

Institution: University of Nottingham		
Unit of Assessment: 2 – Public Health, Health Services and Primary Care		
Title of case study: Development and implementation of QPrediction risk tools for predicting absolute risks of disease		
Period when the underpinning research was undertaken: 2007-2017		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Carol Coupland	Professor of Medical Statistics in Primary Care	1990-current
Julia Hippisley-Cox	Professor of Clinical Epidemiology and General Practice	1995-2019
Period when the claimed impact occurred: August 2013 to December 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact		
<p>The QPrediction tools are a set of validated risk prediction tools for identifying individuals at increased risk of conditions such as cardiovascular disease, diabetes, fracture or of having a currently undiagnosed cancer. High risk individuals can then be reviewed for treatments and interventions to reduce risk, or referred for potential earlier diagnosis. The tools have been extensively integrated into clinical practice by incorporation into NHS computer systems, including the major UK GP clinical system (EMIS) used in more than 55% of GP practices nationally, and covering a population in excess of 30,000,000 people. The tools are also recommended in 5 NICE guidelines. The cardiovascular risk tool (QRisk) is used in NHS Health Checks, estimated to prevent approximately 300 premature deaths and result in an additional 1,000 people free of cardiovascular disease, dementia, and lung cancer at age 80 years in England each year. QRisk has extensive public reach through initiatives supporting people to make lifestyle changes to reduce cardiovascular risk, such as the lifetime version of QRisk on the NHS One You website, which has been completed by over 1,200,000 people.</p>		
2. Underpinning research		
<p>The QPrediction risk tools are a novel set of validated risk prediction tools designed to estimate absolute risks for individuals of future outcomes such as cardiovascular disease, cancer, stroke, diabetes and fracture or an individual's risk of having an existing undiagnosed disease, such as cancer. The overarching aim of the research has been to develop risk tools in large representative UK populations incorporating contemporaneous information on deprivation, ethnic group and specific clinical risk factors so that valid tools are available to identify high risk people most likely to benefit from treatments and interventions, leading to improved clinical outcomes and more effective targeting of resources.</p> <p>The underpinning research involved using statistical modelling to derive clinical risk algorithms using routinely recorded electronic health data on patients' characteristics, symptoms and risk factors in the QResearch database. The QResearch database was founded by Julia Hippisley-Cox in 2002 and contains primary care data linked to hospital, mortality and cancer records; it is one of the largest such databases in the UK and worldwide. The research to develop and validate the algorithms was undertaken by Julia Hippisley-Cox and Carol Coupland between 2007 and 2017.</p>		

The first algorithm developed in 2007 was the QRisk tool, designed to estimate cardiovascular risk over 10 years. Prior to this, the Framingham score, developed from a comparatively small cohort in the US, was used to assess cardiovascular risk in the UK and target high risk individuals for treatment. The original QRisk model has been updated to account for time trends and include additional risk factors. QRisk2 (reference 1) was published in 2008, and in 2017, we published a major update - QRisk3 (www.qrisk.org/three/) (reference 2). QRisk3 is the first cardiovascular risk algorithm to include important risk factors such as serious mental illness, migraine, atypical antipsychotics, corticosteroids and blood pressure variability. A total of 981 general practices across England with 7.89 million patients were used to develop the QRisk3 model and 328 different practices with 2.67 million patients were used to validate the risk scores.

The overarching **QPrediction** set of risk tools comprises several other risk prediction tools including the following:

- **QStroke** (www.qstroke.org). QStroke (reference 3) predicts 10-year absolute risk of stroke to identify high risk patients for whom stroke prevention measures, such as anticoagulation, are likely to be beneficial.
- **QFracture** (www.qfracture.org). QFracture was originally published in 2009 and was updated with additional predictor variables and an extended age range in 2012 (reference 4). It predicts the 10-year risk of having a fragility fracture of the hip, spine, wrist or shoulder so that high risk patients can have interventions to reduce this risk
- **QCancer** (www.qcancer.org). This estimates the risk of a patient having an existing but as yet undiagnosed cancer based on symptoms and risk factors for 12 different types of cancer in men and women (references 5, 6). The tool was developed to help GPs identify patients at increased risk of having cancer for referral for investigations, with the intention of aiding earlier diagnosis. Separate cancer risk scores have been developed to estimate cancer risks over 10 years (reference 7).
- **QDiabetes** (www.qdiabetes.org). The first QDiabetes model was published in 2009, and a new version incorporating additional predictor variables and blood test results was published in 2017 (reference 8). It predicts the 10 year risk of developing type 2 diabetes so that high risk patients can receive interventions to lower their risk.
- **QAdmissions** (www.qadmissions.org) identifies patients at high risk of unplanned hospital admission so that care packages can be put in place to reduce hospital admissions (reference 9).
- **QRisk lifetime** (<https://qrisk.org/lifetime/>) predicts lifetime risk of developing cardiovascular disease to help inform prevention strategies and lifestyle changes (reference 10).

3. References to the research

Key publications for some of the individual algorithms are:

1. **Hippisley-Cox J, Coupland C, Vinogradova Y**, Robson J, Minhas R, Sheikh A, Brindle P. Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2. *BMJ* 2008; 336:1475. DOI: 10.1136/bmj.39609.449676.25
2. **Hippisley-Cox J, Coupland C**, Brindle P. Development and validation of QRISK3 risk prediction algorithms to estimate future risk of cardiovascular disease: prospective cohort study. *BMJ* 2017;357:j2099. DOI: 10.1136/bmj.j2099
3. **Hippisley-Cox J, Coupland C**, Brindle P. Derivation and validation of QStroke score for predicting risk of ischaemic stroke in primary care and comparison with other risk scores: a prospective open cohort study. *BMJ* 2013;346:f2573. DOI: 10.1136/bmj.f2573
4. **Hippisley-Cox J, Coupland C**. Derivation and validation of updated QFracture algorithm to predict risk of osteoporotic fracture in primary care in the United Kingdom: prospective open cohort study. *BMJ* 2012;344:e3427. DOI: 10.1136/bmj.e3427

5. **Hippisley-Cox J, Coupland C.** Symptoms and risk factors to identify men with suspected cancer in primary care: derivation and validation of an algorithm. *British Journal of General Practice* 2013;63:e1-e10. DOI: 10.3399/bjgp13X660724
6. **Hippisley-Cox J, Coupland C.** Symptoms and risk factors to identify women with suspected cancer in primary care: derivation and validation of an algorithm. *British Journal of General Practice* 2013;63:e11-e21. DOI: 10.3399/bjgp13X660733
7. **Hippisley-Cox J, Coupland C.** Development and validation of risk prediction algorithms to estimate future risk of common cancers in men and women: prospective cohort study. *BMJ Open* 2015;5:e007825. DOI: 10.1136/bmjopen-2015-007825
8. **Hippisley-Cox J, Coupland C.** Development and validation of QDiabetes-2018 risk prediction algorithm to estimate future risk of type 2 diabetes: cohort study. *BMJ* 2017;359:j5019. DOI: 10.1136/bmj.j5019
9. **Hippisley-Cox J, Coupland C.** Predicting risk of emergency admission to hospital using primary care data: derivation and validation of QAdmissions score. *BMJ Open* 2013;3:e003482. DOI: 10.1136/bmjopen-2013-003482
10. **Hippisley-Cox J, Coupland C, Robson J, Brindle PM.** Derivation, validation and evaluation of a new QRISK model to estimate lifetime risk of cardiovascular disease: cohort study using QResearch database. *BMJ* 2010;341:c6624 DOI: 10.1136/bmj.c6624

Awards

Publication 2 above was awarded **RCGP research paper of the year 2017** (Category 2: CVD, Renal, Respiratory, Oral, ENT & Ophthalmology). <https://bjgp.org/content/68/676/536>

4. Details of the impact

National health policy and use in clinical practice

Inclusion in national guidelines

Several of the tools have been recommended for use in clinical practice in NICE guidance (**Source 1**). In 2014 QRisk2 was recommended as the sole risk tool of choice to assess cardiovascular disease risk in the NICE Cardiovascular disease guideline [CG181, 2014] (**Source 1.1**). New recommendations in the updated NICE guideline on hypertension in adults [NG136, 2019] (**Source 1.2**) include use of QRisk scores to inform antihypertensive treatment.

QDiabetes is recommended in NICE guidance (**Source 1.3**) on the prevention of type 2 diabetes [PH38, 2017]. The 2016 NICE guideline on multimorbidity [NG56, 2016] recommends using QAdmissions to identify adults with multimorbidity who are at risk of adverse events such as unplanned hospital admission or admission to care homes (**Source 1.4**). Other recommendations in guidelines include QFracture in NICE guidance [CG146, 2017] (**Source 1.5**) and the Scottish Intercollegiate Guideline Network (SIGN) national clinical guideline on osteoporosis management [SIGN 142; 2015] which has a key recommendation that to quantify fracture risk “*Fracture-risk assessment should be carried out, preferably using QFracture*”. This assessment is then used to target pharmacological, and non-pharmacological treatments to reduce fracture risk (**Source 2**).

Implementation into clinical computer systems

All of the tools are publicly accessible, and most including QRisk2, QDiabetes, QFracture, QCancer, QStroke and QAdmissions have been integrated into the major UK GP clinical system (EMIS) (**Source 3.1**) which supplies computer systems to over 55% of GP practices in England, covering a population in excess of 30,000,000 people (**Source 3.2**).

The tools are also available as free open-source software (see links in section 2) to facilitate transparency, further research and use internationally. Google analytics show that since 2014, there have been over 2,000,000 hits to the QPrediction websites, with hits from most countries worldwide (**Source 4**).

Some tools have also been implemented in other GP clinical systems and by other suppliers including occupational health, pharmacy, secondary care and the private sector. For example, Wellpoint health kiosks which use QRisk3 are currently deployed in many occupational settings throughout the UK including the Ministry of Defence, Department of Health, DVLA, Kent County Council, Scottish Power, Scottish Water (**Source 5**).

Use and recommendations in clinical practice

QRisk is integral to policy guidance and practice such as currently being used in NHS Health checks, a national programme offering health checks to adults in England aged 40 to 74 (**Source 6**). It is designed to help prevent and detect early signs of heart disease, kidney disease, Type 2 diabetes and dementia and incorporates assessment of cardiovascular disease risk. Over 6,000,000 people in England received an NHS Health check between 2013 and 2017 (**Source 6, p5**).

The QRisk lifetime version of the tool is used by Public Health England on its NHS One You website (**Source 7**) to estimate heart age, with the aim of increasing awareness of heart health and acting as an incentive to make simple lifestyle changes. This was widely publicised by Public Health England in September 2018. By June 2017 the website had been viewed by approximately 2,900,000 people, with approximately 1,200,000 completions of the tool (**Source 8**).

QCancer is designed to prompt GPs to think about diagnosis of cancer and refer high risk patients to hospital sooner, with the aim of patients being diagnosed at an earlier stage when there are more treatment options likely to improve survival. The QCancer tool is recommended by Cancer Research UK, and its use is being facilitated by Macmillan which has successfully piloted the tool and is promoting its use as a cancer decision support tool in clinical practice across the country (**Source 9**).

Evaluations and evidence of benefits

In the NHS Health Check prevention programme in England people with a 10-year QRisk score of 10% or more are considered to be high risk of cardiovascular disease and are offered lifestyle advice, behaviour change support and considered for statin treatment. A microsimulation study by researchers at the University of Cambridge (**Source 10**) estimated that in England each year the programme is preventing approximately 300 premature deaths (before age 80) and resulting in an additional 1,000 people being free of cardiovascular disease, dementia, and lung cancer at age 80 years. The study also found that the programme has a greater absolute impact on health for people living in the most deprived areas, accordingly the programme as a whole is reducing health inequalities.

An independent study in the Lancet (**Source 11**) compared four strategies for determining eligibility for blood pressure treatment, including one based solely on blood pressure values, two strategies based on NICE hypertension guidelines (2011 and 2019) which consider a combination of QRisk2 scores, blood pressure measurements and medical conditions, and one based on using a threshold for QRisk2 scores alone. The study estimated that 322,921 cardiovascular events would be avoided in the UK over 10 years using QRisk2 scores alone to determine eligibility for blood pressure-lowering treatment compared with 233,152 events based on the 2011 NICE guideline, and 270,233 for the 2019 NICE guideline. It concluded that a risk-based strategy using QRisk2 scores was the most efficient strategy, and could prevent over a third more cardiovascular disease events than the 2011 NICE guideline and a fifth more than the 2019 NICE guideline.

A Public Health England feasibility review in 2016 of tools for identifying people at high risk of developing diabetes in NHS Health Checks found QDiabetes to be more accurate than the method used in NHS Health Checks at the time based on body mass index and blood pressure (**Source 12**). For example, the sensitivity was 66% using QDiabetes compared with 57% (**Source 12, p6**). QDiabetes is now one of the validated risk assessment tools for diabetes included in the NHS Health Check programme (**Source 6**).

An international guideline panel has proposed using QCancer colorectal cancer scores to identify people with increased risk (15-year risk above 3%) for colorectal cancer screening rather than a strategy of screening all people aged 50 to 79 years (**Source 13**). This recommendation was based on a modelling study and a linked systematic review of the benefits, harms, and burdens of colorectal screening. The modelling study predicted that in people with a QCancer risk score of 3% an estimated 5 to 6 colorectal cancer deaths would be prevented over 15 years per 1000 people screened. The panel proposed QCancer as it is “one of the best performing models for both men and women”, and because it has been externally validated, has good calibration, is available as an online calculator and can predict risk over a 15-year time horizon (**Source 13, p13**).

5. Sources to corroborate the impact

- S1 Inclusion of tools in NICE guidance (grouped source of evidence). Includes:
 S1.1 [Clinical guideline \[CG181, 2014\]](#) pages 7, 10, 19, 20, 28, 33, 38;
 S1.2 [NICE guideline \[NG136, 2019\]](#) pages 8, 26;
 S1.3 [NICE public health guideline \[PH38, 2017\]](#) page 35;
 S1.4 [NICE guideline \[NG56, 2016\]](#) pages 6, 23;
 S1.5 [Clinical guideline \[CG146, 2017\]](#) pages 5, 7, 9-12.
- S2 Scottish Intercollegiate Guidelines Network (SIGN). Management of osteoporosis and the prevention of fragility fractures. A national clinical guideline. Edinburgh: SIGN publication no. 142; first published March 2015, revised edition published June 2020. [Pages 5, 14, 25, 32-35, 37, 102, 116, 117, 122, 125]. [Weblink](#)
- S3 S3.1 EMIS clinical calculators - clinical calculators integrated with EMIS Web
 S3.2 Kontopantelis E, et al. Spatial distribution of clinical computer systems in primary care in England in 2016 and implications for primary care electronic medical record databases: a cross-sectional population study. *BMJ Open* 2018;8:e020738. [Page 3]. [Weblink](#)
- S4 Analytics for hits on QPrediction tool websites. [Pages 1-4 in pdf].
- S5 Wellpoint health kiosks. [Weblink](#)
Select CVD risk tab and Heart Age tab to see screens showing QRisk3 is used. Scroll down to see Clients. [Pages 3-5, 9 in pdf].
- S6 NHS Health Check Best practice guidance. Public Health England, October 2017. [Pages 5, 6, 17, 18, 21, 25, 43, 72]. [Weblink](#)
- S7 Heart age tool. [Weblink](#)
For details showing QRisk2 – click on “Find out more about our partners and this tool”, see sections on “NHS Heart Age” and “Risk Model”. [Pages 3 and 4 in pdf].
- S8 Public Health England. Action plan for cardiovascular disease prevention, 2017 to 2018. London: Public Health England, 2017. [Pages 5, 13, 14 in pdf]. [Weblink](#)
- S9 The Macmillan Cancer Decision Support (CDS) tool. [Pages 3, 6-11, 13 in pdf].
- S10 Mytton OT, et al. The current and potential health benefits of the National Health Service Health Check cardiovascular disease prevention programme in England: a microsimulation study. *PLoS Med* 2018; 15: e1002517. DOI: 10.1371/journal.pmed.1002517 [Pages 5-11, 23, 24, 30]. [Weblink](#)
- S11 Herrett E, et al. Eligibility and subsequent burden of cardiovascular disease of four strategies for blood pressure-lowering treatment: a retrospective cohort study. *Lancet* 2019;394:663-71. DOI: 10.1016/S0140-6736(19)31359-5. [Pages 663-671]. [Weblink](#)
- S12 NHS Health Check: Diabetes Filter Consultation. Public Health England. Published: London, September 2016. [Pages 5-11, 13-15 in pdf]. [Weblink](#)
- S13 Helsingen LM, et al. Colorectal cancer screening with faecal immunochemical testing, sigmoidoscopy or colonoscopy: a clinical practice guideline. *BMJ* 2019; 367: i5515 DOI: 10.1136/bmj.i5515 [Pages 2, 13, 16]. [Weblink](#)