

Ergonomic assessment of a community pharmacy-based cardiovascular risk assessment: a new strand to an existing teaching and learning activity

R. Hubbard
School of Pharmacy and Life Sciences
Robert Gordon University

K. Regan
School of Pharmacy and Life Sciences
Robert Gordon University

A. Strath
School of Pharmacy and Life Sciences
Robert Gordon University
a.strath@rgu.ac.uk

H. Vosper
School of Pharmacy and Life Sciences
Robert Gordon University
h.vosper@rgu.ac.uk

Abstract

The science of ergonomics (also known as 'human factors') involves the study of how people interact with the work systems in which they operate. The practice of ergonomics involves applying the theories and methodologies developed through the science to real-life situations, aiming to optimise overall system performance. There has been an increasing drive to develop ergonomic approaches to healthcare, which means that there is a need to include ergonomics teaching within undergraduate healthcare programmes. This paper describes the application of an ergonomics framework to an existing teaching and learning activity on an undergraduate pharmacy course, allowing students to explore the potential risks to safety posed by cardiovascular risk assessment.

Introduction: An ergonomic approach to managing risk in healthcare

"I apologise if my article oversimplifies the complexity of both clinical decision making and human factors. I cannot claim any clinical knowledge, and my understanding of human factors is as a practitioner, not an expert."

In this way, Martin Bromiley – founder and Chair of the Clinical Human Factors Group – opens a commissioned opinion piece published by the Association for Perioperative Practice (2009). More on Martin's history (and how an airline pilot came to be a leading champion of patient safety) can be found in the editorial of this issue of *Communicare*, but this quote clearly articulates the problems facing healthcare practitioners working on the front line. Protecting patients requires staff to recognise potential safety threats and to be able to 'quantify' these risks, in order that resources are appropriately directed to mitigate them effectively. This is far from easy as healthcare scenarios are often incredibly complex, with a single threat associated with multiple risks. Furthermore, the science of patient safety is relatively new, and the evidence-base far from robust, an issue further compromised by a lack of open reporting culture in most healthcare organisations,

which slows the rate of progress (Lawton et al. 2012). The application of ergonomic methodologies to healthcare delivery offers frameworks to support patient safety, something which has been recognised by ergonomics practitioners for many years. However, systematic adoption of such principles has been slow to catch on, and there are a number of reasons for this. Healthcare delivery is complex, involving a great number of stakeholders, as well as multiple hierarchies for decision-making (Hignett et al. 2013). There are other issues that may also explain why healthcare has essentially ignored the human factors developments (and their effective application to other high-risk industries) seen over the last 50 years. Healthcare is one of the industries that often takes the 'bad apple' approach to accident investigation: it is easier to take the view that patients are harmed because of failings of individual practitioners, and that these individuals should be punished. These attitudes are further entrenched by the legal system, which requires that blame be apportioned before damages can be awarded. Patients, and their families and representatives, often (understandably) tend to support this because a sense of closure often requires 'justice to be seen to be done.' It is this that leads to a culture where accidents may only be reported if there is no other option, and there is little or nothing in the way of error reporting and therefore learning opportunities are missed (Leape 2004). Healthcare can also be very tolerant of adverse outcomes: it is different from many other industries in that patient deaths and adverse outcomes are accepted as part of normal operation. Another contributory factor is simply the lack of awareness of alternative ways of managing patient safety, and this is where healthcare educators have an opportunity to make a difference. While developing specific ergonomics module is one option, the systems-based nature of the discipline means that it probably much more appropriate to embed it within existing modules, and this can be challenging.

As with any discipline, the teaching of ergonomics methodologies is much more likely to be effective if students have the opportunity to apply them in situations relevant to their course. This paper discusses how an existing teaching and learning activity could be adapted to provide an opportunity for students to develop skills in ergonomics practice. It focuses on the service delivery aspect of a community pharmacy-based cardiovascular risk assessment but could easily be applied to any clinical activity, real or simulated. To the best of the authors' knowledge, the ergonomic framework described in this paper has not previously been applied to the cardiovascular risk assessment. Consequently, a short pilot study was undertaken by academic staff, giving the researchers a baseline with which to compare the student activity. The results of the pilot study were very interesting, and may be further explored in a future study. For this reason, data from this first part of the work is not presented in any detail, and is used merely to illustrate the usability of the framework as a teaching activity.

The community pharmacy-based cardiovascular risk assessment

Cardiovascular disease (CVD) accounts for more than one-third of UK deaths (Department of Health 2008, 2013), a figure consistent with the global picture (Hourihan et al. 2003; Lalonde et al. 2006; Kaczorowski et al. 2011). Current

thinking is that CVD is best managed as a 'family' of diseases, including coronary heart disease; stroke; hypertension; hypercholesterolemia; heart failure; diabetes; chronic kidney disease; peripheral arterial disease and vascular dementia (Department of Health 2008, 2013). These conditions share a common pathology (atherosclerosis), meaning people present with multiple diseases, linked by common risk factors, modifiable and non-modifiable (**Table 1**).

| Table 1: Risk factors for CVD | |
|--|--|
| Non-modifiable | Modifiable |
| <ul style="list-style-type: none"> • Age • Gender • Ethnicity • Family history (related to genetic factors) • Diabetes (genetic component of) | <ul style="list-style-type: none"> • Plasma cholesterol level • Blood pressure • Extent of overweight or obesity • Smoking or tobacco use • Diet • Level of physical activity • Psychosocial stress • Alcohol consumption • Diabetes (lifestyle component of) |

Health is a devolved issue in the UK (Greer 2009) and although there is high convergence around CVD treatment and prevention, there are strategic differences. The activities described in this paper are based on the management of cardiovascular risk in England, but similar schemes exist throughout the UK, including Scotland (Scottish Government 2009).

There is a quantitative relationship between risk factors and disease incidence (Grundy 1999; Heidenrich et al. 2011). A number of high quality longitudinal studies have allowed this relationship to be mathematically modelled, underpinning 'risk engines' such as QRisk2 which measure individual risk and how it changes following intervention (Kannel 2000; Guzder et al. 2005; Collins and Altman 2010). These engines are driven by algorithms which take into account the risk contribution of the factors listed in **Table 1**.

Targeting population risk is considered to be an effective strategy (Barton et al. 2011): CVD deaths in the UK peaked in the 1970s/80s and recognition of the health and social care impact (Department of Health 1999) led to the 2000 National Service Framework which aimed to reduce mortality by 40%. These targets were achieved, but CVD remains problematic (National Institute for Health and Care Excellence 2014), and further improvement requires health promotion as well as disease prevention (Kaczorowski et al. 2011; Goff et al. 2014). Identifying high-risk individuals and optimising primary care prevention is thought to reduce population risk (Heidenrich et al. 2011; National Institute for Health and Care Excellence

2014), and in England, individual risk is targeted through NHS Health Checks (Department of Health 2008; McNaughton et al. 2011), a screening programme for those aged 40-74.

The Health Check itself involves taking a detailed patient history, measurements of height and weight, and carrying out some simple near-patient testing, including measurement of blood pressure and cholesterol. The patient history attempts to capture all the risk factors in Table 1 that cannot be measured directly, such as ethnicity. During early commissioning, it was intended that the Health Check would be offered through General Practice, but as part of widening access to the check, most commissioning bodies have adopted a multi-pronged approach, offering the check in other venues, including the community pharmacy. GPs remain the central repository for information generated from the Health Check, and are responsible for taking in the lead for follow-up if any disease is identified. The details of the Health Check, and where it fits within the overall cardiovascular risk management strategy can be seen in **Figures 1 and 2** (based on figures provided by the Department of Health; presented in PSNC, 2009). One of the outcomes may be that the client is referred to other services such as smoking cessation, which the pharmacy may also be able to offer. Consequently, cardiovascular risk assessment is seen as being a very relevant activity for pharmacy students to undertake, and it has been successfully used in a Second Year Clinical Pharmacology and Therapeutics module for some years (Brown and Vosper 2013; Buchan et al. 2014). As a discrete service, articulating with other services within an overall risk management system, it also offers an excellent opportunity to apply a systems-based ergonomics framework, allowing students not only to practice applying the methodology, but also offering an opportunity to consider risk recognition and mitigation in everyday situations that they will encounter in practice.

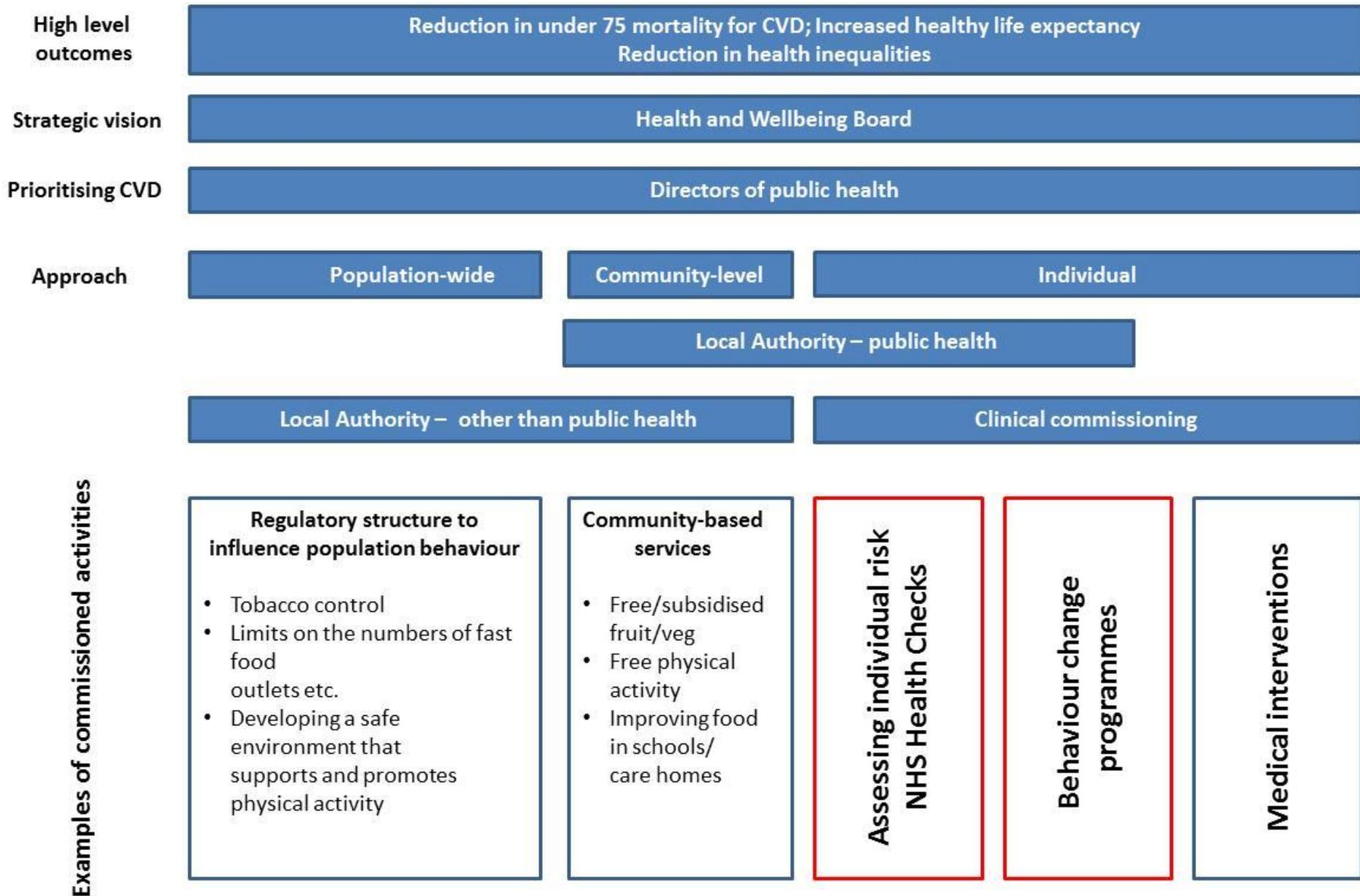


Figure 1: Identifying individuals at high risk of CVD is only part of the strategy. Risk reduction requires behavioural change, which needs the wider environment to support healthy choices. Red boxes indicate the position the Health Check occupies within the national framework.

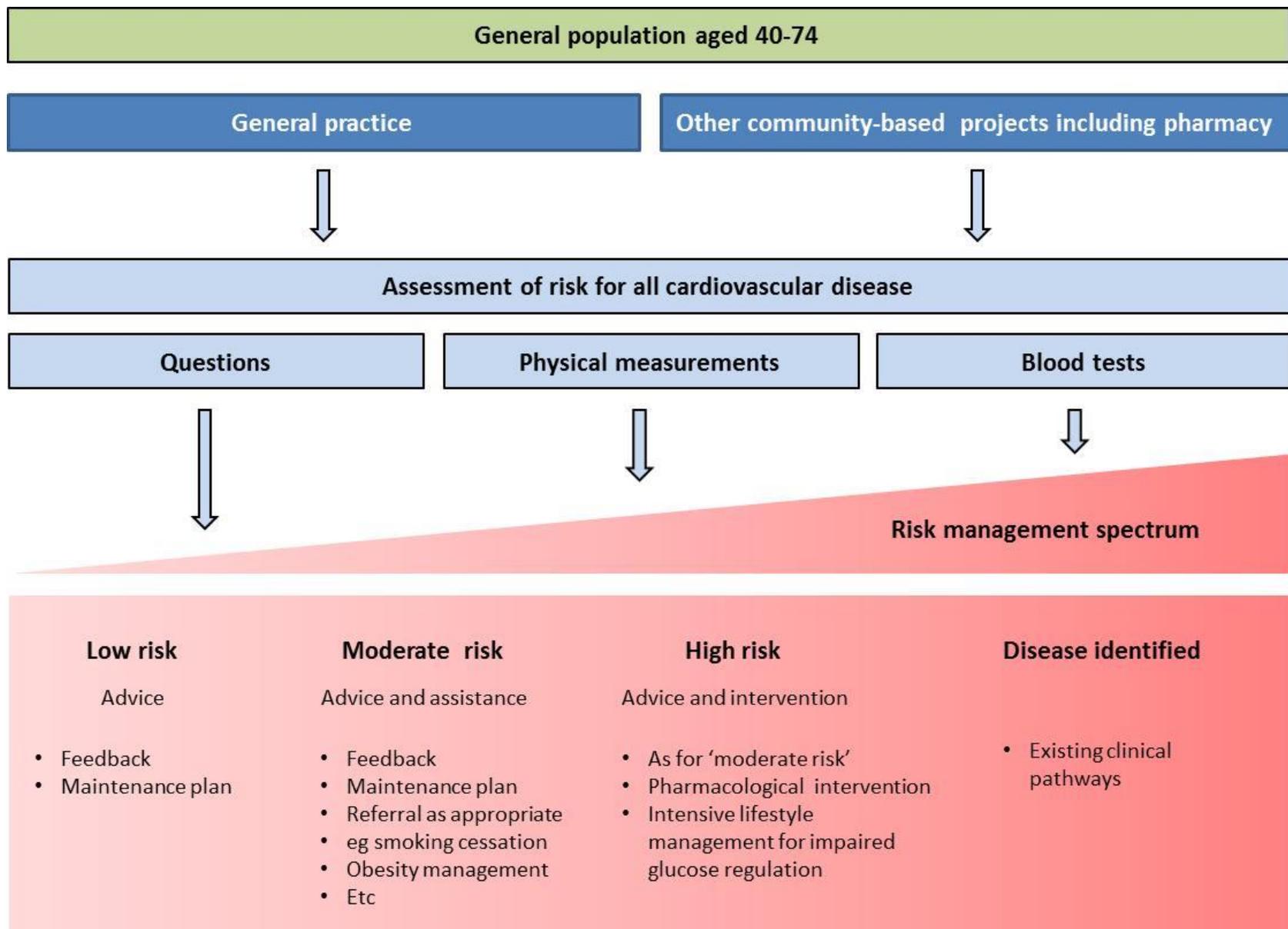


Figure 2: Summary of the NHS Health Check service. Target population is those aged 40-74. Clients may be invited to attend either their GP or a local pharmacy, depending on local commissioning strategy. The Check involves client history, measurements and blood tests. Data is entered into an appropriate risk engine, and a 10-year risk of a CVD event is calculated. For the client, this is summarised as 'low', 'moderate' or 'high.' Existing disease may be identified, in which case the client will be referred to existing care pathways.

Systems Engineering Initiative in Patient Safety (SEIPS)

The Systems Engineering Initiative for Patient Safety (SEIPS 2.0; **Figure 3**) can be used for mapping service delivery. SEIPS draws on ergonomic and healthcare quality models, supporting identification of factors influencing safe and effective clinical practice (Carayon et al. 2006; 2014; Holden et al. 2013). It is useful when considering commissioned services such as this, as the model considers organisational factors, including financial viability, a critical part of modern healthcare often overlooked by students. The model considers that people use tools/technologies to complete tasks in specific locations, influenced by both organisational and external factors. Tasks form part of processes generating system outcomes. In case of the cardiovascular risk assessment, SEIPS is used for proactive hazard analysis. Before considering the detail, it is important to define system boundaries.

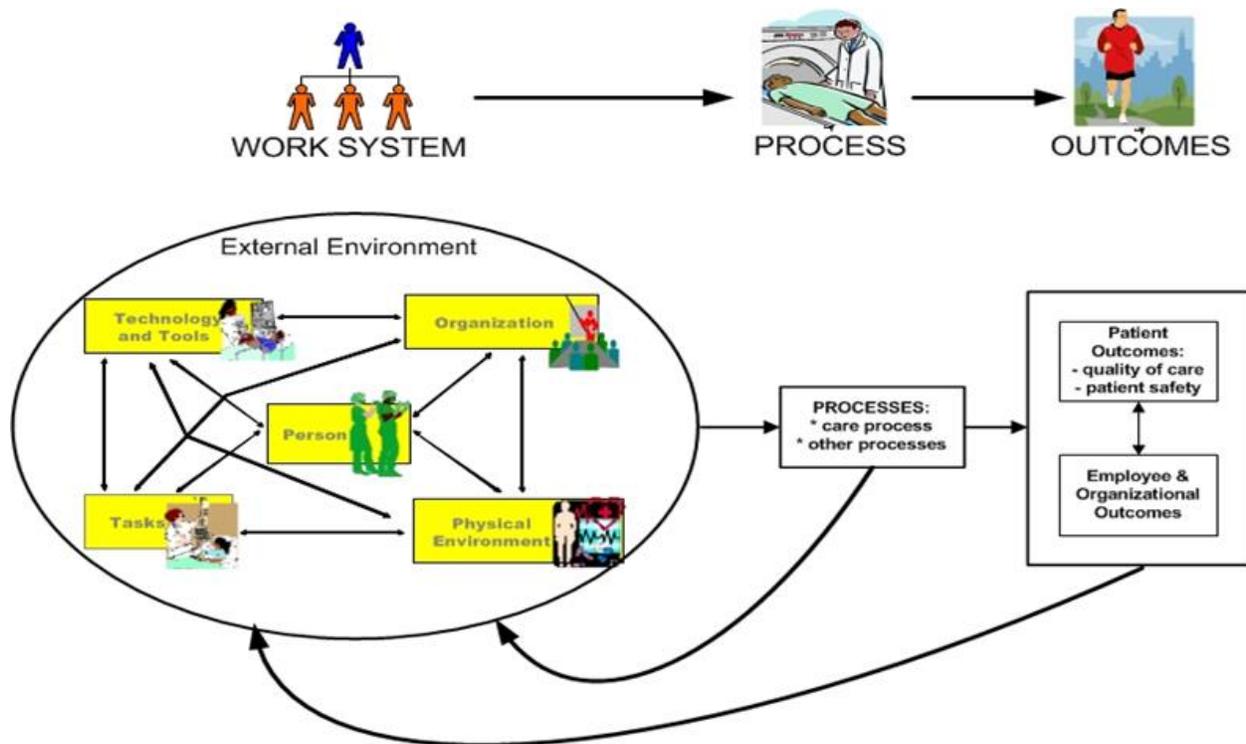


Figure 3: The SEIPS framework (from Carayon 2006)

Figure 4 illustrates the major boundary: purple boxes indicate care-related activities happening within the pharmacy. Processes include: **risk assessment**, **communication of risk** and **management of risk**. Consequently, this can be viewed as a process boundary, critical to safety because successful risk management requires referral to other services. Referral is also a spatiotemporal boundary, requiring separate appointments, often with different care providers. Such boundaries risk 'losing' clients and must be actively managed through good communication between partner service providers.

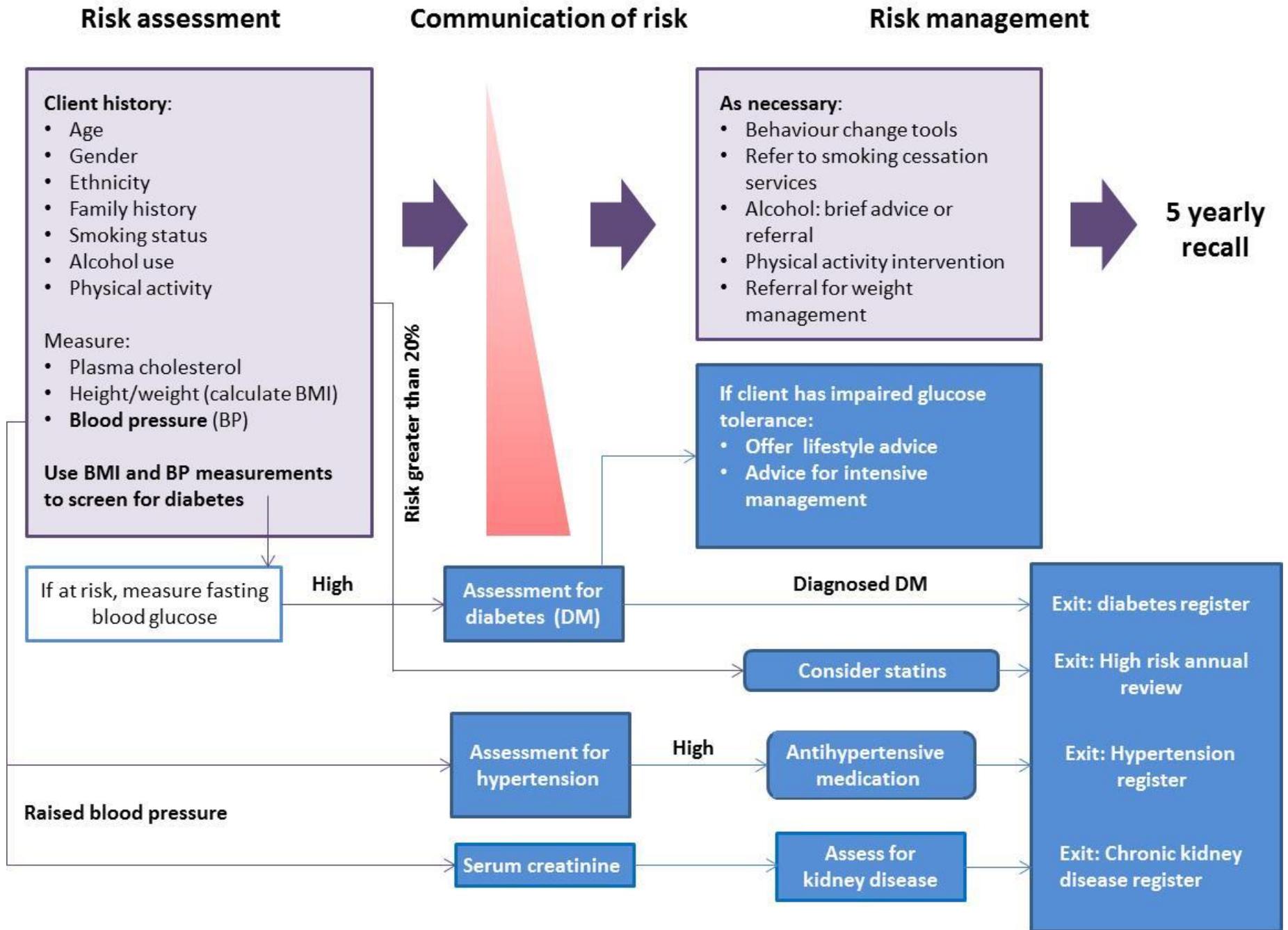


Figure 4: The NHS Health Check: Boundaries and referral pathway

Investigation design

For the pilot study, the SEIPS mapping was completed by a member of teaching staff with considerable experience of the cardiovascular risk assessment. The approach used for the mapping was contextual inquiry (Gurses et al. 2012), which involved shadowing pharmacists as they carried out the Health Check and asking questions triggered by the pharmacist's actions. This supports the use of the SEIPS model, which requires identification of *adaptations*, a normal feature of dynamic systems: if processes don't appear to be leading to desired outcomes, behaviours can change in order to 'close performance gaps' (Holden et al. 2013), and contextual inquiry can unpack the reasoning behind such behaviour. Three Health Checks were shadowed, with additional data gathered from simulated activities, following which focus groups with the staff involved were used to complete the mapping. The transcripts from the focus groups were thematically analysed and the three care processes subjected to *configural analysis* (Holden et al. 2013). Processes are shaped by complex interactions of individual components and, while all elements can interact, some interactions are more likely than others. Configural diagrams highlight interactions that most strongly influence performance: the number of links between two elements of the work system gives an indication of how tightly coupled those elements are. Tight coupling between elements mean that errors arising from these elements (such as a task being completed incorrectly) are likely to have a big effect on the system outcomes. The result of the configural analysis for the 'risk assessment' care process is shown in **Figure 5**. These results were then used to identify hazards as a basis for making recommendations (Gurses et al. 2012).

The staff experience of observing the risk assessment was used to develop a number of simulated risk assessment scenarios. These simulations were carried out by academic staff under student observation. The students involved had a range of experience, including one summer student with very little experience in the field of patient safety. All students had received training in the theory and practice of the cardiovascular risk assessment as well as a brief introduction to the SEIPS theory. Following this, they were given an opportunity to try the mapping process for themselves (**Figure 6**).

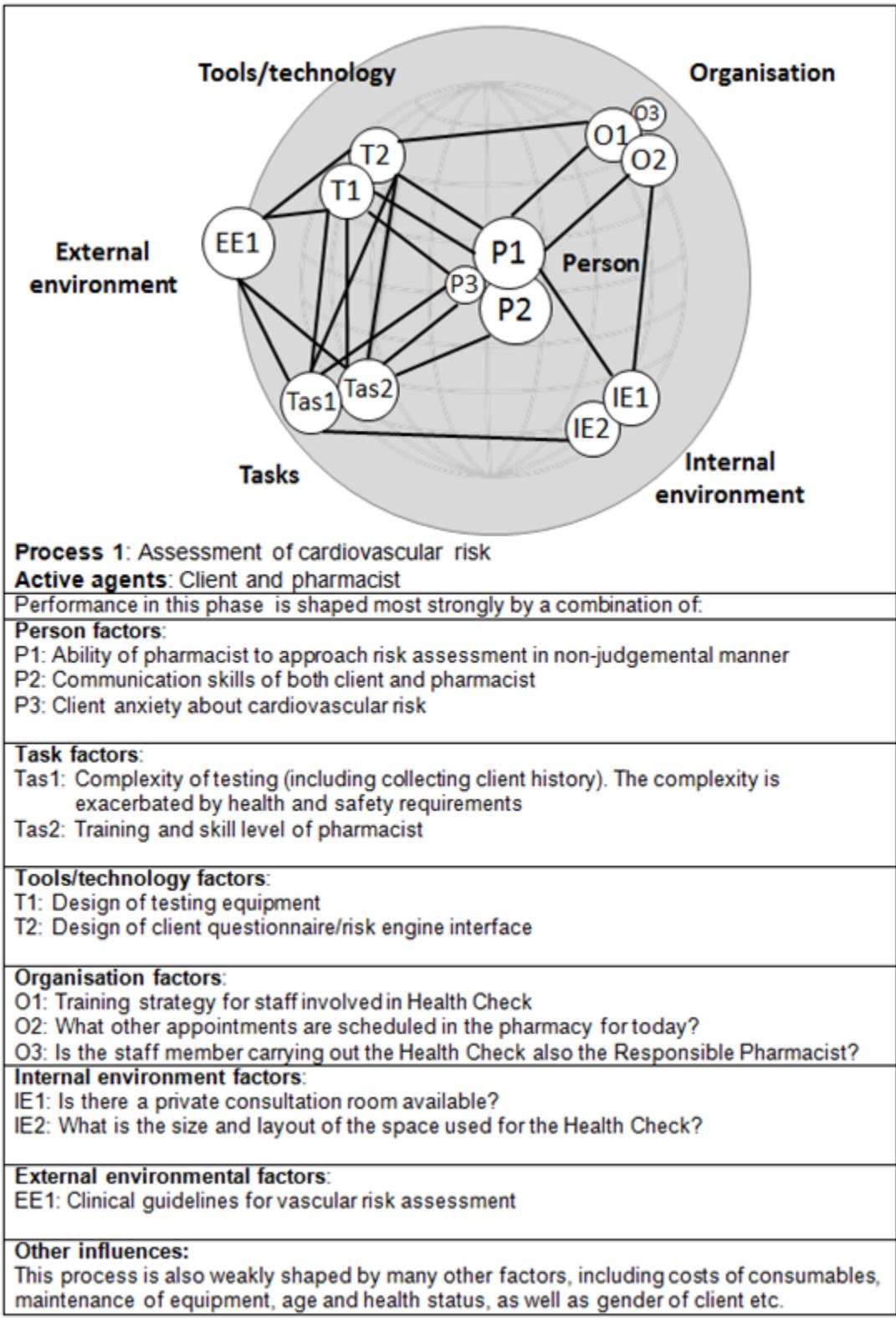


Figure 5. Configurational analysis for the 'risk assessment' care process, showing a tight coupling between task factors and the tools and technologies used



Figure 6: Student engagement with SEIPS mapping

Results and discussion

A full discussion of the results is beyond the scope of this paper, but the common themes arising from both the staff and student mapping are discussed below. The quotes in this section are from the staff phase of the study, and have been chosen merely to illustrate the themes.

Outcomes

SEIPS encourages the system investigator to consider both immediate ('proximal') as well as longer-term ('distal') outcomes, and these should not be limited to care issues – financial and health and safety considerations are critical to the viability of any service. In this study, there was generally a greater focus on proximal outcomes. Most participants recognised a key outcome was the client leaving the pharmacy with a management plan they understood, were committed to, and 'works for them.'

Participant 4: "There's no point telling someone to give up smoking when they're not ready - focus on something they can change! It's not easy, especially when smoking is the only thing they're doing wrong."

Participants agreed referral to other services (particularly General Practice) must be managed. Missing serious problems was a unanimous concern, but most also understood that over-referral diminished the value of the Check as a screening tool. Consequently, accuracy of risk assessment was seen as critical. This is a national issue: pilot studies suggest that 70% of pharmacy-based Checks result in referral (Horgan et al. 2010).

The only distal outcomes referred to without prompting were organisational, concerning the long-term financial sustainability of the community pharmacy-based version of the Health Check. It was felt this required an increase in 'market share' and therefore those involved in commissioning must be able to trust pharmacies' ability to deliver.

When the observer prompted consideration of longer-term outcomes, it was agreed that reducing prevalence of risk factors and disease across the population was important, but there was scepticism:

Participant 1: "I'm not convinced there's hard evidence of outcomes. It's all based on hypothetical modelling of 'maybe' events."

This reflects national concerns (Khunti et al. 2011; Public Health England 2013), with Public Health England acknowledging reservations exist at all levels. This is important, as there is danger of 'half-hearted' delivery if the pharmacist does not believe in its value. Interestingly, the students were much more comfortable when it came to discussing the actual evidence base – the professionals within this study were not able to cite specific studies. This probably reflects the fact that today's health professional curricula articulate the importance of evidence-based approaches to treatment.

The work system

Person(s)

SEIPS decomposes processes by considering who is engaged in delivering outcomes. The Health Check was considered to be **collaborative work** - care processes require the pharmacist and client to be actively involved. 'Pharmacist' describes the professional, although pharmacy technicians are able to carry out this role if trained. The 'client' is the person undergoing the Check: referring to clients as 'patients' leads to a sense of impaired agency (Haque and Waytz 2012). It is important the client retains control to achieve lifestyle changes. Interestingly, all the professional participants in this study used the term 'patient', while students didn't – probably due to the fact that policy changes very rapidly find their way into

the curriculum. The pharmacist and client are considered 'agents', but others are involved, including clients' family and friends. These 'co-agents' become increasingly important in risk management, as their attitudes impact on the client's ability to sustain changes.

Person factors

Success of Health Checks depends on the interaction between health professional and client attitudes. If clients feel judged, they may withhold or minimise information (observed in one real-life case, where the client claimed not to smoke, despite evidence to the contrary). Furthermore, studies suggest healthcare professionals deliver less information to minority ethnic and lower socio-economic groups perceiving them as less educated, even less intelligent (Willems et al. 2005; Honey et al. 2013). Clients must believe lifestyle changes have benefit, and efforts must be made to understand social circumstances influencing client behaviour. Underpinning all these factors are communication skills (of both client and pharmacist).

Anxiety is also relevant: among those likely to attend are those worried about CVD. Anxiety may affect measurements, but was also sometimes behind the pharmacist's decision to measure only total cholesterol (see 'task factors').

Risk engines require ethnic origin to be entered. The question this poses is 'what genes do you have that contribute to CV risk?' However, in today's political climate, this can be interpreted as racist (Simpson et al. 2015). In the observer's 10-year experience of cardiovascular risk assessment, this question appears particularly challenging. In this study, the following was observed:

Pharmacist: What's your ethnic origin?

Client (of Asian appearance): British.

Pharmacist: No, where would you say you come from?

Client: Glasgow.

(Pharmacist entered ethnic origin as 'white or not stated')

This could impact on the risk calculation sufficiently to incorrectly class a client as 'low risk,' missing the opportunity for medical intervention.

Task factors

The main issue is the complexity (and cognitive demands) of tests and measurements, such as blood pressure and cholesterol testing. Whilst not individually demanding, scheduling within a 40-minute consultation is problematic. For example, the service specification for the Health Checks indicates that both total and HDL-cholesterol should be measured. Both measurements take ~15 minutes, but there are gaps where the pharmacist is waiting for a reading. Other tasks (taking the client history etc) are fitted into these gaps. The observer noted that conversation around history was often fragmented because of this.

In over half the scenarios observed the pharmacist only measured total cholesterol. On questioning, this was time-related, but underpinned by an assumption about 'normal' HDL levels.

Participant 2: "I often just measure total [cholesterol]. Doing both eats into the time and HDL is usually about 1 [mmol/l] anyway, so it shouldn't affect the ratio too much. I think it's better spending time on the management plan."

Normal HDL levels *are* around 1 mmol/l, but the riskiest profiles combine high total cholesterol and low HDL, and the decision to undertake a single test may result in a client being classed as low risk, when, in fact, they should have been referred for intervention. Undertaking only the total cholesterol measurement conflicts with the notion of accuracy (mentioned previously) being critical. Lack of understanding may well be an education issue.

Tools/technology factors

The main tools are devices for measuring cholesterol, weight, height and blood pressure, and usability is important. Design must meet clinical needs *and* user requirements. Choice is often driven by procurement decisions, made remotely from frontline operation (Martin et al. 2008). For blood pressure, the mercury sphygmomanometer (or equivalent) remains the gold standard for non-invasive measurement (Stergiou et al. 2012). There are usability issues, especially if the practitioner is not current. For convenience, electrical devices are often used. These are known to under read, possibly underestimating cardiovascular risk (Sebo et al. 2014). Accurate measurement requires the arm to be held at heart height, which didn't always happen. In all Health Checks observed, a selection of tools was available, with choice influenced by personal preference and time pressures.

BMI requires height and weight measurements. The measure used in the simulations (**Figure 7**) reads height at the red line. During one simulation, the height was taken from the top (131 cm), moving the BMI from 'healthy' to 'obese'.



Figure 7: Where is the height measurement read?!!

Organisation

Time was the main organisational factor, which heavily influenced task-related decisions. Other issues related to education/training. Although none of the study participants felt insufficiently trained, the literature suggests training for Health Check delivery is not always adequate (Nicholas et al. 2012).

Internal environment

This relates to physical space and its uses: the rooms observed all contained equipment unrelated to the Health Check. Tables formed physical barriers, especially when the computer monitor couldn't be moved to show the client. In one 'real-life' scenario, table height meant the arm was below heart level, possibly resulting in over-reading of blood pressure. The different uses of the consultation space meant keeping to time was crucial.

External environment

An external driver of Health Check delivery is national guidelines (Pharmacy Services Negotiating Committee 2009; National Institute for Health and Care Excellence 2012; 2014). Proximity of (and relationship with) supporting services is very important, to avoid losing clients at this boundary:

Participant 1: "The more services we can offer here, the less likely it is that [clients] will be lost. It'll be good when there are more independent prescribers – we'll be able to manage medical interventions."

Adaptations

A number of adaptations were observed, the most significant being failure to complete full cholesterol testing. Another adaptation was the selection of 'white or not stated' for ethnicity if the conversation became uncomfortable. Again, as a result of time pressures, electronic blood pressure measurement devices were commonly used.

Configural analysis

As Waterson (2009) notes, complexity arises when multiple simple tasks are highly interconnected. In tightly coupled systems, small changes (such as increased time to get blood samples) can have profound effects. Several conclusions can be drawn from the configural analysis. Firstly, communication skills and staff education/training underpin the process. Secondly, for the risk assessment process, tools and technologies are tightly coupled with task factors (illustrated by the dense

connection network on the left-hand side of **Figure 5**). This would be the sensible area to focus interventions. **Table 2** provides a summary of the hazards identified.

Table 2: Hazards revealed through the SEIPS modelling

Pharmacist

- Insufficient education and training, especially with respect to understanding the significance of not measuring HDL-cholesterol
- Non-standardised approach to the Health Check as a result. This may be the result of habits and preferences, but is also contributed to by level of education and training
- Poor consultation skills that may result in failure to elicit critical information from the client
- Judgemental approach to risk assessment may result in client not disclosing relevant information. This may also result in the development of a management plan that does not suit the client and is therefore unlikely to be delivered on
- Pharmacist may under- or over-estimate risk

Client

- Client anxiety may impact on the risk assessment – especially if the anxiety is to do with blood tests

Tasks

- Failing to measure HDL cholesterol
- This is often due to time pressures, although patient anxiety is a factor
- Failure to accurately measure BMI
- Failure to accurately measure blood pressure
- Failure to elicit appropriate information may also be due to ‘fragmentation’ of the Health Check by the multiple activities required by each task

Tools and technologies

- Poor usability, especially with regard to clinical analyser (cholesterol measurement), blood pressure measuring devices and scales
- Poor usability of risk engine interface
- No standardisation in tools used across pharmacies

Physical environment

- The need for a private space which is also used for other consultations means that the time pressures are amplified
- Furniture not suitable for carrying out the consultation and testing; table heights often not ideal for blood pressure measurement, potentially resulting in an inaccurate reading
- Working across a table makes it more difficult to engage with the client in forming a management plan

Organisational factors

- Focus on profitability of the Health Check
- This is most frequently manifested as a deep need to keep to time
- Failure to involve front-line staff in procurement decisions, resulting in equipment that may be difficult to use
- Lack of appropriate protocols (or failure to enforce them). The failure to measure HDL happened sufficiently frequently (without apparent comment) suggesting that it was a violation that was tolerated
- Inadequate training

Care processes

- Failure to stick to guidelines

In developing an improvement plan, accurately ranking hazards would be useful. This is difficult in healthcare as many risk management tools are based on identification of a single likelihood-consequence pairing. In reality, multiple risks are usually associated with the same hazard. A single risk score is unlikely to reflect this. Card et al. (2013) suggest the use of modified matrices, accounting for multiple likelihood-consequence pairings. While this is an enhancement, it is still difficult to apply to the Health Check as there is (as yet) little evidence describing outcomes inaccurately capturing cardiovascular risk. The NHS must collect quality data from Health Checks so that it can be linked to hard outcomes. Data should be collected at local *and* national level and used to revise risk assessment tools, improving robustness for the context in which they are used.

Table 3 summarises the recommendations resulting from the SEIPS analysis

Table 3: Recommendations (those considered most important are highlighted in **bold**)

- **Change cholesterol measurement tools/technologies (there are machines available that can measure all blood lipids from a single blood sample)**
- **Changes should be done with input from front-line staff and service users. Simulation may be useful to support this**
 - Explore extent of interest from other local service providers such as GPs to reduce costs
 - Consider standardising equipment such as scales and blood pressure measurement devices across all pharmacies involved in the Health Check
 - Again, this should be done in consultation with front-line staff
- **Provide additional training.** Technical skills are important for the Health Check (proficiency would allow staff to make the most of the time available). Training **in non-technical skills** is equally important. This would provide an opportunity to develop strategies for dealing with complex issues such as communication and the discussion of ethnicity.
- **Training should be supported by education** – some of the issues were thought to stem from a lack of knowledge and understanding of cardiovascular disease. This would have benefits beyond the Health Check
- Cognitive aids such as checklists may be valuable in supporting non-technical skills. These could also be used to reinforce the importance of not missing items out of the Health Check
- Sharing practice: the Health Check involves a single staff member. Regular debriefings with the clinical lead and other staff would support both safety and profitability
- Collect as much data as possible. The modelling processes that underpin the projection of future benefits depend on the Health Check being carried out as per the service description. If this doesn't happen, it is critical that this data is captured. Effective audit tools have been developed, and their increasing use is likely to prevent violations as well as providing valuable data about the risk assessment
- Some of the participants indicated a lack of belief in the value of the Health Check. This needs to be addressed at a national strategic level by ensuring that evaluations of the service are based on hard outcomes. **It may help to consider using something like the Quality and Outcomes Framework (QOF; HSCIC, 2014) to set short-term measurable targets**

Conclusion

The SEIPS analysis proved a very effective mechanism for considering safety aspects of the cardiovascular risk assessment, although the purpose of this study was not to analyse the efficacy of the Health Check, but was an academic exercise in exploring the usability of an established ergonomics framework in a less conventional setting. Hazard identification and mitigation (so-called 'threat and error management') is becoming increasingly commonplace in obviously high-risk endeavours such as surgery, obstetrics and emergency medicine. However, the challenge is recognising risk within seemingly more benign activities. The results of the assessment were very interesting – it would certainly be worth undertaking a broader investigation of the Health Check itself. From a teaching and learning perspective, students were more than able to engage fully with the framework (even the 'pre-university' summer student with little or no relevant experience). Students picked up on many of the same issues as the professionals did, and they felt that the activities were very valuable:

"Reflecting on my experience now, I believe that the mapping was the most challenging part of the project. It takes time and an open mind to see the multiple connections between each area of the work system. However, I found the experience very enjoyable and extremely rewarding, as it has granted me insight into a particular work system, but using a methodology that could easily be applied in other systems."

References

- BARTON, P., et al., 2011. Effectiveness and cost-effectiveness of cardiovascular disease prevention in whole populations: modelling study. *BMJ*, 343: d4044.
- BROMILEY, M. and MITCHELL, L., 2009. Would you speak up if the consultant got it wrong?...and would you listen if someone said you'd got it wrong? *Journal of Perioperative Practice*, 19(10), pp. 326-329.
- BROWN, A., and VOSPER, H., 2013. Development of a blended learning environment to support achievement of graduate outcomes through optimal learning in an undergraduate pharmacy course. *Pharmacy*, 1(2), pp. 204-17.
- BUCHAN, S., et al., 2014. Students as partners in a quality improvement approach to learning enhancement: a case study from an undergraduate pharmacy course. [online]. *Communicare*, 1(1). Available from: <http://journals.rgu.ac.uk/communicare/article/view/18> [Accessed 31 May 2015].
- CARAYON, P., et al., 2006. Work system design for patient safety: the SEIPS model. *Quality and Safety in Health Care*, 15(Suppl I), pp. 150-i58.
- CARAYON, P., et al., 2014. Human factors systems approach to healthcare quality and patient safety. *Applied Ergonomics*, 45, pp. 14-25.

CARD, A.J., WARD, J.R. and CLARKSON, P.J., 2013. Trust-level risk evaluation and risk control guidance in the NHS in the East of England. *Risk Analysis*, 34(8), pp. 1469-1481

COLLINS, G.S. and ALTMAN, D. G., 2010. An independent and external validation of QRisk2 cardiovascular disease risk score: a prospective open cohort study. *BMJ* 340(7758), pp. 1231.

DEPARTMENT OF HEALTH, 2000. *National Service Framework: Coronary Heart Disease*. [online]. London: gov.uk. Available from: <https://www.gov.uk/government/publications/quality-standards-for-coronary-heart-disease-care> [Accessed 31 May 2015].

DEPARTMENT OF HEALTH, 2008. *Vascular checks: risk assessment and management. 'Next steps' guidance for Primary Care Trusts*. [online]. London: Department of Health. Available from: http://www.theisn.org/images/taskforce/United%20Kingdom/Putting%20Prevention%20First_Vascular%20Checks_Risk%20Assessment%20and%20Management%20Next%20Steps%20Guidance%20for%20Primary%20Care%20Trusts.pdf [accessed 31 May 2015].

DEPARTMENT OF HEALTH, 2013. *Cardiovascular disease outcomes strategy: improving outcomes for people with or at risk of cardiovascular disease*. London: gov.uk. Available from: <https://www.gov.uk/government/publications/improving-cardiovascular-disease-outcomes-strategy> [Accessed 31 May 2015].

GOFF, D.C., et al., 2014. 2013 ACC/AHA guideline on the assessment of cardiovascular risk. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*, 129(Suppl 2), pp. S49-S73.

GUZDER, R.N., et al., 2005. Prognostic value of the Framingham cardiovascular risk equation and the UKPDS risk engine for coronary heart disease in newly-diagnosed type 2 diabetes: results from a United Kingdom study. *Diabetic Medicine*, 22(5), p. 554-562.

GREER, S.L. 2009. Devolution and health policy in the UK. *Eurohealth*, 14(4), p. 22-24.

GRUNDY, S.M., et al., 1999. Assessment of cardiovascular risk by use of multiple risk-factor assessment. *Journal of the American College of Cardiologists*, 34, pp. 1348-59.

GURSES, A.P., et al., 2012. Identifying and categorising patient safety hazards in cardiovascular operating rooms using an interdisciplinary approach: a multisite study. *BMJ Quality and Safety*, 21, pp. 810-818.

- HAQUE, O.S., and WAYTZ, A., 2012. Dehumanization in medicine. Causes, solutions, and functions. *Perspectives in Psychological Science*, 7(2), pp. 176-186.
- HEIDENRICH, P.A., et al., 2011. Forecasting the future of cardiovascular disease in the United States. *Circulation*, 123, pp. 933-944.
- HIGNETT, S.M, et al., 2013. State of science: human factors and ergonomics in healthcare. *Ergonomics* 56(10), pp. 1491-1503.
- HOLDEN, R.J., et al., 2013. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. *Ergonomics* 56(11): 1669-1686.
- HONEY, S., et al., 2013. Differences in the perceived role of the healthcare provider in delivering vascular health checks: a Q methodology study. *BMC Family Practice*, 14, p. 172.
- HORGAN, J. M., BLENKINSOPP, A., and MCMANUS, R. J., 2010. Evaluation of a cardiovascular disease opportunistic risk assessment pilot ('Heart MOT' service) in community pharmacies. *Journal of Public Health*, 32(1), pp. 110-6.
- HOURIHAN, F., KRASS, I. and CHEN, T., 2003. Rural community pharmacy: a feasible site for a health promotion and screening service for cardiovascular risk factors. *Australian Journal of Rural Health*, 11, pp. 28-35.
- KACZOROWSKI, J., et al., 2011. Improving cardiovascular health at population level: 39 community cluster randomised trial of Cardiovascular Health Awareness Plan (CHAP). *BMJ*, 342, p. d442.
- KANNEL, W.B., 2000. Fifty years of Framingham study contributions to understanding hypertension. *Journal of Human Hypertension*, 14(2), pp. 83-90.
- KHUNTI, K., et al., 2011. Unanswered questions over NHS Health Checks. *BMJ*, 342, p. c6132.
- LALONDE, L., et al., 2006. Evaluation of a decision aid and a personal risk profile in community pharmacy for patients considering options to improve cardiovascular health: the OPTIONS pilot study. *IJPP*, 14, pp. 51-62.
- LAWTON, R., et al, 2012. Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. [online]. *BMJ Quality and Safety*. Available from: <http://dx.doi.org/doi:10.1136/bmjqs-2011-0004443> [Accessed 5 May 2015].
- LEAPE, L.L. 2004. Human factors meets healthcare: The ultimate challenge. *Ergonomics in Design*, 12(3), pp. 6-12.

MARTIN, J.L., et al., 2008. Medical device development: the challenge for ergonomics. *Applied Ergonomics*, 39, pp. 271-283.

MCNAUGHTON, R., et al., 2011. Making a success of providing NHS Health Checks in community pharmacies across Tees Valley: a qualitative study. *BMC Health Services Research*, 11, pp. 222.

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE, 2012. *Commissioning guides: Services for the prevention of cardiovascular disease*. [online]. London: NICE. Available from: <http://www.nice.org.uk/guidance/cm45> [Accessed 26 May 2015].

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE, 2014. *Lipid modification. Cardiovascular risk assessment and the modification of blood lipids for the primary and secondary prevention of cardiovascular disease. NICE Clinical Guideline CG181*. [online]. London: NICE. Available from: <http://www.nice.org.uk/guidance/cg181> [Accessed 29 May 2015].

NICHOLAS, J.M., et al., 2012. Variations in the organization and delivery of 'NHS Health Check' in primary care. *Journal of Public Health*, 35(1), pp. 85-91.

PHARMACY SERVICES NEGOTIATING COMMITTEE, 2009. *Vascular risk assessment (Vascular Checks) – a new Local Enhanced Service. Part 1: Background information. Version 1.2*. [online]. London: PSNC. Available from: <http://psnc.org.uk/services-commissioning/locally-commissioned-services/en15-nhs-health-check/> [Accessed 29 May 2015].

PUBLIC HEALTH ENGLAND, 2014. *NHS Health Check Programme standards: a framework for quality improvement*. PHE Publications Gateway Number: 2013503. London: Public Health England.

SCOTTISH GOVERNMENT, 2009. *Better heart disease and stroke care action plan*. [online]. Edinburgh: Scottish Government . Available from: www.gov.scot/Publications/2009/06/29102453/0 [Accessed 27 May 2015].

SEBO, P., et al., 2014. Blood pressure measurements are unreliable to diagnose hypertension in primary care. *Journal of Hypertension*, 32(3), pp. 509-517.

SIMPSON, L., WARREN, J., and JIVRAJ, S., 2015. *Do people change their ethnicity over time? In Ethnic identity and inequalities in Britain: the dynamics of diversity*. University of Bristol: Policy Press.

STERGIOU, G.S., et al., 2012. Requirements for professional office blood pressure monitors. *Journal of Hypertension*, 30, pp. 537-542.

WATERSON, P., 2009. A critical review of the systems approach in patient safety research. *Ergonomics*, 52(10), pp. 1185-1195.