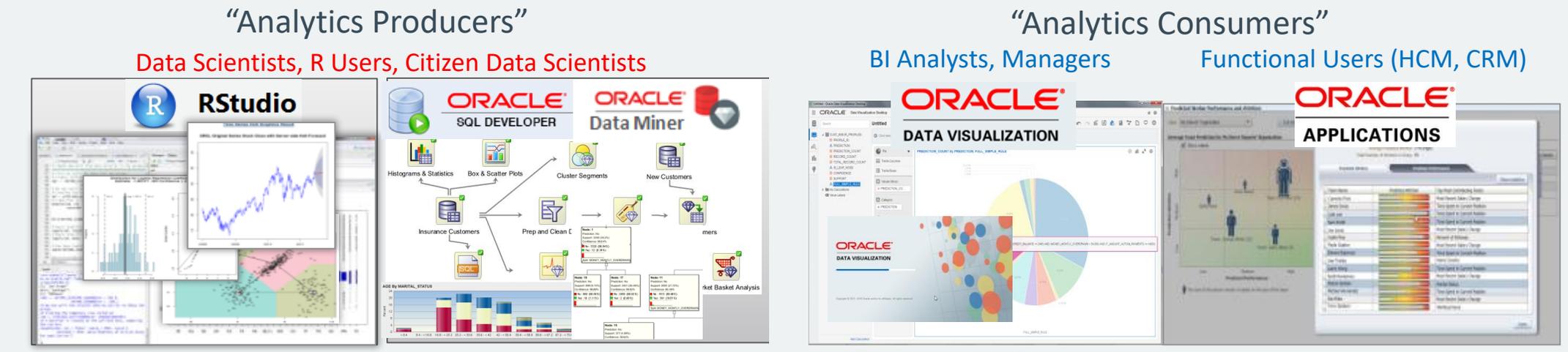
- CRAN R Algorithm Packages through Embedded R Execution
- Spark MLlib algorithm integration

## EXPORTABLE ML MODELS

- C and Java code for deployment

# Oracle's Machine Learning/Advanced Analytics Platforms

## Machine Learning Algorithms Embedded in the Data Management Platforms



**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

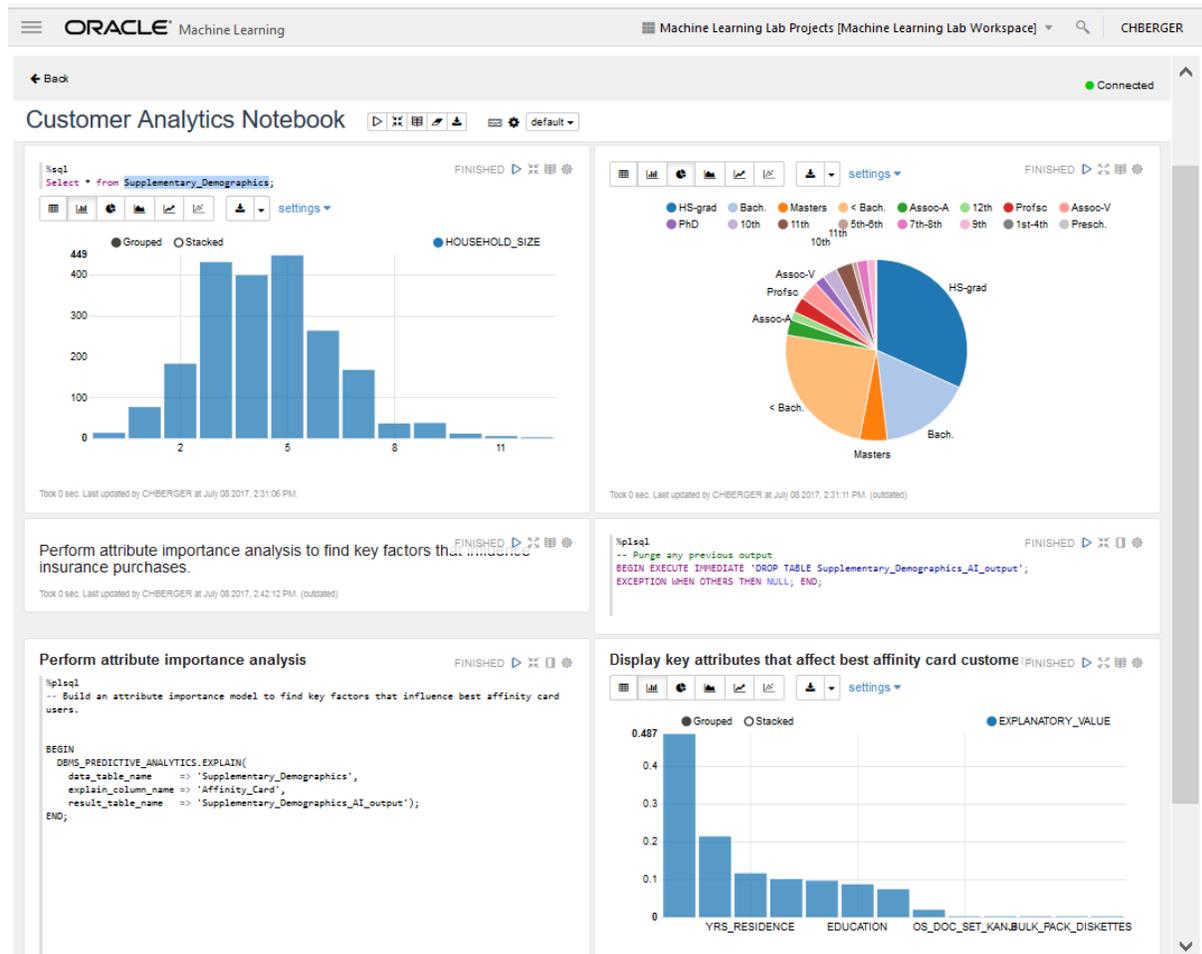
# Oracle Machine Learning

## Machine Learning Notebook for Oracle Autonomous Database Cloud



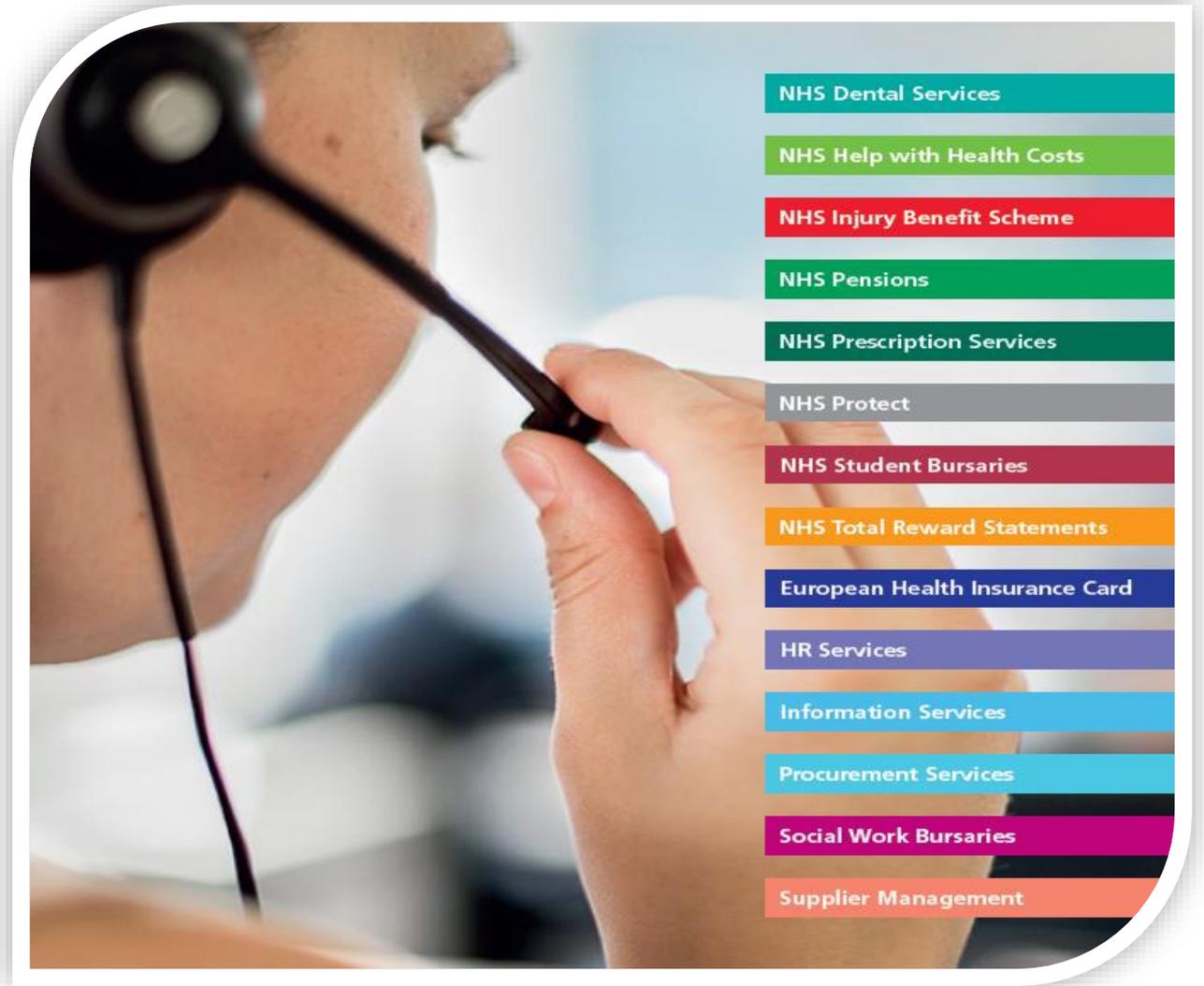
### Key Features

- 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.



## 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



our contact centre handled

**4,095,121**

calls in 2016/17

and **622,037** emails



Over **£34 billion**

the amount of money we handle on behalf of our stakeholders every year

**5.8 million**



EHICs provided to UK residents in 2016/17

**45,119,982**



FP17 dental claim forms processed in 2016/17



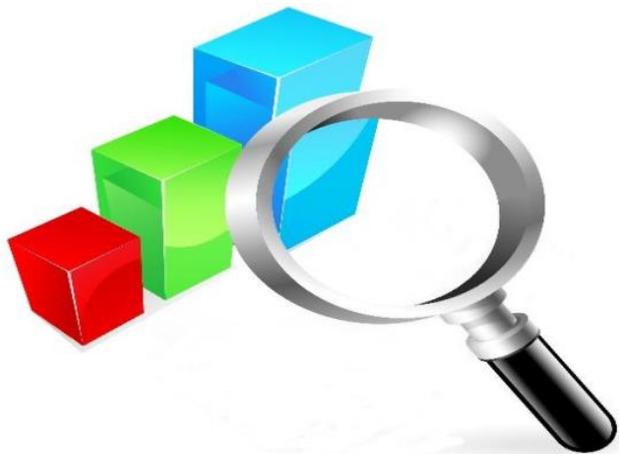
**£581 million**

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?





## 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



## 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:**

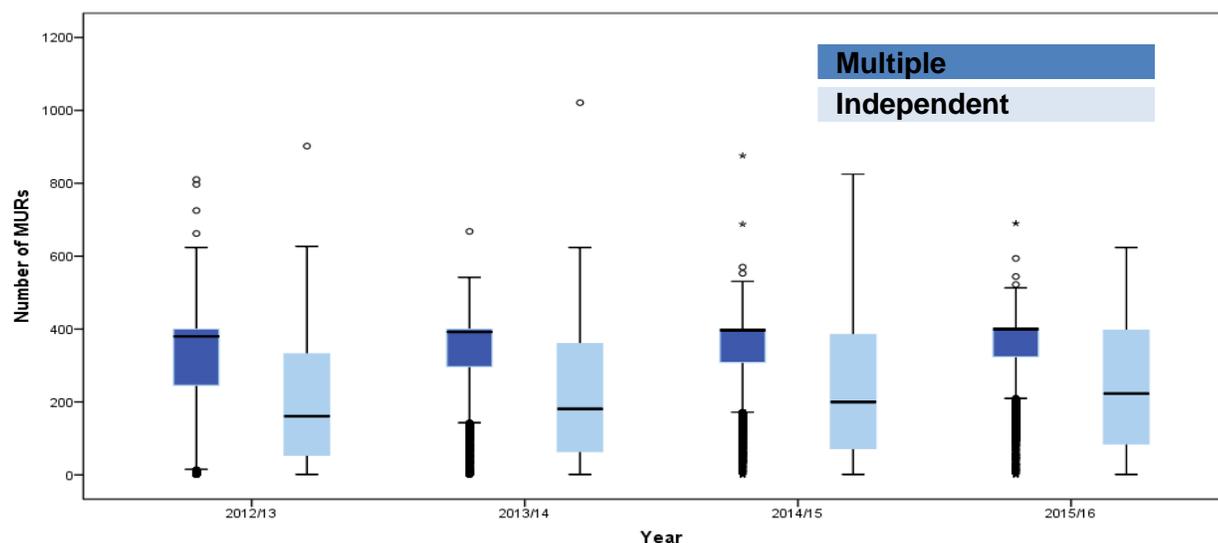
- Identify unusual behaviour which may require further investigation.
- Provide an overview of patterns of pharmacy contractor behaviour for MURs.
- Help inform the work of the NHSBSA Provider Management Team.



## 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:

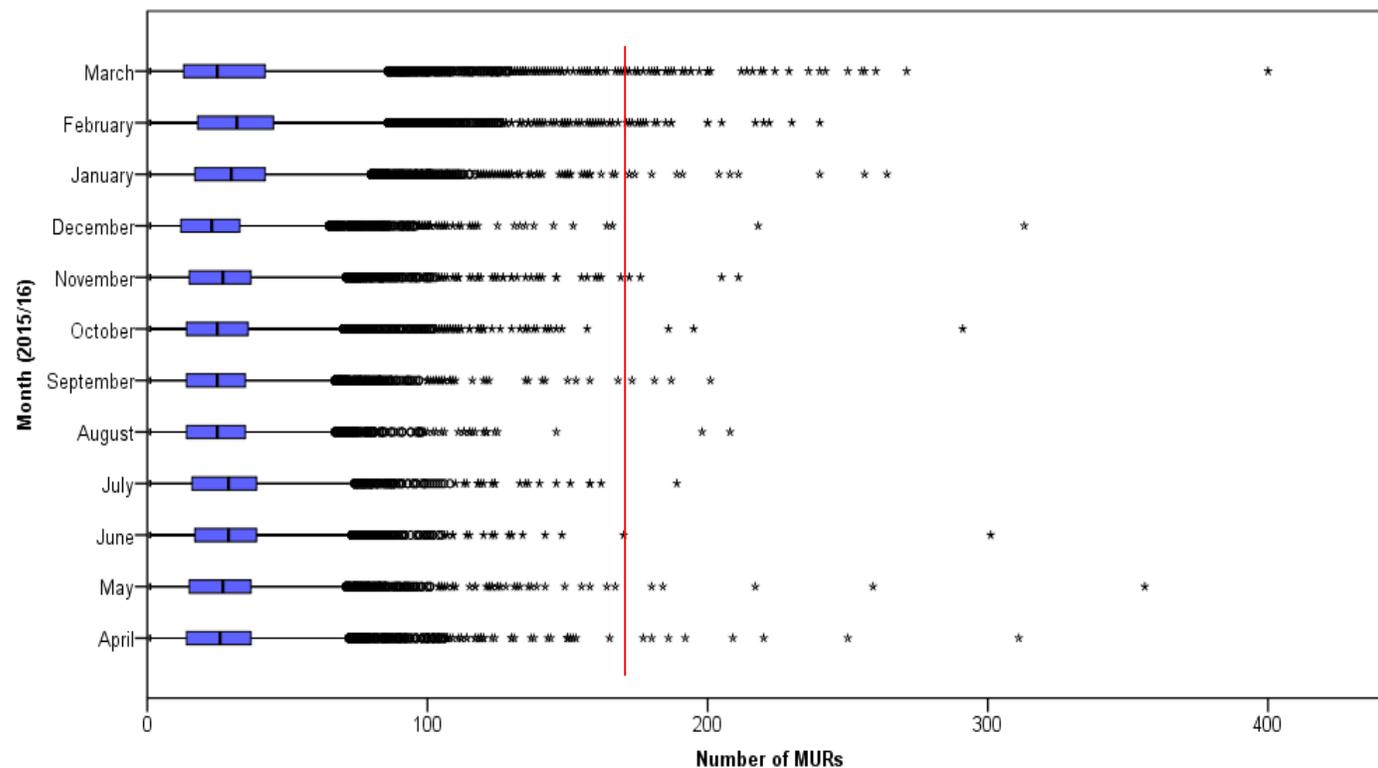
- High number of MURs in a given month.

<b>Median average</b>	<b>27</b>
<b>Extreme value</b>	<b>108+</b>
<b>Maximum</b>	<b>400</b>

- High ratio of MURs to 100 items

<b>Median average</b>	<b>0.4</b>
<b>Maximum</b>	<b>13.7</b>

- 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



**Claiming free treatment?**

- If you claim free NHS dental treatment that you're not entitled to, you could be facing a **£100 penalty charge** – as well as the cost of your treatment.
- Not all benefits entitle you to free treatment.** If you're not sure whether you qualify, please pay for your treatment – you may be able to claim a refund later.
- If you're certain that you qualify for free treatment, please **show proof of your entitlement** to the practice staff before signing the patient declaration.

Please see the 'Claiming free treatment?' factsheet for more information.

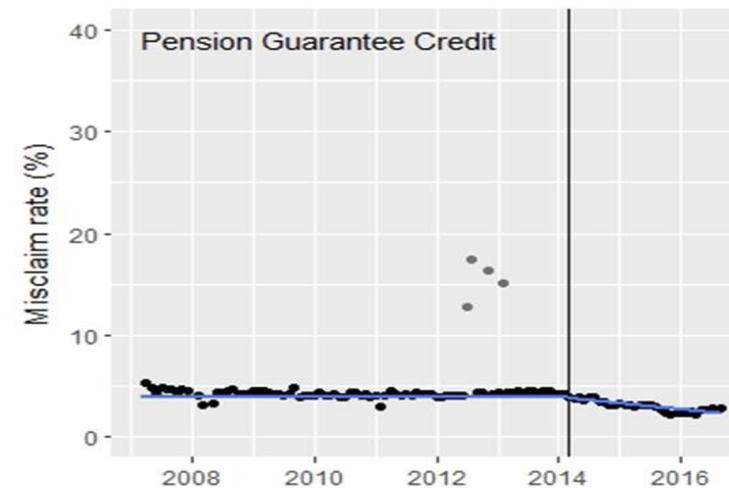
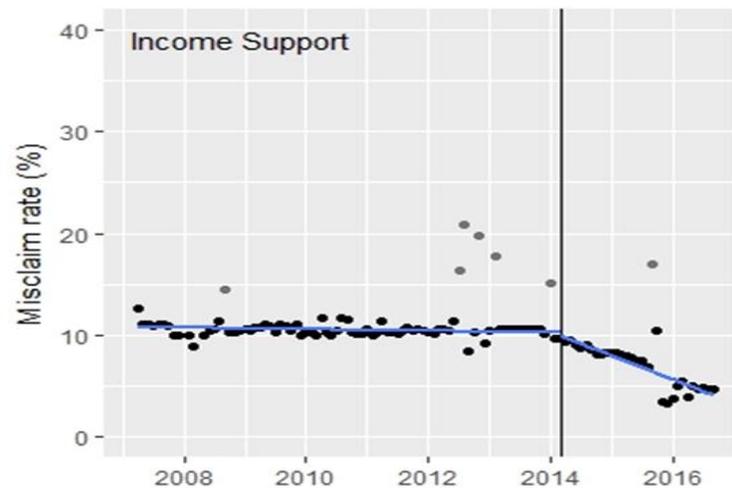
NHS Dental Services  
provided by  **Business Services Authority**

### 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

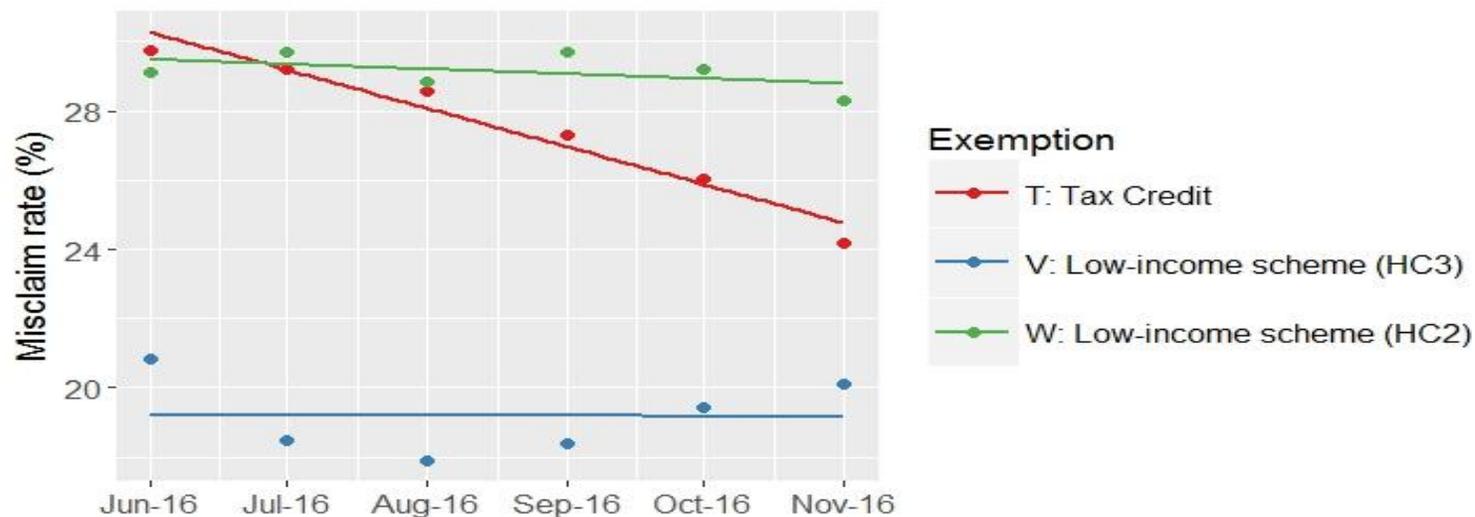
- *Changepoint* modelling showed that the rate of reduction in the misclaim increased statistically significantly in only two of four exemption categories:



- 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 - DEC's

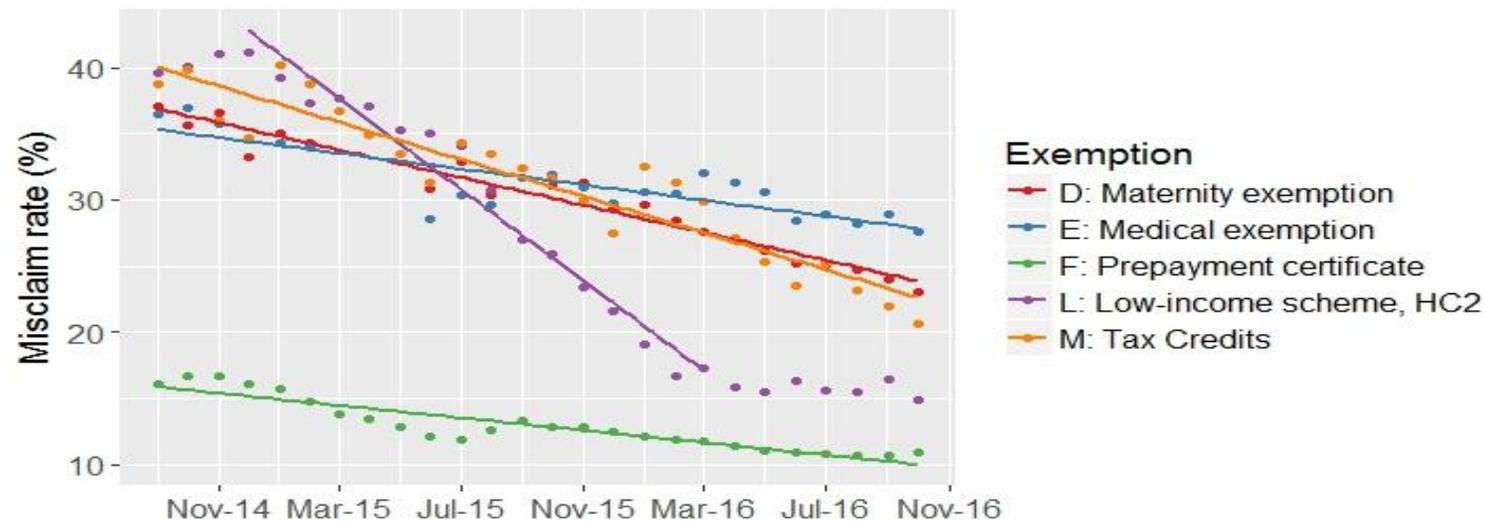
- DEC's is the youngest scheme, running since June 2016. There were no intervention awareness campaigns in DEC's.
- The misclaim rate in DEC's-checked categories declined statistically significantly in only one of three exemption categories: Tax Credit.



- 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

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Health

## Antibiotic resistance now 'global threat', WHO warns

By Pippa Stephens  
Health reporter, BBC News

© 30 April 2014 | Health

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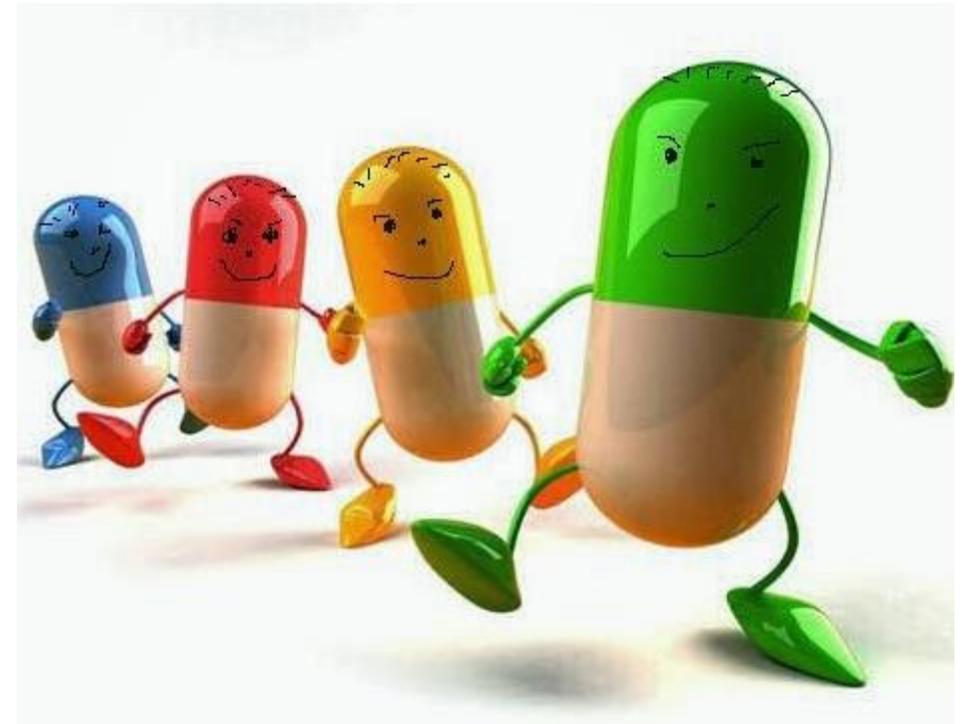


**What we urgently need is a solid global plan of action which provides for the rational use of antibiotics**

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

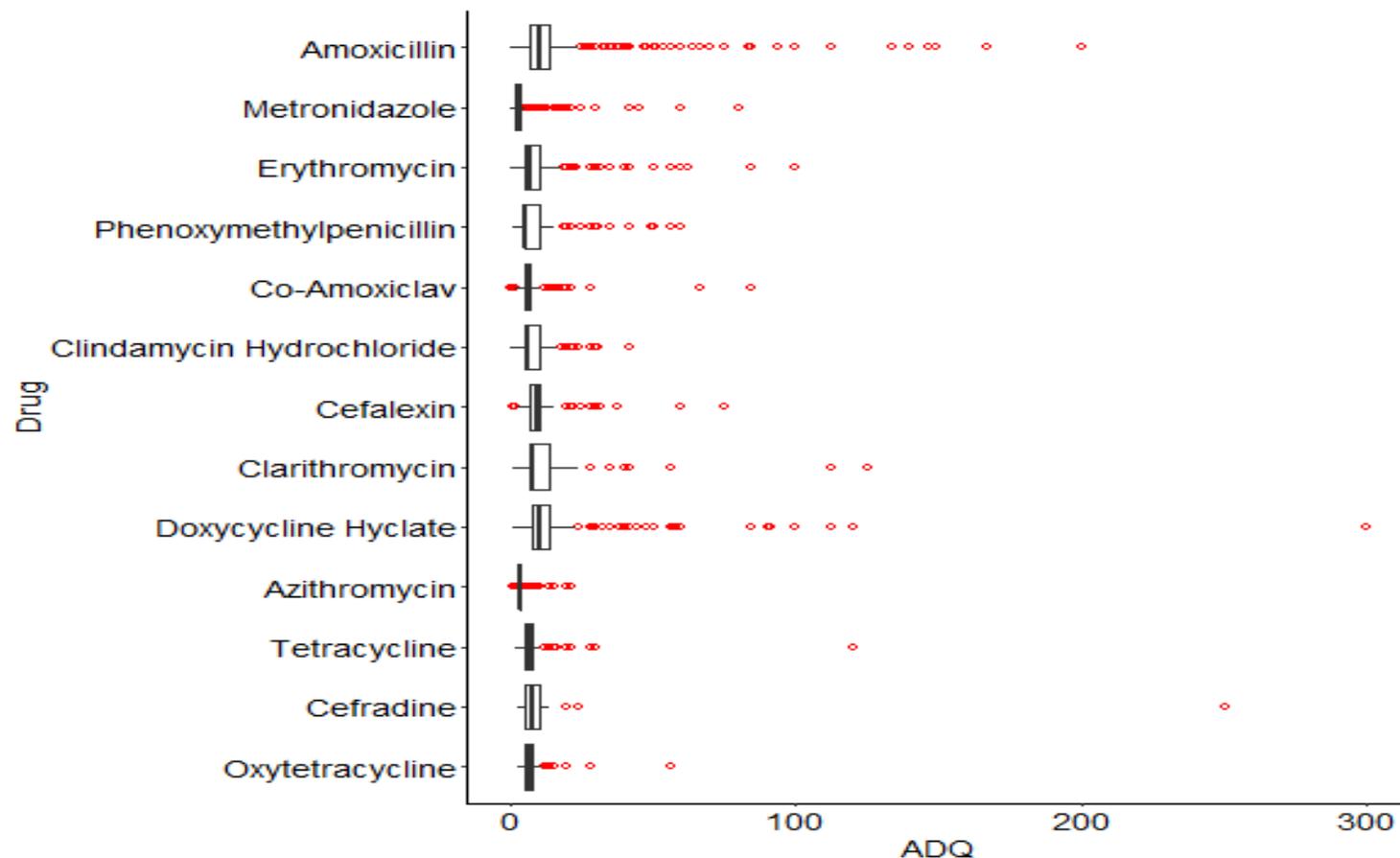
We found:

- 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.



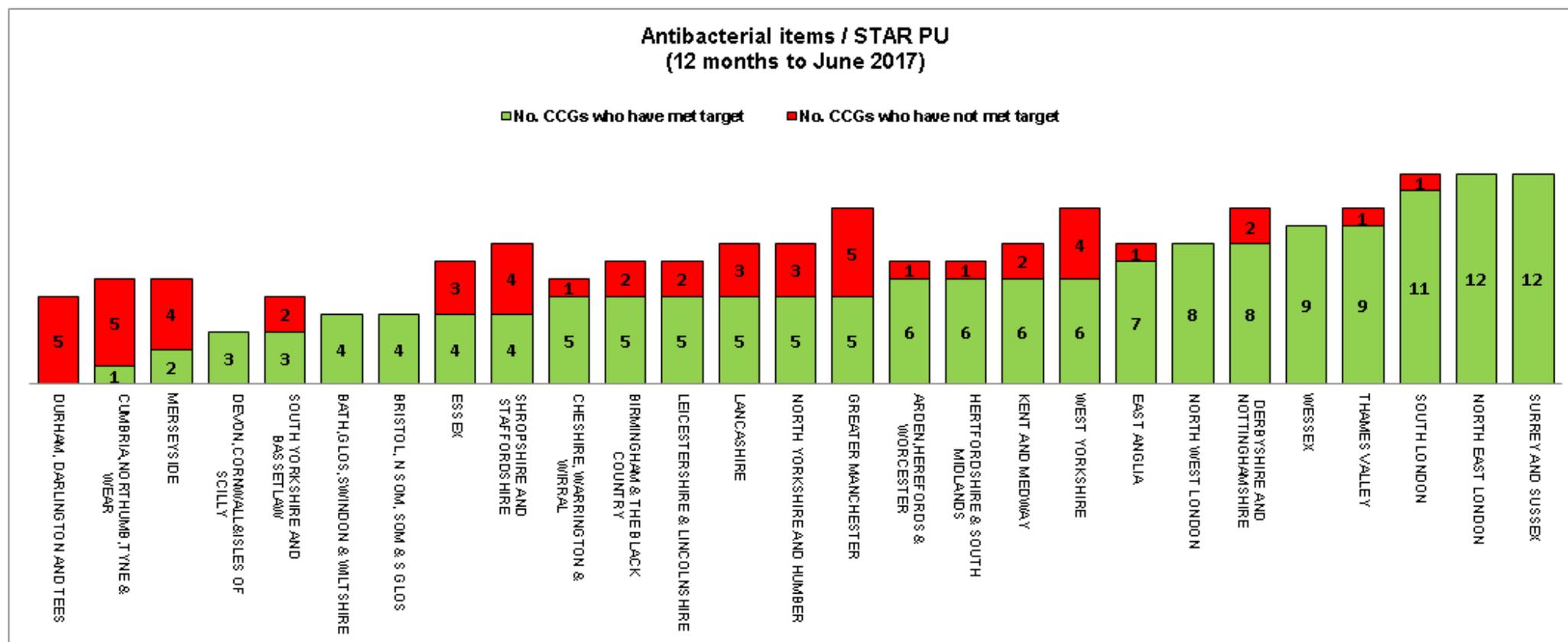
## Dental antibiotic prescribing

- 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

ORACLE Business Intelligence
Search All  Advanced Help Sign Out

Home Catalog Favorites Dashboards New Open Signed In As stbuc

### Polypharmacy Dashboard

Average number of unique medicines per patient

Results for "All CCGs" during "201504"

**Dashboard Criteria Selection**

\* Please select a metric analysis to view: Average number of unique medicines per patient

\* Please select report view: All CCGs

\* Please select month: 201504

\* Please select CCG to view: NHS Airedale, Wharfedale and Craven CCG

**ORGANISATION DETAILS**

**CCG:-** NHS Airedale, Wharfedale and Craven CCG (02N00)

**Area(s):-** West Yorkshire Area (Q52)

**Academic Health Science Network(s):-** Yorkshire & Humber AHSN (AHSN15)

**CCG Cluster(s):-** Pyramid (CLS4)

**PRESCRIBING PRACTICES**

Display: Practice List

NAME	CODE	GP PRACTICE
ADDINGHAM SURGERY	B83620	Y
BINGLEY DERMATOLOGY CLINIC	Y00631	N
CROSSHILLS GROUP PRACTICE	B82020	Y
CURRERGATE CARE HOME	Y02898	N
DERMATOLOGY CLINIC	Y00167	N
DYNELEY HOUSE SURGERY	B82053	Y
FARFIELD GROUP PRACTICE	B83021	Y

\* Select Practice to highlight: ADDINGHAM SURGERY

**METRIC RESULTS FOR 201504**

**NHS Airedale, Wharfedale and Craven CCG** 3.27

**National Total** 3.27 +0.00

**Area Team Total** 3.32 -0.04

**AHSN Total** 3.41 -0.14

**CCG Cluster Total** 3.19 +0.08

**ALL CCGS NATIONALLY**

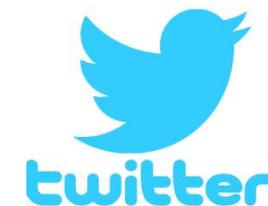
Display: Chart

**TREND OVER TIME FOR: NHS Airedale, Wharfedale and Craven CCG**

Display: Chart

## 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](http://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?

## 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