Data-driven versus theory-driven methods to understand health service implementation problems: A case study of childhood vaccination barriers

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Abstract

Background

Effective implementation requires identifying and addressing behavioural barriers to uptake. This study aimed to compare data-driven and theory-driven approaches to understanding implementation issues. We used childhood vaccination coverage as a case study, with international relevance and wide-ranging barriers contributing to low vaccine uptake.

Methods

The study utilised the Behaviour Change Wheel framework, which incorporates both individual and system level barriers to behaviour, and is based on several levels of theory: the three components of the COM-B model (capability, opportunity and motivation) can be mapped to the 14 domains of the Theoretical Domains Framework (TDF), which is based on 84 underlying constructs. We first conducted a review of systematic reviews of parent-level barriers to childhood vaccination. Subsequently we: 1) inductively coded these barriers into a data-driven framework, using thematic analysis; and 2) conducted theory-driven mapping of these barriers to TDF domains and constructs. Coding and mapping were undertaken by two authors independently, and discrepancies were resolved through discussion. The data-driven and theory-driven results were compared.

Results

The data-driven process coded 583 descriptions of barriers identified from the literature into a framework of 74 barriers in 6 categories. The initial definitions used to compare data-driven barriers with theory-driven domains/constructs led to 89% agreement at the domain level. Resolving discrepancies required further definitions at the construct level. Of the 14 TDF domains, 10 were clearly identified in the data from the barrier reviews. Some domains were not specific enough to differentiate between types of barriers (e.g. Environmental Context and Resources), while other domains were not represented in the review data (e.g. Behavioural Regulation).

Conclusions

Using both data- and theory-driven approaches can help achieve a more comprehensive understanding of barriers to health service implementation. The data-driven categories represented the review data in a clearer way than the theoretical domains, with better differentiation; but the missing domains were useful as a way to identify additional issues to investigate further. Both approaches resulted in a comprehensive list of barriers to vaccination that would not have been achieved using either approach alone. This will inform a diagnostic tool to measure the causes of under-vaccination.

Contributions To The Literature

- It is unclear whether theoretical approaches to understanding implementation problems, such as the TDF and COM-B, produce different results when compared to data-driven approaches, such as literature reviews
- This paper outlines a new behavioural diagnosis procedure comparing theory-driven and data-driven approaches to understand an implementation problem of global significance
- We illustrate a unique methodology using several levels of theory, and identify new directions to improve the specificity of theoretical behavioural constructs in future research
- The paper illustrates how data-driven and theory-driven approaches synergise to produce a more comprehensive understanding of health service barriers than using either approach alone

Background

Effective implementation of a health service program, guideline or treatment requires identifying and addressing behavioural barriers to uptake. This may involve reviewing existing literature if the problem is well researched, or conducting original research if the context or problem is new. Incorporating theoretical models or frameworks can ensure all possible behavioural influences are considered[1].

Behaviour change is complex. The use of theoretical models enables us to understand the mechanisms of change in behaviour, which can then be targeted in interventions. Multiple theories are used in healthcare, from simple models of individual health behaviour change like the Theory of Planned Behaviour[2], to broader systems thinking approaches to map the complexity of policy drivers[3]. The Behaviour Change Wheel (BCW) is one approach that attempts to bring individual and system level factors together [4], based on the COM-B model that synthesises the 14 more specific behavioural constructs in the Theoretical Domains Framework (TDF) [5] into broader categories.

The TDF summarises the many overlapping constructs in the behaviour change literature, and was developed through expert consensus from 128 theoretical constructs in 33 theoretical models of behaviour[6]. It provides an overview of 14 key theoretical constructs that explain health behaviour, and is a descriptive framework rather than a theory of causality. A separate systematic review of 19 frameworks for behaviour change interventions led to the BCW, which aims to guide the development of interventions by connecting the determinants of behaviour with behaviour change techniques[4]. Developed in conjunction with the BCW, and at its central core, is the COM-B model which proposes that behaviour is a product of the interaction between capability (psychological or physical), opportunity (social or physical) and motivation (automatic or reflective)[4,6].

The COM-B and TDF have been mapped to each other, but there is some duplication of the current 14 TDF domains across the COM-B components. Capability is the *psychological* or *physical* ability to enact a behaviour, which includes the TDF domains of knowledge, skills, memory/attention/decision processes, and behavioural regulation. Opportunity is the *physical* and *socia*l environment that enables the behaviour, which includes social influences and environmental context/resources. Motivation is the

reflective and *automatic* mechanisms that activate or inhibit a behaviour, which includes the widest range of TDF domains: social/professional role and identity, beliefs about capabilities and consequences, optimism, intentions, goals, reinforcement and emotion. Table 1 summarises this theoretical relationship.

Primary research is often used to identify barriers to implementation in different health service contexts, and this is the approach generally used with the TDF[6]. Some issues have been well researched , but this evidence must be synthesised in order to inform comprehensive intervention design[7]. Previous reviews have applied theoretical frameworks to help with this. For example, the BCW can be used to describe interventions in terms of broader functions[8], and the COM-B can be used to display barriers and facilitators at multiple levels (patient, provider and system)[8]. The TDF can be used together with the COM-B to group barriers and facilitators of health outcomes[9], or as a stand alone framework[10].

These reviews have not compared the utility of this deductive approach (i.e. theory-driven grouping of barriers according to the existing TDF or COM-B construct categories) versus inductive approaches (i.e. data-driven grouping of barriers based on thematic similarities derived from the barrier descriptions themselves). There are potential advantages and challenges to each approach. A deductive application of these theoretical frameworks ensures that all psychological constructs relevant to behaviour are considered, even if research has not identified every construct. However, since these theoretical frameworks are based heavily on psychological theory, the internal 'motivation' aspect is more clearly defined than the more external 'opportunity' aspect. This imbalance does not necessarily align with the prevalence and significance of practical issues in health service implementation, which might be defined as "physical opportunity".

The aim of this paper is to illustrate how data-driven and theory-driven approaches can complement each other to produce a more comprehensive understanding of health service barriers than using either approach alone, using parent uptake of childhood vaccination – an international issue with wide ranging barriers identified in multiple reviews – as a case study.

Methods

Theoretical approach

The study was based on the BCW framework because it incorporates both individual and system level barriers to behaviour, and is based on several levels of theory: the three components of the COM-B model can be mapped to the 14 domains of the TDF, which is based on 84 underlying constructs [4].

Context: The Vaccine Barriers Assessment Tool (VBAT project)

This analysis is based on data gathered for the Vaccine Barriers Assessment Tool (VBAT) project, which aims to design and validate a survey tool to diagnose the causes of under-vaccination in children under five years. Developed in Australia and New Zealand, VBAT aims to incorporate both access and acceptance barriers in a comprehensive tool which will include both short and long form versions, for

different uses. A review of systematic reviews of barriers to childhood vaccination was conducted, and 583 descriptions of parental barriers to childhood vaccination uptake were extracted and categorised into data-driven categories[11]. Barriers were extracted if they were reported from or relevant to the specific perspective of parents of children under five years; barriers from the perspective of health professionals or the health system alone were not included. The findings of the review were thematically organised into a data-driven framework of barriers. In a separate theory-driven process, the 583 barrier descriptions were mapped to the 14 domain version of the TDF, to check whether any theoretical determinants of childhood vaccine uptake were missing in the systematic review data. The purpose of this exercise for the VBAT project was to ensure that a comprehensive pool of potential survey questions could be generated that captured both access and psychological or acceptance barriers. The data-driven review and development of the VBAT items will be reported separately. In this paper, specific terms are used to refer to data-driven versus theory-driven concepts as outlined in Table 2.

Process

Two authors with expertise in Cochrane systematic review methods and vaccination (JK, JT) independently conducted the data-driven coding of barriers in Excel. Two authors with expertise in behavioural science (CB) and vaccination (JT) independently conducted the theory-driven mapping of barriers to domains and constructs in a separate Excel spreadsheet. In both instances, disagreements were resolved through discussion. The data-driven and theory-driven categories were compared using cross-tabulations. Discrepancies between the two approaches were discussed with the wider VBAT study team, which includes expertise in vaccination programs and public and primary health (MD, DD, LT, ST) and psychometric assessment (DC).

The data-driven coding process produced 74 barriers (reported in detail elsewhere) within 7 categories (access, clinic or health system factors, concerns and beliefs, social determinants (e.g. socio-economic status), health perceptions and experiences, knowledge and information, social or family influence). The theory-driven mapping of barriers was initially based on the 14 domains of the most recent TDF version, but this was expanded to consider the 84 constructs when it was difficult to categorise some barriers. The final mapping was therefore completed using a combination of domain and construct, with definitions documented for how these would be applied to the childhood vaccine context from the specific perspective of *parents* (not health professionals or health systems).

Results

Mapping data-driven barriers to theory-driven domains

The initial definitions used to compare data-driven barriers with theory-driven domains/constructs led to 89% agreement at the domain level (e.g. all barriers relating to the clinic setting will be under the domain of Environmental Context and Resources). Resolving disagreements for the domains and subsequent constructs required further definitions at the construct level before 100% agreement was reached. Table 3

illustrates this for the domain of Environmental Context and Resources, e.g. we decided that issues relating to how appointment times are managed will be under the construct of Organisational culture/climate; while issues relating to inconvenient access for the parent will be under the construct of Person x Environment Interaction. The full list of definitions in available in Appendix 1.

Figure 1 shows the number of barriers represented in each theoretical domain, and Table 4 shows the relationship between the theory-driven COM-B components and TDF domains, and the data-driven barriers identified in the systematic review. Of the 14 TDF domains, 10 were clearly identified in the data from the barrier reviews. Some domains were not specific enough to differentiate between types of barriers, while other domains were not well covered in the review data. Two domains did not specify the data-driven barriers clearly, with many different concepts grouped together under generic terms (Beliefs within Beliefs about Consequences; Barriers and Facilitators within Environmental Context/Resources). Six domains were not covered by the first coder but two were included after discussion with the second coder (issues relating to good/bad communication between parent and provider were moved to Skills; things that help the parent to vaccinate their child on time such as including with another appointment were moved to Reinforcement). Four domains were not clearly covered in the final agreed coding: Optimism, Intentions, Goals and Behavioural Regulation (with the exception of two very general barriers for Intentions and Goals with no further explanation). Within the 14 TDF domains, many specific constructs were not identified in the data, especially those relating to health professional perspectives (e.g. Skills) or interventions (e.g. Behavioural Regulation). This is shown in yellow in Appendix 1.

Discussion

Overall, we found it useful to synthesise health service implementation barriers using both data-driven and theory-driven methods to gain a comprehensive understanding of the barriers to childhood vaccination. The data-driven categories represented the review data in a clearer way than the theoretical domains, with better differentiation; but the four missing theoretical domains were useful as a way to identify key gaps to be addressed in the item pool for developing a new tool to diagnose the causes of childhood under-vaccination.

Resolving conflicts at the domain level was relatively easy, with 100% agreement reached quickly for the most relevant domain. However there were some barriers that could have been placed in 2 or 3 domains, e.g. previous experience of vaccine side effects could be framed as knowledge, beliefs or salient events. Resolving conflicts at the construct level was more difficult because many constructs within a domain were very similar when applied to the brief barrier descriptions extracted from reviews, for example the influence of family member opinions could fit within group identity, social norm or social pressure. The decisions made at construct level were arguably more subjective than the domain level, but both needed to be considered to make sense of many barriers that could be framed in different ways.

For this study it was necessary to go into more theoretical detail than the commonly used models: the COM-B and TDF. Importantly, the gaps identified in our data-driven review would not have been found if

the analysis had only been done at the COM-B level, as all six components were addressed by the 10 data-driven domains. In addition, the 14 TDF domains were still not specific enough for two coders to reliably map the barrier data so we were required to go back a step to the 84 theoretical constructs that informed the TDF development. We found it helpful to use a combination of domain and construct level to map the data. A previous review using the TDF identified some issues that could not be mapped to the TDF (e.g. clinician and patient characteristics), but some of these could be mapped at the construct level depending on the framing, e.g. under professional identity, skills, environment x person and resources constructs[12].

This paper provides a methodology for anyone seeking to understand an implementation issue that already has a large amount of qualitative and/or quantitative research – complementing an earlier paper that focuses on how to apply the TDF in primary qualitative research [6]. There are several practical implications for other researchers seeking to comprehensively understand implementation barriers using theoretical models in this way. Firstly, you need to decide on very specific framing for a health situation, e.g. only looking at the parent perspective on vaccinating their child determines how you frame barriers relating to the doctors' knowledge. Conducting this process from the health professional perspective would produce different results in terms of the theoretical constructs identified in the literature. Secondly, the COM-B model was not specific enough with uneven explanation of different barrier types; so you may need to go into more detail at domain and construct level to interpret the data. Thirdly, theory was useful for identifying gaps in a data-driven review of literature, but data driven categories made more sense for the specific implementation topic. So the value of using a theory-driven approach may depend on the purpose of conducting the review. For our purposes, this review will inform the development of a diagnostic tool to measure the causes of under-vaccination, requiring us to include the widest possible range of behavioural drivers. For other projects, it may be more prudent to focus only on the theoretical drivers that are within an organisation's control to address, or to identify data-driven issues from the perspective of key stakeholders to ensure their interest and support.

More generally, this study has implications for theoretical models commonly used in implementation science. Some constructs are vague and became catch alls – e.g. barriers and facilitators in this case. On the other hand some constructs are too specific and hard to distinguish – e.g. group vs social norms, so it makes sense to combine this into one TDF domain. In our experience, the decision was often between constructs in different domains, rather than constructs within a domain, suggesting that there are some issues with the way the TDF domains are differentiated. On the other hand, the construct level was often too subjective and detailed to identify clear gaps in data. This suggests that overarching models like the COM-B and TDF need to be supplemented with more context-specific models for different health areas (e.g. prevention versus treatment of infectious disease), targets of behaviour change (e.g. parents versus doctors), and the context (e.g. higher resource settings where psychological barriers may be more important, versus lower resource settings where practical access issues require greater differentiation). Another option would be to use broad implementation frameworks that include practical issues like cost, such as the Consolidated Framework for Implementation Research (CFIR)[13]. Other researchers have

found it helpful to combine the TDF and CFIR for a more comprehensive approach[14]. A third option would be to add more specific domains to the next version of the TDF to better differentiate between issues relating to “Environmental Context and Resources”. In our review, this covered a very wide range of issues: socio-economic issues such as having low income, societal issues like the influence of media, health system issues like vaccine supply and cost, and individual access issues like distance and time. This was found to be a catch all category in many previous reviews of clinicians and patients using the TDF[12,15–19], so is not limited to the issue of vaccination barriers. For example, a review of barriers to low back pain guidelines found this domain was common to 4/5 clinician behaviours while many other domains were not covered at all[17]. Another review on diabetic screening identified 17 barriers in this domain versus 6 for the next most common domain[15]. Further development of this construct may need to be specific to different health topics.

The TDF domains that weren’t covered well by the vaccination barrier review data – optimism, behavioural regulation, intentions and goals – may have been found in other areas of the literature. Optimism is often researched as a personality-based predictor of health[20], and this conceptualisation is unlikely to be identified as a public health barrier or the target of a public health intervention. Behavioural regulation may not relate as well to occasional behaviours like vaccination, compared to something like eating healthy food, which requires daily monitoring[21]. Intentions and goals may be more likely found in theory-based intervention literature where intention is a common outcome[22], rather than the barrier literature where intention is conceptualised more as a product of the barriers. These domains may be appropriate to understand other health contexts, but for this case study they were less relevant. However, the low prevalence of these domains appears to be similar to some previous barrier reviews on different topics (e.g. the reviews on low back pain guidelines and diabetic screening described above[15,17]).

This study addressed reliability by using a method of independent coding using both inductive and deductive approaches. Our team included a wide variety of expertise to help contextual framing for theoretical constructs as applied to data-driven barriers. The limitations include restricting our review data to parent barriers only, which affected the way that health professionals’ and heatlh system barriers were conceptualised. We also applied only one overarching framework to behaviour change models, and acknowledge that there are many other approaches to this theoretical issue.

In conclusion, using both data and theory approaches can help achieve a more comprehensive understanding of health service implementation problems. However, the process is subjective so requires a wide range of expertise to reduce biased interpretation and to maximise utility of the identified barriers for the specified purpose.

Conclusions

Using both data- and theory-driven approaches can help achieve a more comprehensive understanding of barriers to health service implementation. The data-driven categories represented the review data in a

clearer way than the theoretical domains, with better differentiation; but the missing domains were useful as a way to identify additional issues to investigate further. Both approaches resulted in a comprehensive list of barriers to vaccination that would not have been achieved using either approach alone. This will inform a diagnostic tool to measure the causes of under-vaccination.

Declarations

Ethics approval and consent to participate

Ethical approval not applicable.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interest to declare.

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Authors' contributions

CB planned the study, conducted the analysis, and drafted the paper. JT and JK conducted the analysis and were major contributors in writing the manuscript. DC, DD, LT, ST and MD contributed to group discussions about the analysis approach and interpretation of the results, and revised the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1: Relationships between the TDF and COM-B (adapted from Tables 2 & 3 in Cane et al.) [5]

COM-B components	TDF domain definitions
Capability: Psychological	**Knowledge:** An awareness of the existence of something
	Behavioural Regulation: Anything aimed at managing or changing objectively observed or measured actions
Capability: Psychological and Physical	**Skills:** An ability or proficiency acquired through practice
Capability: Physical	**Memory, Attention and Decision Processes:** The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives
Opportunity: Physical	**Environmental Context and Resources:** Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour
Opportunity: Social	**Social influences:** Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours
Motivation: Reflective	**Beliefs about Consequences:** Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation
	Beliefs about Capabilities: Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use
	Intentions: A conscious decision to perform a behaviour or a resolve to act in a certain way
	Goals: Mental representations of outcomes or end states that an individual wants to achieve
Motivation: Reflective and Automatic	**Social/Professional Role and Identity:** A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting
	Optimism: The confidence that things will happen for the best or that desired goals will be attained
Motivation: Automatic	**Reinforcement:** Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus
	Emotion: A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event

Table 2: Definition of terms for data-driven and theory-driven approaches

Level of categorisation	Data-driven terms	Theory-driven terms
Low level (specific)	*Barrier descriptions* refers to the 583 individual descriptions of implementation issues extracted from systematic reviews in the VBAT review of the vaccination uptake literature	*Construct* refers to the more detailed list of 84 unique theoretical concepts that informed the TDF and COM-B models
Example	*Belief that the vaccine is more dangerous than the illness*	*Consequents*
Mid level	*Barrier* refers to the 74 groups of barrier descriptions across studies identified in the VBAT review of the vaccination uptake literature	*Domain* refers to the 14 broad categories of behavioural drivers described in the most recent version of the TDF (Theoretical Domains Framework)
Example	*Concern about vaccine safety*	*Beliefs about consequences*
High level (broad)	*Category* refers to the 7 groups of barriers identified in the VBAT review of the vaccination uptake literature	*Component* refers to the 6 components in the simplest theory-driven model of behavioural drivers, the COM-B model (Capability, Opportunity, Motivation – Behaviour)
Example	*Concerns and beliefs*	*Reflective motivation*

Table 3: Example of definitions required to code TDF domains

Domain	Construct	Notes on decision making
Environmental Context and Resources (Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour)	Environmental stressors	Role of media
	Resources/material resources	Cost issues, lack of supply
	Organisational culture/climate	How clinic is managed (e.g. appointment time)
	Salient events/critical incidents	Specific adverse event/illness in past
	Person x Environment Interaction	Inconvenience to specific parent (e.g. location)
	Barriers and facilitators	General access factors/catch all for "other"

*Note: there were 14 Domains and 84 constructs

Table 4: Relationship between theory-driven and data-driven concepts

COM-B component	TDF domain	Data-driven barriers
Capability	Knowledge	Lack of information about vaccination, false contraindications
	Skills	Staff are unpleasant or poor communication, language barriers
	Memory, Attention and Decision Processes	Reminder notice, missed opportunities, forgot
	*Behavioural Regulation	**Not represented**
Opportunity	Environmental Context and Resources	First child, low income, media, distance, supply, cost, time
	Social influences	Social exclusion, peer influence, trust, compliance, natural immunity
Motivation	Social/professional role and identity	Traditional beliefs and customs, role of parent, lack of coordinated care
	Beliefs about Capabilities	Can control pathogens child is exposed to, lower parental satisfaction with care
	*Optimism	**Not represented**
	Beliefs about Consequences	Anticipated guilt, vaccine efficacy, disease severity/susceptibility, pain
	Reinforcement	Well-baby clinic counseling, benefit to others, vaccination delay at 3mths
	*Intentions	Practices about health and prevention (n=1 with lenient interpretation)
	*Goals	Lack of motivation (n=1 with lenient interpretation)
	Emotion	Anxiety about vaccination, fear of needles, psychosocial distress

*Note: These 4 domains were not included in the first round of coding. Intentions and goals were later included after discussion with a very lenient interpretation of the data-driven barriers to maximise he number of domains covered, given the aim of the exercise was to generate questionnaire items covering all possible behavioural influences. No data-driven barriers could be interpreted as behavioural regulation or optimism.

Figures

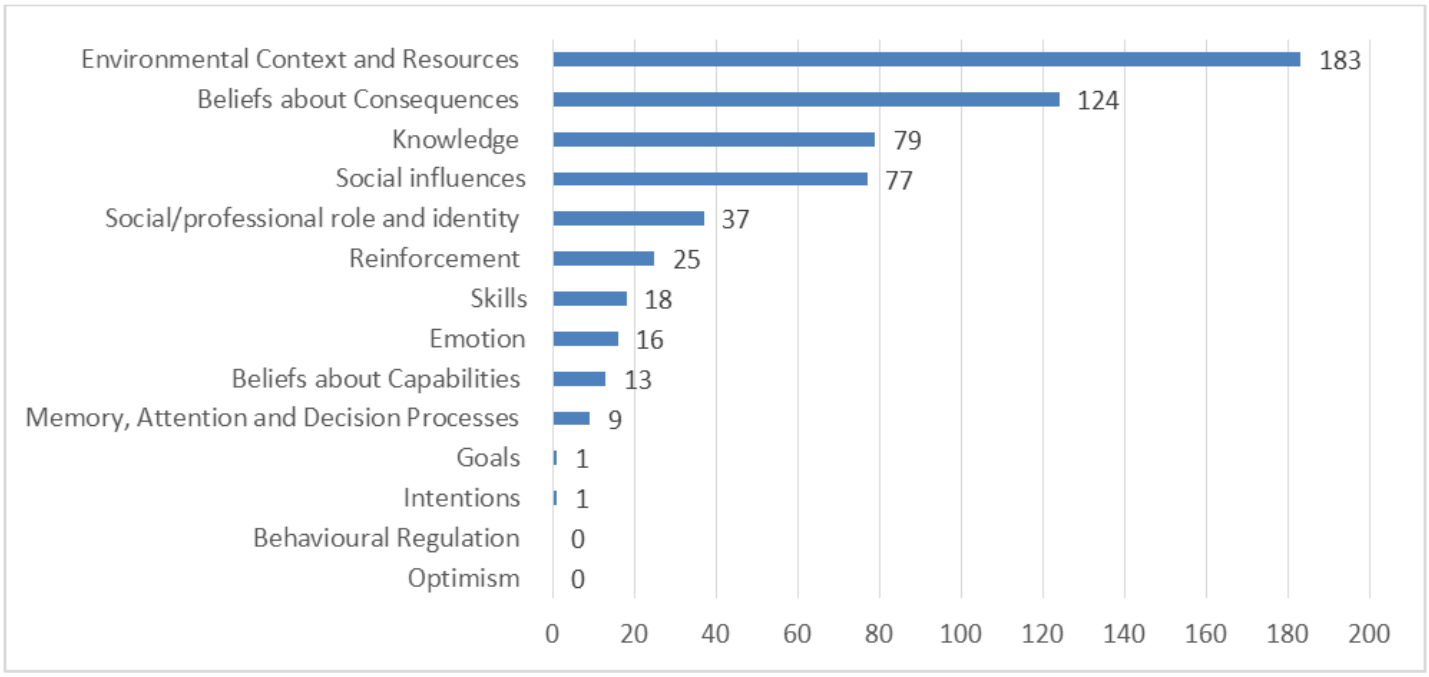

Figure 1

Number of data-driven barriers in each TDF domain

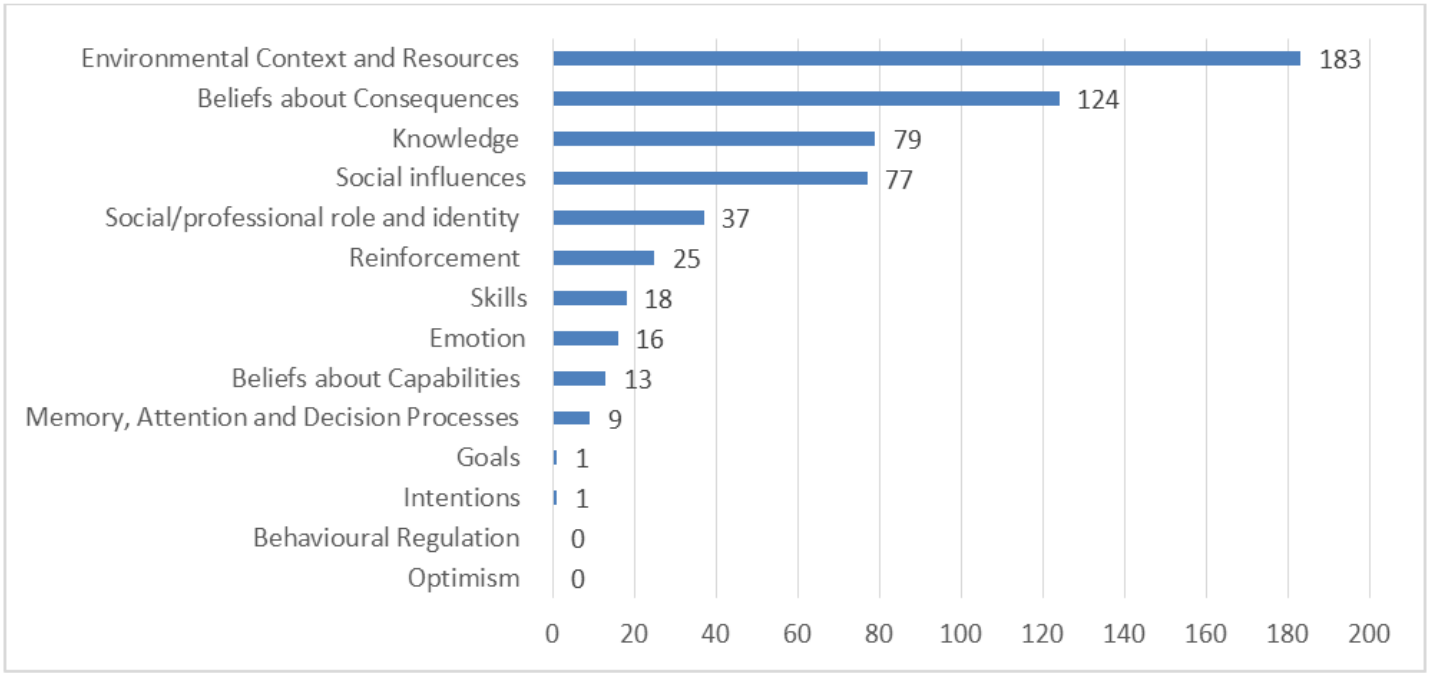

Figure 1

Number of data-driven barriers in each TDF domain

Supplementary Files

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- VBATPaperAppendix1.png
- VBATPaperAppendix1.png