Applying COM-B to medication adherence
A suggested framework for research and interventions

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On average only fifty percent of people with long term conditions are adherent to their treatment across diverse disease and patient groups (Holloway & van Dijk, 2011; Sabaté, 2003). Medication non-adherence leads to reduced clinical benefit, avoidable morbidity and mortality and medication wastage (DiMatteo, Giordane, Lepper, & Croghan, 2002). With increases in life expectancies as well as the number of patients managing chronic illnesses, this problem may well become worse in the next few years. Consequently, policy makers have called for successful interventions to address the causes of non-adherence and improve the population's use of medicines (Holloway & van Dijk, 2011; Horne, Weinman, Barber, Elliott, & Morgan, 2006; Nunes et al., 2009; Sabaté, 2003). Indeed, it has been estimated that $269 billion worldwide could be saved by improving patient medication adherence (IMS Institute for Healthcare Informatics, 2012).

Unfortunately, many adherence interventions to date have not been effective (Haynes, Ackloo, Sahota, McDonald, & Yao, 2008). Medical Research Council guidelines recommend that appropriate theory and evidence should be identified to inform the development of an intervention (Craig et al., 2008). However, most adherence interventions are developed without a sound theoretical base, which may be one of the reasons they have not been effective (Horne et al., 2006). Successful interventions have often involved a level of complexity that would be too difficult and expensive to implement in practice (Haynes et al., 2008).

Explanations and models of medication adherence/non-adherence have changed over the years. Early work tended to focus on the role of doctor-patient communication and its effects on patient satisfaction, understanding and forgetting as key determinants of subsequent treatment adherence (Ley, 1988). However, health behaviour research has consistently demonstrated that the provision of information alone is not an effective way to change behaviour, and so research has now moved onto approaches and models which focus on patients' beliefs, motivation and planning abilities as the core explanatory variables. Many of these are social cognition or self-regulatory models which emphasize the importance of the beliefs which individuals have about their illness and treatment as well as their own ability to follow the treatment and advice which they are given (see Conner & Norman, 2005). Existing models and frameworks are not comprehensive since they neglect automatic processes such as habit (for example, Ajzen, 1985; Bandura, 1977, 1986; Horne, 1997, 2003; Leventhal, Nerenz, & Steele, 1984; Pound et al., 2005; Rosenstock, 1974), do not describe dynamic behaviours whereby the experience of adherence/non-adherence can alter predisposing factors such as beliefs about medication (for example, Ajzen, 1985; Bandura, 1977, 1986; Horne, 2003; Pound et al., 2005; Rosenstock, 1974) and neglect factors at a systems level (for example, Horne, 2000, 2003; Leventhal et al., 1984; Pound et al., 2005; Rosenstock, 1974). In addition, the often used

categories of 'intentional' and 'unintentional' non-adherence have limited use in implementing adherence interventions because there is much overlap between categories. For example, forgetting can be unintentional but might be influenced by intentional or motivational factors, such as lack of perceived need for treatment (McHorney & Spain, 2011).

Finally, while these models and frameworks have identified a wide range of explanatory factors (see Kardas, Lewek, & Matyjaszczyk, 2013), they do not specify how to bring about change. Understanding what underpins non-adherence is a necessary first step, but consideration also needs to be given to how to change it.

Developments in the behaviour-change field

In recent years, increased attention has been paid to the delineation and classification of behaviour change techniques in order to develop and refine interventions within the field of health psychology. The many methods that have been used to attempt to change different health-related behaviours have been brought together and integrated as part of an over-arching taxonomy of behaviour change techniques (Michie et al., 2013; Michie, Hyder, Walia, & West, 2011). The latest version of the taxonomy describes 93 distinct techniques that can be used to change behaviour (Michie et al., 2013). The taxonomy has been applied to identifying and understanding effective methods of changing a range of health-related behaviours, including physical activity (Michie, Abraham, Whittington, McAteer, & Gupta, 2009), healthy eating (Michie et al., 2009) and tobacco use (Lorencatto, West, & Michie, 2012). For example, interventions which incorporated the technique of "self-monitoring" (where the

participant monitors and records their behaviour (Michie et al., 2013)) were significantly more successful at promoting physical activity and healthy eating than interventions which did not include this technique (Michie et al., 2009). Successful smoking cessation interventions targeted at pregnant women used techniques such as 'facilitating goal setting 'and 'action planning' (Lorencatto et al., 2012).

The Capability, Opportunity and Motivation (COM-B) model of behaviour
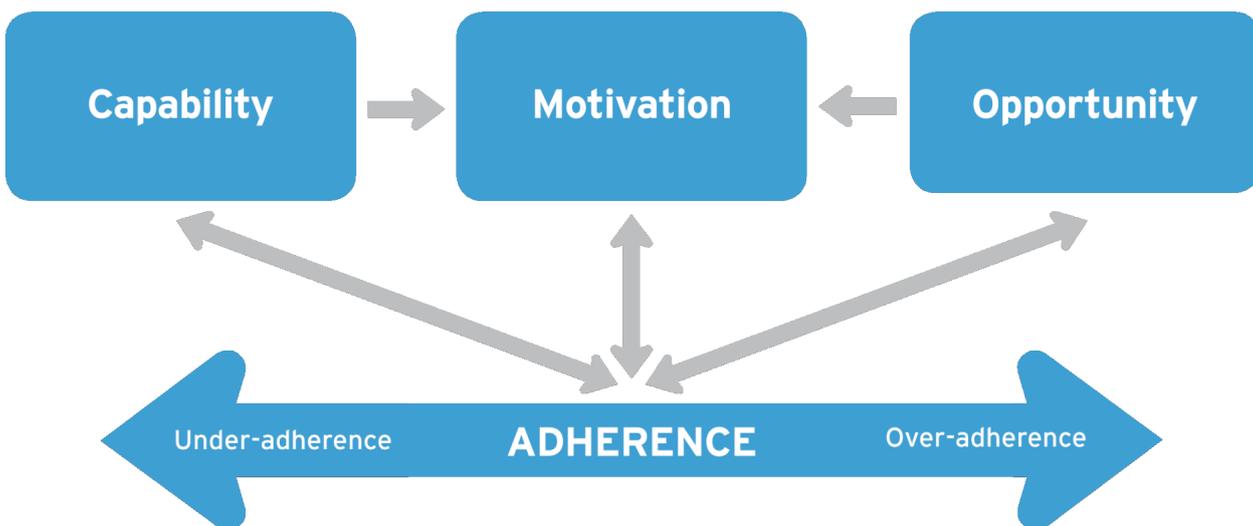
The development of a taxonomy of behaviour change techniques has resulted in new ways of conceptualising the factors which explain or determine individual health-related behaviours. At the core of this new approach is a psychological model for explaining human behaviour intended to capture the range of mechanisms that may be involved in change (Michie, van Stralen, & West, 2011). COM-B is intended to be comprehensive, parsimonious and applicable to all behaviours, and was developed with reference to existing theories of behaviour and a US consensus meeting of behavioural theorists, which considered the prerequisites for the performance of a specified volitional behaviour (Michie et al., 2011). COM-B is intended as a starting point in order to choose interventions that are most likely to be effective, and specific interventions to address each component have been suggested (Michie et al., 2011). The model hypothesises that interaction between three components, Capability, Opportunity and Motivation (COM) causes the performance of Behaviour (B) and hence can provide explanations for why a recommended behaviour is not engaged in. These components are described in more detail below. Each component can influence behaviour

directly and, in addition, Opportunity and Capability might influence Motivation and so affect behaviour. In addition, it is a dynamic model whereby performance of a behaviour can in turn influence Capability, Opportunity and Motivation. Our depiction of the model as it relates to adherence is shown in Figure 1.

In this paper, we examine how COM-B could be applied to describe the wide range of factors which have been identified to explain non-adherence to medication. The purpose of this exercise is not only to achieve a more coherent framework for explaining all types of medication non-adherence but also to make it easier to

and social environment, which can facilitate or impede the behaviour and, as such, is an explicit consideration of external resources, which are not usually included in other health behaviour models. Motivation comprises 'all those brain processes that energise and direct behaviour, not just goals and conscious decision-making' but also 'habitual processes, emotional responding' and 'analytical decision-making' (Michie et al., 2011, p.4). Each component is divided into sub-components to capture important distinctions within the research literature. Capability is subdivided into Psychological Capability (capacity to engage in

Figure 1. Application of COM-B to adherence

identify appropriate behaviour change techniques to improve adherence.

Capability, Motivation and Opportunity are collectively described as "components" influencing behaviour. Capability is defined as the 'individual's psychological and physical capacity to engage in the activity concerned' (Michie et al., 2011, p.4). Opportunity covers all those 'factors that lie outside the individual that make the behaviour possible or prompt it'. Thus, it includes aspects of the individual's physical

necessary thought processes) and Physical Capability (capacity to engage in necessary physical processes) (Michie et al., 2011). Opportunity is subdivided into Physical Opportunity (provided by the environment) and Social Opportunity (cultural milieu that dictates the way we think about things) (Michie et al., 2011). Motivation is subdivided into Reflective Motivation (evaluations and plans) and Automatic Motivation (emotions and impulses arising from associative learning and/or innate

dispositions) (Michie et al., 2011).

Applying COM-B to medication adherence

When representing the COM-B framework for adherence, we chose to depict adherence as a continuum (Figure 1), which reflects the extent any treatment recommendation is adopted. Thus it can include adherence to recommended lifestyle change or to psychological therapies (e.g. Gearing et al, 2013). The global term 'medication adherence' incorporates initiating the prescription, actual dosing in relation to the prescription, and persisting with treatment (Vrijens et al., 2012). This definition captures categorisations such as primary and secondary non-adherence (not redeeming a prescription, and not using a redeemed treatment as prescribed respectively) and non-persistence. However, the definition does not include treatment acceptance (accepting the offer of treatment within a consultation).

Three comprehensive reviews synthesising qualitative and quantitative studies of medication adherence were used to identify and map the different factors associated with adherence. Since adherence has been investigated in both quantitative and qualitative studies, we selected these three sources to identify factors commonly associated with medication adherence (Kardas, Lewek, & Matyjaszczyk, 2013; Nunes et al., 2009; Pound et al., 2005). Kardas et al. (2013) undertook a systematic review of 51 systematic reviews of factors associated with non-adherence. Pound et al. (2005) used a systematic search and analysis procedure to synthesise qualitative papers exploring patients' views of medication. They included 38 papers from 1992 – 2001. Nunes et al. (2009) replicated this process for papers from 2002 and included 45 qualitative

papers. Between them these papers provide a comprehensive overview of what is currently known regarding factors associated with non-adherence.

In order to identify all the factors associated with non-adherence, we first extracted those found by Pound et al. (2005) and Nunes et al. (2009) and then examined the 461 factors listed by Kardas et al. (2013). The evidence was examined by 2 independent raters, who then agreed on a final list of common factors from all three reviews and also on how each of these mapped (or did not map) onto the COM-B model, using the definitions listed above regarding components and sub-components. This secondary analysis indicated that the COM-B proved a workable way to group most of the known determinants of adherence. Table 1 shows how factors extracted from the literature mapped onto COM-B.

While most of the factors could be readily classified within the COM-B framework, four factors associated with non-adherence did not map directly onto a single sub-component of COM-B. These were depression, substance abuse, marital status and forgetting. Their effects on adherence can be explained by a number of different factors. For example, depression and substance abuse might have an effect on adherence by impacting mood (Motivation/Automatic), perceptions of illness and treatment or self-efficacy (Motivation/Reflective), availability of social support (Opportunity/Social), or impairing cognitive function (Capability/Psychological). Marital Status might have an effect on adherence by impacting the availability of social support (Opportunity/Social), cost (Opportunity/Physical) or access (for example ability to travel to hospital for appointments) (Opportunity/Physical). Forgetting might be the outcome of impaired cognitive or executive function (Capability/Psychological), regimen

Table 1. *Applying COM-B to factors associated with adherence*

CAPABILITY	MOTIVATION	OPPORTUNITY
The individual's physical and psychological capacity to engage in the behaviour*	*All brain processes that energise and direct behaviour*	*All factors lying outside the individual that make performance of the behaviour possible or prompt it*
Psychological *Capacity to engage in necessary thought processes*	**Reflective** *Evaluations and plans*	**Physical** *Physical opportunity provided by the environment*
•Comprehension of disease and treatment •Cognitive functioning (e.g. memory, capacity for judgement, thinking) •Executive function (e.g. capacity to plan)	•Perception of illness (e.g. cause, chronic vs. acute etc.) •Beliefs about treatment (e.g. necessity, efficacy, concerns about current or future adverse events, general aversion to taking medicines) •Outcome expectancies •Self-efficacy	•Cost •Access (e.g. availability of medication) •Packaging •Physical characteristics of medicine (e.g. taste, smell, size, shape, route of administration) •Regimen complexity •Social support •HCP-patient relationship / communication
Physical *Capacity to engage in necessary physical processes*	**Automatic** *Emotions and impulses arising from associative learning and/or innate dispositions*	**Social** *Cultural milieu that dictates the way we think about things*
•Physical capability to adapt to lifestyle changes (e.g. diet or social behaviours) •Dexterity	•Stimuli or cues for action •Mood state/disorder (e.g. depression and anxiety)	•Stigma of disease, fear of disclosure •Religious/cultural beliefs

*statements in italics represent definitions given by Michie et al. (2011)

complexity or requirement to change daily lifestyle (Capability/Physical), beliefs about illness and treatment (for example if treatment is not perceived as necessary) (Motivation/Reflective), or absence of cues or stimuli for action (Motivation/Automatic).

The hypothesised interaction whereby Capability and Opportunity can influence Motivation enables description of the complex ways in which a known determinant of non-

adherence, such as treatment complexity might have its effect. A complex regimen (e.g. multiple varying medication schedules throughout the day) might be beyond the planning capabilities of some (Capability/Psychological), whereas for others, although it is within their ability to follow, it may be a factor that negatively influences motivation to take treatment (Motivation/Reflective). For example, Nunes et al. (2009) reported that individuals with

complex regimens chose to take those medications offering symptom relief or for the most feared condition, suggesting that complex regimens might be a challenge to both capability but also motivation to take treatment. The feedback loop between adherence and Motivation fitted well with the findings of the reviews. Pound et al. (2005) reported that individuals might stop or alter medication and watch the effects thereby influencing perceptions of the need for medication and efficacy of medication. Kardas et al. (2013) listed disappearance of symptoms/feeling better or cured as factors associated with non-adherence. We posit that feedback loops between adherence and Capability and Opportunity are also possible. For example, experience of using medical equipment (such as inhalers or injections) will improve Physical Capability to use the medication (that is, the capacity to perform the behaviour improves with practice). An example of adherence improving Opportunity would be an improved relationship with a HCP following adherence: playing the role of the 'good' patient may encourage the HCP to view the patient in a more positive light and then provide more encouragement or support, which, in turn, could result in better treatment persistence over time.

From our work on this, we feel that COM-B provides a more comprehensive explanation of adherence than existing models. Firstly, it includes automatic processes such as habit (unlike social cognition models which have been applied to adherence). Secondly, it explicitly includes factors at a systems level (unlike many social cognition models and the Perceptions and Practicalities Approach (Horne, 2000)). Thirdly, the specificity of components within the COM-B model, and hypothesised relationships between them, allows a precise description of the relationship between individual determinants and adherence, making it easier to identify

appropriate interventions. Since this framework allows a more comprehensive and fine grained analysis of the causes of non-adherence, this should mean that an intervention can be selected more precisely to target a particular cause. Consequently it helps us move beyond simply dichotomising adherence into 'intentional' and 'unintentional' categories. In COM-B the determinants of non-adherence are Capability, Opportunity and Motivation, some of which may be conscious ('Intentional') and some unconscious or outside the individual's control ('Unintentional'). Adherence relates simply to the behaviour itself - using treatment at the right time, for the right period, in the right quantity, and in the right manner.

Not all factors identified from the literature review fitted into exactly one sub-component but might have their effects via a number of components (depression, substance abuse, marital status, forgetting). We do not feel that this is a limitation of the model since the effects of the factors are explained by components within the model. It highlights that in order to improve adherence research should be undertaken to investigate how a particular factor has its effect in order to generate clear hypotheses about processes. For example, marital status is sometimes cited as a factor associated with non-adherence, but the appropriate intervention would not be to set up matchmaking services, rather to understand what benefits are conveyed by marital status and find a way of extending these to unmarried people.

Implications and applications in practice.

In order to have the greatest chance of success, relevant theory and evidence should be identified before an intervention is designed

(Craig et al., 2008). As a first stage, an adherence intervention designer should identify factors associated with non-adherence within their target population through reference to existing literature or primary research. These factors could be assigned to Capability, Opportunity, and Motivation (recognising that some factors may have specific effects on different components). Mapping the evidence to the COM-B model is helpful for making sure that the intervention designer does not get drawn in to thinking of adherence only on one level (for example on an individual or systems level).

In a second stage, the designer could identify intervention types and behaviour change techniques that are appropriate for the sub-components identified in the first stage. Here the designer could use intervention types and techniques that have already been described and could readily be applied to adherence (Michie et al., 2013; Michie et al., 2011). With reference to both Michie et al. (2011) and the taxonomy of behaviour-change techniques (Michie et al., 2013) we would suggest that improved Physical Capability can be achieved through interventions such as feedback and monitoring, demonstration of the behaviour, repetition, or through enabling interventions such as provision of aids (e.g. monitored-dosing box) (Michie et al., 2013; Michie et al., 2011). Psychological Capability can be achieved through techniques such as shaping knowledge, feedback and monitoring, and through enabling interventions (Michie et al., 2013; Michie et al., 2011). Reflective Motivation can be improved through techniques such as shaping knowledge, giving information about consequences, comparison of outcomes, comparison of behaviour, setting goals and improving self-belief (Michie et al., 2013; Michie et al., 2011). Automatic Motivation can be improved through associations (e.g. presence of prompts or cues), imitative learning (e.g. watching someone else

performing the behaviour), and repetition (Michie et al., 2013; Michie et al., 2011). Finally, Physical and Social opportunity can be achieved through environmental change (changing the physical or social context) (Michie et al., 2011). When determining appropriate techniques, the designer would also take into account available resources, and the target population. For the interested reader, links are also made between each intervention type and policy categories which enable or support that intervention type (Michie et al., 2011).

Finally, as the evidence around effective behaviour change techniques grows, it will be possible to determine which techniques are most effective at addressing each of the components. Researchers across research groups and disciplines will be able to move forward together to develop a science of behaviour change. We are not aware of any interventions using COM-B to improve medication adherence, but a recent systematic review of adherence to cardiovascular medication did use it as a framework for grouping existing interventions (Laba et al., 2013). Within other research areas, work is underway to identify the types of behaviour change techniques that are effective (e.g. Webb, Joseph, Yardley, & Michie, 2010) and COM-B has been used in the design of interventions in areas as diverse as eating (Robinson et al., 2013; Watt et al., 2013), risk of Alzheimer's disease (Anstey, Bahar-Fuchs, Herath, Rebok, & Cherbuin, 2013), and condom use (Newby, French, Brown, & Lecky, 2013).

In conclusion, we believe that COM-B has advantages over existing theories of adherence. It can account for a wide range of factors affecting adherence (including cognitive and emotional factors, individual factors such as forgetting and dexterity and external influences of the healthcare system, policy and media). Additionally, this dynamic framework also explains how the performance of a behaviour

can in turn influence capability, opportunity and motivation. Lastly, the framework has been explicitly developed to inform behaviour change interventions and as such can be used to guide both adherence researchers and health care practitioners involved in the care of non-adherent patients. The publication of interventions applying COM-B in combination with related intervention types and behaviour change techniques will enable the growth of a body of knowledge regarding effective elements of adherence interventions.

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Conflict of interests

Christina Jackson and Lina Eliasson are full-time employees of Atlantis Healthcare. John Weinman is a part-time employee of Atlantis Healthcare. Nick Barber has no conflicts to report.

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