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Review

The 5As: A practical taxonomy for the determinants of vaccine uptake

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ABSTRACT

Suboptimal vaccine uptake in both childhood and adult immunisation programs limits their full potential impact on global health. A recent progress review of the Global Vaccine Action Plan stated that "*countries should urgently identify barriers and bottlenecks and implement targeted approaches to increase and sustain coverage*". However, vaccination coverage may be determined by a complex mix of demographic, structural, social and behavioral factors. To develop a practical taxonomy to organise the myriad possible root causes of a gap in vaccination coverage rates, we performed a narrative review of the literature and tested whether all non-socio-demographic determinants of coverage could be organised into 4 dimensions: *Access*, *Affordability*, *Awareness* and *Acceptance*. Forty-three studies were reviewed, from which we identified 23 primary determinants of vaccination uptake. We identified a fifth domain, *Activation*, which captured interventions such as SMS reminders which effectively nudge people towards getting vaccinated. The 5As taxonomy captured all identified determinants of vaccine uptake. This intuitive taxonomy has already facilitated mutual understanding of the primary determinants of suboptimal coverage within inter-sectorial working groups, a first step towards them developing targeted and effective solutions.

1. Introduction

A recent progress review of the Global Vaccine Action Plan (GVAP) stated that "*countries should urgently identify barriers and bottlenecks and implement targeted approaches to increase and sustain coverage*" in immunisation programs [1]. The EU council recently highlighted the failure of member states to reach influenza vaccine coverage targets, leaving approximately 60 million elderly and at-risk patients unvaccinated every year [2,3]. To achieve the goals of vaccination policies, programmatic and supply challenges must be addressed, but there is also increasing awareness that vaccine hesitancy, recently defined a delay in acceptance or refusal of vaccines despite availability of vaccination services [4], may be an important cause of suboptimal vaccine uptake (defined as the use of a vaccine in an immunisation program). Vaccine hesitancy may be due to a complex mix of behavioral and social factors, and most interventions to increase vaccine acceptance have shown little or no effect [5]. Furthermore, where hesitancy has been assumed to be the root cause of poor vaccine uptake, closer study may reveal the greater importance of other reasons related to, for example, delivery of vaccination [6].

To effectively address a gap in coverage in a vaccination program, we must therefore begin by identifying and weighting the primary determinants of vaccine uptake. The root causes of suboptimal uptake are complex and context-dependent, and even the equation "*vaccination uptake = access + acceptance*" [7] seems too simplistic to offer a viable explanation. A number of reviews have identified, and several have recently attempted to classify, the myriad possible determinants of vaccine hesitancy, and more broadly vaccine uptake [8–15]. However, these classifications of possible causal factors are often conceptual, focused on a single vaccine, or difficult to translate into practice.

There is a need for a pragmatic methodology to facilitate the diagnosis of the possible root causes of a vaccination coverage gap and support the subsequent design of a robust, evidence-based, interventions. To this end, we aimed to develop a practical taxonomy for the myriad possible root causes of a vaccination gap. Building upon a previous proposal of access plus acceptance[16], we hypothesised four vaccination-related dimensions which could influence vaccination uptake: Access, Affordability, Awareness, and Acceptance. A fifth dimension, Activation, was uncovered during the review of the literature. Table 1 provide a working definition for each of these five dimensions.

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Table 1
Working definitions and contributing factors of the 5As.

Root cause	Definition
Access	The ability of individuals to be reached by, or to reach, recommended vaccines
Affordability	The ability of individuals to afford vaccination, both in terms of financial and non-financial costs (e.g., time)
Awareness	The degree to which individuals have knowledge of the need for, and availability of, recommended vaccines and their objective benefits and risks
Acceptance	The degree to which individuals accept, question or refuse vaccination
Activation	The degree to which individuals are nudged towards vaccination uptake

In this narrative review, we used these dimensions to organise the literature to assess whether this was a reliable, comprehensive and operational taxonomy for the non socio-demographic determinants of vaccine uptake.

2. Method

2.1. Search strategies

A search was conducted via Social Sciences Citation Index (SSCI)—1970-present, using the string (vacci* OR immuni*) AND uptake, with the time span between 1st January 2003 to 29th January 2013.

2.2. Inclusion and exclusion criteria

A total of 485 records were exported in full into Excel. Abstracts were first reviewed to identify eligible abstracts against the inclusion and exclusion criteria (see Fig. 1). Literature was included if the targeted vaccinations sourced from World Health Organisation (WHO) prequalified vaccinations [17] were mentioned in either the abstract or title, this included the vaccination full name and the appropriate abbreviations (measles, mumps, rubella, MMR).

Human Papillomavirus (HPV) vaccine was excluded due to a recent review of factors associated with its uptake [18]. Equally, only the targeted countries were included: Estonia, Latvia, Lithuania, Brazil, Venezuela, Columbia, Peru, Bolivia, Argentina, Chile, Nigeria, Russia, India, Australia, United States (USA) and UK (England, Scotland and Wales).

Exclusion of literature included: Reviews, Editorial Material, Article proceedings paper and articles that did not mention the targeted vaccinations or countries. Furthermore, articles were also excluded if in relation to other drugs, livestock/animal, food services, cost effectiveness, cost utility, feasibility, prenatal services/health services not inclusive of specific vaccination information, disease control systems, infection rates, effect on cancer rates, effects on uptake of cancer/hearing screening. Finally, articles were excluded when there was insufficient or no information provided in the title or abstract indicative of evidence pertaining to the identification of a barrier to, or driver for, vaccine uptake.

2.3. Data extraction and final selection

The initial selection identified 65 articles. Full text papers were obtained for each of these articles. A follow-up assessment of the articles identified a further 27 articles that did not meet the exclusion inclusion criteria, analysed data which preceded 2003, only referred to socio-demographic determinants of vaccine uptake or did not provide evidential statements in relation to barriers or drivers of vaccine uptake where evidence included direct facts or information to support the validity of the barrier or driver identified (see Fig. 1).

2.4. Content analysis method

KR first reviewed each selected article and recorded statements providing evidence of a determinant of vaccine uptake in database (e.g., "A significantly higher proportion of infants born in hospitals were vaccinated in the first six weeks compared to those born outside hospitals" [19]). She then categorised each piece of evidence as pertaining to access, affordability, awareness, acceptance, or other, using the definitions of each dimension (see Table 1). This initial categorisation was reviewed and discussed with GVT and disagreements were discussed and resolved through consensus. Subsequently, KR coded the subcategories of evidence classified under each dimension of the 4As. For example, the piece of evidence mentioned above was classified as evidence pertaining to the location of uptake within the access dimension. Subcategories were again reviewed and discussed with GVT and disagreements were resolved through consensus. Finally, the 'other' dimension was further content analysed and the factors identified were classified into those that could be modified through an intervention (subsequently labelled "activation factors") and those that could not (e.g., sociodemographic predictors of uptake, subsequently excluded from the analysis).

3. Results

3.1. Study characteristics

Of the 38 studies included in the final sample, 15 studies focused on Influenza (39%), 12 on MMR (32%), 2 on DTP/DTP3, 1 on

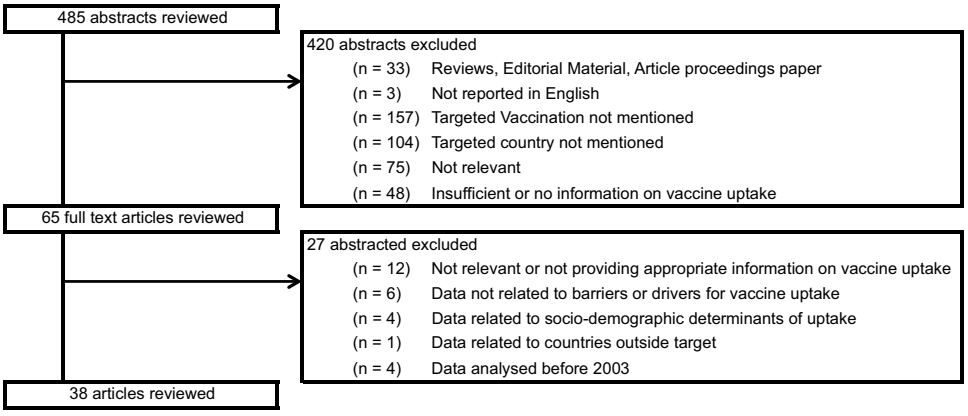

Fig. 1. Flow chart of selection process for inclusion of articles in review.

Table 2
Vaccine, country of origin, method, sample sizes (*N*), and population tested for the studies reviewed.

Authors	Vaccine	Country	Method	*N*	Respondents
Olusanya [19]	BCG	Nigeria	Retrospective data	5171	Infants 0–3 mths
Athavale et al. [21]	BCG	UK	Cohort data	557	Infants 0–3 mths
Elliott and Farmer [32]	childhood immunisations	India	Survey	470	Parents (child aged 9 mths–6 yrs)
Antai [10]	childhood immunisations	Nigeria	Interviews	3725	Women aged 15–49
Crocker et al. [11]	DTP	UK	Survey	7	Health boards
Babalola et al. [20]	DTP3	Nigeria	Interviews	1,472	Men and women of reproductive age who have children aged 12–35 months (one child per household selected)
Marshall et al. [42]	H1N1	Australia	Survey	3936	General population
Brown, Kroll et al.[38]	H1N1	UK	Questionnaire	142	Parents
Ambrose and Sifakis [9]	H1N1	USA	Retrospective data	3320	38 schools in the 6 localities (students enrolled)
Galarce et al. [12]	H1N1	USA	Survey	1569	Nationally representative sample of U.S. adults age 18 and teachers ($n = 58$), others: administrative staff, counsellors and media specialists
Gargano et al. [7]	H1N1	USA	Survey	66	
Kumar et al. [40]	H1N1	USA	Survey	2079	Adults age 18+
Macdonald et al. [50]	HBV	Australia	Observational	2085	Adults with no evidence of HBV immunity
Cox et al. [26]	HBV	USA	Interviews	1175	Adults recruited from three sexually transmitted disease clinics in the USA over 28 months.
Baars et al. [44]	Hep B	USA	Interviews	320	Men who have sex with men (MSM)
Halliday et al. [22]	Influenza	Australia	Survey	606	Staff in residential aged care facilities
Horby et al. [25]	Influenza	Australia	Survey	7,681	Australians aged 65+
Dip and Cabrera [39]	Influenza	Brazil	Interviews	396	Elderly (age 60–95yrs)
Blank et al. [29]	Influenza	European	Questionnaire	15	15 countries: information regarding elderly 65+
Telford and Rogers [43]	Influenza	UK	Interviews	20	Aged 75+
Holm et al. [37]	Influenza	UK	Survey	10,095	Population age 16+
Smedley et al. [27]	Influenza	UK	Survey	6302	Healthcare workers
Uwemedimo et al. [48]	Influenza	USA	Interviews	168	Non-Hispanic Black and Hispanic children aged 6 months–3 years at the time of interview
Zhang et al. [35]	Influenza	USA	Survey	522	Nurses
Chi et al. [24]	Influenza and Pneumococcal	USA	Survey	54,330	Aged 65+ Veterans
Lawrence et al. [33]	MMR	Australia	Interviews	506	Parents of children in sample
Brown, Long et al. [47]	MMR	UK	Interviews	24	Mothers
Hilton et al. [46]	MMR	UK	Interviews	72	Parents
Jackson et al. [49]	MMR	UK	Interviews	142	Parents
Tickner et al. [36]	MMR	UK	Interviews	21	Parents (of child 2-5yrs)
Brown, Fraser et al. [8]	MMR	UK	Questionnaire	535	Parents of children aged 5–18
Brown, Shanley et al. [41]	MMR	UK	Questionnaire	365	Parents (child aged 5-18)
Cassell et al. [34]	MMR	UK	Questionnaire	452	Mothers (of child aged children aged 15–24mths)
Wroe et al. [45]	MMR	UK	Questionnaire	114	Parents
Bolton-Maggs et al. [23]	MMR	UK	Survey	2456	Students
Hamilton-West [31]	MMR	UK	Survey	252	Students
Tickner et al. [30]	MMR, dTaP/IPV	UK	Questionnaire	255	Parents (child aged 3–5yrs)
Stokley et al. [28]	Pneumococcal conjugate	USA	Survey	66,362	Child (19–35mths)

Hepatitis B, 2 on BCG, 1 on Pneumococcal conjugate, 2 on childhood immunisations and 2 on HBV, (Table 2). Almost half of the studies were conducted within the United Kingdom (17/38). Sample size ranged from 7 to 66,362 (median 514): 31/38 (82%) studies had a sample size greater than 100 and 15/38 (39%) exceeded a sample size of 1000. The majority of the included studies were either surveys or questionnaires (22/38, 58%) or interviews (12/38, 32%), the rest consisted of retrospective, cohort, and observational data. The largest group of respondents were parent(s) 12/38 (32%).

3.2. Application of the 4As taxonomy

Evidence for a total of 23 factors influencing vaccine uptake were identified from the 38 articles reviewed, the largest category being Acceptance factors (12/23, 52%). Table 3 summarises the factors identified under each dimension of the initial 4As taxonomy (Access, Affordability, Awareness, Acceptance) as well as the factors identified under the fifth dimension identified during the literature review (Activation). The following subsections summarise the evidence for each factor identified.

3.2.1. Access factors associated with vaccine uptake (n = 13)

Studies classified under this category revealed that access could be mediated by the place of birth. Three studies conducted in Nigeria found that a significantly higher proportion of infants born within a hospital, or a health facility had the highest proportion of age appropriate immunisations [10,19,20]. The geographical location of the vaccination also had an impact on uptake. Targeting parents prior to discharge from maternity units may improve BCG uptake [21]. Vaccine uptake was also found to increase when arranged by the workplace [22], University [23] or schools [9,11]. The role of access on vaccine uptake was also reflected in the impact of regular contact with the health care system. Students who were registered with a GP were significantly more likely to be vaccinated with MMR [23]. Elderly people in frequent contact with health care services had higher vaccination rates than infrequent users [24], and presence of a chronic disease may be an independent predictor of influenza vaccination [25]. Finally, convenience of access was also related to vaccine uptake. Uptake of HBV vaccine was strongly influenced by perceived inconvenience [26]. Vaccination programs conducted within school hours had higher uptake than if the

Table 3
Summary of the contributing factors identified under each of the 5As dimensions.

Root cause	Bibliographic source
1. Access	
1.1. Place of birth	10, 19, 20
1.2. Location of vaccination	9, 11, 21, 22, 23
1.3. Contact with healthcare systems	23, 24, 25
1.4. Convenience of access	8, 26, 27
2. Affordability	
2.1. Financial incentives	28, 29
2.2. Time costs	27, 30, 31
3. Awareness	
3.1. Knowledge of vaccines and vaccination schedule	32, 33, 34, 35
3.2. Availability of information	27, 36
3.3. Consideration of vaccination	37
4. Acceptance	
4.1. Vaccine	
4.1.1. Perceived safety	7, 12, 22, 27, 31, 35, 36, 38, 39, 40
4.1.2. Perceived efficacy	22, 25, 27, 39
4.1.2. Attitude valence	8, 27, 31, 36, 40, 41
4.2. Disease	
4.2.1. Perceived severity	7, 23, 37, 42
4.1.2. Vulnerability to risk	26, 35, 43, 44
4.3. Individual characteristics	
4.3.1. Health beliefs	34
4.1.2. Omission bias	31, 38, 45
4.1.3. Trust	43, 46, 47
4.1.3. Past behaviour	12, 22, 36, 40, 48
4.4. Social context	
4.2.1. Social responsibility	8, 36, 47
4.1.2. Peer influence	20, 31
4.1.3. HCW influence	7, 36, 37, 44
5. Activation	
5.1. Prompts and reminders	20, 22, 29, 32, 48, 49, 50
5.2. Workplace policies	22, 29

program was after school hours [8]. Over one-third of UK healthcare workers stated they could be persuaded to vaccinate in future if access was more convenient [27].

3.2.2. Affordability factors associated with vaccine uptake (n = 5)

Only two studies among the selected sample examined the impact of financial incentives on vaccine uptake. A US study found an association between state financing policy and full course pneumococcal vaccination [28]. The delivery of vouchers for free influenza vaccination was a contributing factor to high vaccine uptake in the elderly [29]. Three additional studies examined the impact of non-financial costs on vaccine uptake, with time costs as the most prominent non-financial affordability constraints. Parents of children aged 2–5 years reported commitments such as work or other children as a barrier to timely immunisation [30]. Lack of time to attend a vaccination clinic was a stated deterrent for vaccine uptake in 22% of HCWs surveyed [27], and was a significant predictor of non-vaccination with MMR in university students [31].

3.2.3. Awareness factors associated with vaccine uptake (n = 10)

The most common reasons given by parents for failure to vaccinate were poor education and lack of knowledge about the vaccination schedule [32,33]. Conversely, non-compliers of vaccination were significantly more likely to have attended meetings and to have read books on MMR [34]. Increased knowledge of vaccines also improves uptake among HCWs: UK nurses with high knowledge levels were more likely to get vaccinated than those with low knowledge [35]. Besides acquired knowledge, the amount of information available was associated with lower uptake intentions. Parents were dissatisfied with the lack of information about pre-school doses and the lack of contact with a HCW, leading some to question the importance of pre-school immunisation [36]. Conversely, those provided with more information about personal benefit and risk were more willing to be vaccinated [27]. One of the most frequent reasons for not receiving influenza vaccination among UK respondents was simply not having considered immunisation [37].

3.2.4. Acceptance factors associated with vaccine uptake

Acceptance was the most commonly researched aspect of vaccine uptake. The acceptance factors identified pertained to the vaccine itself, the disease it aims to protect individuals from, individual characteristics, as well as the social context.

3.2.4.1. Acceptance factors related to the vaccine (n = 13). Safety concerns including side effects associated with vaccination can have disproportionately detrimental effects on uptake [7,12,22,27,31,35,36,38–40]. For instance, if a vaccine is believed to be safe, vaccination is five times more likely than if it is deemed unsafe [12]. Other determinant factors included concerns or lack of belief in vaccine efficacy [22,25,27,39]. Finally general attitudes towards the vaccine were also predictors of vaccine uptake. Parents with maximum intention to have their child vaccinated had more positive beliefs in regards to MMR vaccine [36]. Likewise positive MMR attitudes independently predicted uptake for both MMR doses [8,41] as were perceived benefits of vaccines and vaccination [27,31,40].

3.2.4.2. Acceptance factors related to the disease (n = 8). A higher perceived severity of a disease increases the intention to receive vaccination [7,23,37,42]. Conversely, perception of influenza as a mild disease reduced willingness to get vaccinated [42]. Other factors associated with vaccine acceptance included the level of perceived risk and vulnerability to the infection was [26,35,43,44].

3.2.4.3. Acceptance factors related to individual characteristics (n = 12). Individual health beliefs were found to influence vaccination acceptance. Mothers who had consulted a homeopath, or

Table 4
Comparison of the dimensions highlighted by existing taxonomies for the root causes of a vaccination gap.

Tailoring immunisation programs (TIP) (key issues)	UNVACC (core problem areas)	SAGE working group (determinants of vaccine hesitancy)	5As (root causes)
Environmental opportunity factors	Physical access to health services	Contextual influences	Access
Supportive ability factors	Missed opportunities during health service delivery	Vaccine and vaccination-specific issue	Affordability
Personal motivation factors	Health worker knowledge, practice & attitude	Individual/social group influences	Awareness
	Vaccine availability		Acceptance
	Care-giver information, beliefs & attitudes		Activation
	Community/societal factors		

who believed that "it is better to get immunity naturally" were significantly less likely to immunise their children with MMR [34]. Similarly, individuals' emotions and cognitive biases have been shown to influence uptake. Omission bias, in which harm from an action is rated less favourably than harm from inaction even when those outcomes are objectively similar, was also identified as a barrier to vaccination decisions [31,38,45]. Individuals' feelings of trust were also related to acceptance. Significantly more mothers who expressed lack of trust in the government or in pharmaceutical companies did not vaccinate their children with MMR [46]. Trust in health professionals and vaccine policy was found to be central to acceptance of MMR [47] as is trust of modern medicine for influenza uptake in the elderly [43]. Besides cognitive and emotional individual characteristics, past behaviour and previous vaccination acceptance was also a strong predictor of vaccine uptake [12,22,36,40,48].

*3.2.4.4. Acceptance factors related to the social context (*n = *8).* Social attitudes, including viewing vaccination as a social responsibility and the feeling that one ought to protect others' children predicted uptake [8,36,47]. Peer influence is also important. In Nigeria, perceived social approval significantly predicted DTP3 uptake [20] while perceived peer acceptance of MMR vaccination significantly predicted uptake in university students [31]. Finally, personal recommendations by HCWs were also found to have a strong normative influence on vaccine uptake among patients, parents, or teachers [7,36,37,44].

*3.2.5. Activation factors associated with vaccine uptake (*n = *8)*

A few studies mentioned factors associated with vaccine uptake which were not anticipated by the 4As taxonomy, calling for a fifth dimension, which we labelled Activation. Activation refers to the actions that nudge people who intend to get vaccinated towards vaccine uptake. Two types of nudging techniques to boost activation were identified: Prompts and reminders as well as workplace policies. Children attending facilities with reminder systems in place were five times more likely to receive a flu vaccine, in comparison to healthcare facilities without these systems [48]. Similarly, providing reminders to staff in aged care facilities significantly increased influenza vaccination uptake [22] and children in Nigeria with immunisations cards were 2.5 times more likely to be immunised than those without the cards [20,32]. Likewise, providing a leaflet and a parent meeting [49], sending of a personal letter [29], decreasing the time lag between consultation and vaccination [50] were all associated with higher vaccine uptake. Finally, workplace policies and practices such as information to HCW staff [22] and predetermined targets for HCW vaccination coverage was also associated with vaccination uptake [29].

4. Discussion

The objective of this narrative review was to determine whether the 4 domains of *Access*, *Affordability*, *Awareness* and *Acceptance* could adequately describe and organise all of the non-socio-demographic determinants of vaccine uptake. We deliberately sought to develop a taxonomy that may facilitate the identification and analysis by public health practitioners and vaccination program managers of the multiple causes that may underpin a vaccination coverage gap, to inform the implementation of evidence-based interventions. Compared to other classifications of determinants of uptake, this taxonomy is deliberatively simple, intuitive and alliterative, with the express aim of facilitating a mutual understanding of a complex problem (see Table 4 for a comparison of existing classification schemes). Socio-demographic factors were excluded from this taxonomy because these factors, while important, cannot be influenced by interventions. This review identified a fifth domain, *Activation*, which interestingly captured some of the most effective interventions.

Consistent with many studies that have shown that provision of information and increased knowledge (Awareness) may not change intentions or behaviours [16,51], these findings suggest that although there is a relationship between knowledge and acceptance, it is far from straightforward. Awareness and knowledge may be associated with an increase in acceptance among practitioners, but with a decrease in uptake in the general public. Moreover, in many contexts, access to, and affordability (both financial and non-financial costs) of immunisation remain barriers to uptake.

Another finding was that the most commonly studied predictors of vaccination uptake were related to *Acceptance*. Consistent with a traditional psychological approach to the study of the determinants of health behaviour (e.g., the health belief model [52] or the theory of planned behaviour [53,54]), factors included judgements about one's susceptibility to contract an infectious disease, the perceived severity of a contamination as well as perceived benefits and judged efficacy of vaccination, concerns about side effects and the impact of social norms. Interestingly, using *Acceptance* as a coding category also highlighted additional possible determinants such as trust, cognitive biases and past behaviours.

The fifth classification that we termed *Activation* (deliberately alliterative) emerged from this study in the form of interventions that made vaccination as easy as possible through facilitation of access, made it a net positive, rather than negative, experience with small incentives [49], made vaccination the default rather than a choice, or provided reminders [40].

There is some ambiguity and possible overlap between the A's for some factors. Convenience could, for example, be *Access*, *Affordability*, or *Activation* depending on the context and interpretation. However, the 5As taxonomy has been developed here with a very pragmatic objective—to facilitate the classification and characterisation of various possible determinants of a coverage gap by an inter-sectorial working group. Thus, this taxonomy should be conceived as a set of working definitions rather than a rigid nomenclature.

4.1. Limitations of the review

Although this systematic review attempted to cast a wide net over many countries and vaccinations, developing countries were underrepresented and many vaccines were not included in the analysis. The vast majority of research was conducted within the UK, USA and Australia (86%). We should thus be cautious in assuming that these results can be generalised or have a strong degree of applicability to understand the vaccination gap in developing countries or for a variety of vaccines.

Moreover, we did not conduct a meta-analysis of the weight of the determinants identified given the variance in vaccine type, populations and countries. As such, this study did not aim to comprehensively capture nor weight the various determinants of vaccine uptake. Instead, it was intended to provide a preliminary proof-of-concept for using the 5As as a conceptual framework to identify and classify the different determinants of vaccine uptake with a view to inform future research and interventions aiming to reduce immunisation gaps.

5. Conclusions

Previous research on vaccine uptake has identified a multitude of potential determinants. As a result, it is difficult to decide which determinant should be targeted when designing interventions to improve uptake. The 5As taxonomy effectively captured all of the determinants of vaccine uptake identified in this literature

review. Future research may use this taxonomy to systematically compare and weight the importance of each of the 5As in explaining a vaccination gap for different vaccines or for one vaccine in different socio-cultural contexts. This in turn, would allow targeted, research-informed, interventions aiming to increase coverage rates. This taxonomy is currently being tested in pilots of an integrated approach to diagnose and improve a vaccination gap. It has already effectively facilitated a mutual understanding of the primary determinants of suboptimal coverage among intersectorial working groups in four countries, a first step towards them developing targeted and effective solutions.

Conflict of interest statements

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References

[1] WHO. Meeting of the Strategic Advisory Group of Experts on immunization October 2014—conclusions and recommendations. Wkly Epidemiol Rec 2014;89:561–76.
[2] Preaud E, Durand L, Macabeo B, Farkas N, Sloesen B, Palache A, et al. Annual public health and economic benefits of seasonal influenza vaccination: a European estimate. BMC Public Health 2014;14:813, http://dx.doi.org/10.1186/1471-2458-14-813.
[3] European Commission. The state of health policy of vaccination in the EU. 2014. ⟨http://ec.europa.eu/health/vaccination/docs/20141223_state_health_vaccination_en.pdf⟩ (accessed July 3, 2015).
[4] Hickler B, Guirguis S, Obregon R. Vaccine special issue on vaccine hesitancy. Vaccine 2015;33:4155–6, http://dx.doi.org/10.1016/j.vaccine.2015.04.034.
[5] Sadaf A, Richards JL, Glanz J, Salmon DA, Omer SB. A systematic review of interventions for reducing parental vaccine refusal and vaccine hesitancy. Vaccine 2013;31:4293–304, http://dx.doi.org/10.1016/j.vaccine.2013.07.013.
[6] Smith PJ, Marcuse EK, Seward JF, Zhao Z, Orenstein WA. Children and adolescents unvaccinated against measles: geographic clustering parents' beliefs, and missed opportunities. Public Health Rep Wash DC 1974, vol. 130; 2015. p. 485–504.
[7] Gargano LM, Painter JE, Sales JM, Morfaw C, Jones LM, Murray D, et al. Seasonal and 2009 H1N1 influenza vaccine uptake, predictors of vaccination, and self-reported barriers to vaccination among secondary school teachers and staff. Hum Vaccin 2011;7:89–95, http://dx.doi.org/10.4161/hv.7.1.13460.
[8] Brown K, Fraser G, Ramsay M, Shanley R, Cowley N, van Wijgerden J, et al. Attitudinal and demographic predictors of measles–mumps–rubella vaccine (MMR) uptake during the uk catch-up campaign 2008–09: cross-sectional survey. PLoS ONE 2011;6:e19381, http://dx.doi.org/10.1371/journal.pone.0019381.
[9] Ambrose CS, Sifakis F. Factors associated with increased vaccination in 2009 H1N1 school-located influenza vaccination programs. Hum Vaccin 2011;7:864–7, http://dx.doi.org/10.4161/hv.7.8.16281.
[10] Antai D. Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants. BMC Infect Dis 2009;9:181, http://dx.doi.org/10.1186/1471-2334-9-181.
[11] Crocker J, Porter-Jones G, McGowan A, Roberts RJ, Cottrell S. Teenage booster vaccine: factors affecting uptake. J Public Health 2012;34:498–504, http://dx.doi.org/10.1093/pubmed/fds047.
[12] Galarce EM, Minsky S, Viswanath K. Socioeconomic status, demographics, beliefs and A(H1N1) vaccine uptake in the United States. Vaccine 2011;29:5284–9, http://dx.doi.org/10.1016/j.vaccine.2011.05.014.
[13] WHO. The guide to tailoring immunization programmes (TIP). World Health Organization; 2013.
[14] Eggers R. Tools for identifying root causes of children remaining unvaccinated; 2014 (http://www.globe-network.org/sites/default/files/en/network/resource/12.eggers-rudi-tools-for-identifying-root-causes-of-children-remaining-unvaccinated.pdf) (accessed December 7, 2015).
[15] Larson HJ, Jarrett C, Eckersberger E, Smith DMD, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007–2012. Vaccine 2014;32:2150–9, http://dx.doi.org/10.1016/j.vaccine.2014.01.081.
[16] National University of Ireland, Galway, European Centre for Disease Prevention and Control. In: Cairns G, editor. Systematic literature review of the evidence for effective national immunisation schedule promotional communications: insights into health communication. Stockholm: ECDC [u.a.]; 2012.
[17] WHO. WHO prequalified vaccines. WHO; 2015. ⟨http://www.who.int/immunization_standards/vaccine_quality/PQ_vaccine_list_en/en/⟩ (accessed November 23, 2015).
[18] Kessels SJ, Marshall HS, Watson M, Braunack-Mayer AJ, Reuzel R, Tooher RL. Factors associated with HPV vaccine uptake in teenage girls: a systematic review. Vaccine 2012;30:3546–56.
[19] Olusanya BO. Pattern and determinants of BCG immunisation delays in a sub-Saharan African community. Health Res Policy Syst 2010;8(1), http://dx.doi.org/10.1186/1478-4505-8-1.
[20] Babalola S. Determinants of the uptake of the full dose of diphtheria–pertussis–tetanus vaccines (DPT3) in Northern Nigeria: a multilevel analysis. Matern Child Health J 2009;13:550–8, http://dx.doi.org/10.1007/s10995-008-0386-5.
[21] Athavale D, McCullough S, Mactier H. Implementing the new BCG vaccination guidelines—a maternity hospital-based clinic approach. J Public Health 2006;28:133–6, http://dx.doi.org/10.1093/pubmed/fdi078.
[22] Halliday L, Thomson JA, Roberts L, Bowen S, Mead C. Influenza vaccination of staff in aged care facilities in the ACT: how can we improve the uptake of influenza vaccine? Aust N Z J Public Health 2003;27:70–5, http://dx.doi.org/10.1111/j.1467-842X.2003.tb00383.x.
[23] Bolton-Maggs D, Conrad D, Keenan A, Lamden K, Ghebrehewet S, Vivancos R. Perceptions of mumps and MMR vaccination among university students in England: an online survey. Vaccine 2012;30:5081–5, http://dx.doi.org/10.1016/j.vaccine.2012.05.078.
[24] Chi R-C, Reiber GE, Neuzil KM. Influenza and pneumococcal vaccination in older veterans: results from the behavioral risk factor surveillance system. J Am Geriatr Soc 2006;54:217–23, http://dx.doi.org/10.1111/j.1532-5415.2005.00577.x.
[25] Horby PW, Williams A, Burgess MA, Wang H. Prevalence and determinants of influenza vaccination in Australians aged 40 years and over—a national survey. Aust N Z J Public Health 2005;29:35–7, http://dx.doi.org/10.1111/j.1467-842X.2005.tb00745.x.
[26] Cox AD, Cox D, Cyrier R, Graham-Dotson Y, Zimet GD, Can self-prediction overcome barriers to Hepatitis B. vaccination? A randomized controlled trial. Health Psychol 2012;31:97–105, http://dx.doi.org/10.1037/a0025298.
[27] Smedley J, Poole J, Waclawski E, Stevens A, Harrison J, Watson J, et al. Influenza immunisation: attitudes and beliefs of UK healthcare workers. Occup Environ Med 2006;64:223–7, http://dx.doi.org/10.1136/oem.2005.023564.
[28] Stokley S, Shaw KM, Barker L, Santoli JM, Shefer A. Impact of state vaccine financing policy on uptake of heptavalent pneumococcal conjugate vaccine. Am J Public Health 2006;96:1308–13, http://dx.doi.org/10.2105/AJPH. 2004.057810.
[29] Blank P, Schwenkglenks M, Szucs TD. The impact of European vaccination policies on seasonal influenza vaccination coverage rates in the elderly. Hum Vaccines Immunother 2012;8:328–35, http://dx.doi.org/10.4161/hv.18629.
[30] Tickner S, Leman PJ, Woodcock A. Factors underlying suboptimal childhood immunisation. Vaccine 2006;24:7030–6, http://dx.doi.org/10.1016/j.vaccine.2006.06.060.
[31] Hamilton-West K. Factors influencing MMR vaccination decisions following a mumps outbreak on a university campus. Vaccine 2006;24:5183–91, http://dx.doi.org/10.1016/j.vaccine.2006.03.084.
[32] Elliott C, Farmer K. Immunization status of children under 7 years in the Vikas Nagar area North India. Child Care Health Dev 2006;32:415–21, http://dx.doi.org/10.1111/j.1365-2214.2006.00623.x.
[33] Lawrence GL, MacIntyre CR, Hull BP, McIntyre PB. Measles vaccination coverage among five-year-old children: implications for disease elimination in Australia. Aust N Z J Public Health 2003;27:413–8, http://dx.doi.org/10.1111/j.1467-842X.2003.tb00419.x.
[34] Cassell JA, Leach M, Poltorak MS, Mercer CH, Iversen A, Fairhead JR. Is the cultural context of MMR rejection a key to an effective public health discourse? Public Health 2006;120:783–94, http://dx.doi.org/10.1016/j.puhe.2006.03.011.
[35] Zhang J, While AE, Norman IJ. Nurses' knowledge and risk perception towards seasonal influenza and vaccination and their vaccination behaviours: a cross-sectional survey. Int J Nurs Stud 2011;48:1281–9, http://dx.doi.org/10.1016/j.ijnurstu.2011.03.002.
[36] Tickner S, Leman PJ, Woodcock A. Parents' views about pre-school immunization: an interview study in southern England. Child Care Health Dev 2010;36:190–7, http://dx.doi.org/10.1111/j.1365-2214.2009.01020.x.
[37] Holm MV, Blank PR, Szucs TD. Developments in influenza vaccination coverage in England Scotland and Wales covering five consecutive seasons from 2001 to 2006. Vaccine 2007;25:7931–8, http://dx.doi.org/10.1016/j.vaccine.2007.09.022.
[38] Brown KF, Kroll JS, Hudson MJ, Ramsay M, Green J, Vincent CA, et al. Omission bias and vaccine rejection by parents of healthy children: Implications for the influenza A/H1N1 vaccination programme. Vaccine 2010;28:4181–5, http://dx.doi.org/10.1016/j.vaccine.2010.04.012.
[39] Dip RM, Cabrera MAS. Influenza vaccination in non-institutionalized elderly: a population-based study in a medium-sized city in Southern Brazil. Cad Saúde Pública 2010;26:1035–44, http://dx.doi.org/10.1590/S0102-311X2010000500025.
[40] Kumar S, Quinn SC, Kim KH, Musa D, Hilyard KM, Freimuth VS. The social ecological model as a framework for determinants of 2009 H1N1 influenza vaccine uptake in the United States. Health Educ Behav 2012;39:229–43, http://dx.doi.org/10.1177/1090198111415105.

[41] Brown KF, Shanley R, Cowley NAL, van Wijgerden J, Toff P, Falconer M, et al. Attitudinal and demographic predictors of measles, mumps and rubella (MMR) vaccine acceptance: development and validation of an evidence-based measurement instrument. Vaccine 2011;29:1700–9, http://dx.doi.org/10.1016/j.vaccine.2010.12.030.

[42] Marshall H, Tooher R, Collins J, Mensah F, Braunack-Mayer A, Street J, et al. Awareness, anxiety, compliance: community perceptions and response to the threat and reality of an influenza pandemic. Am J Infect Control 2012;40:270–2, http://dx.doi.org/10.1016/j.ajic.2011.03.015.

[43] Telford R, Rogers A. What influences elderly peoples' decisions about whether to accept the influenza vaccination? A qualitative study. Health Educ Res 2003;18:743–53, http://dx.doi.org/10.1093/her/cyf059.

[44] Baars JE, Boon BJ, Garretsen HF, van de Mheen D. The reach of a hepatitis B vaccination programme among men who have sex with men. Eur J Public Health 2011;21:333–7, http://dx.doi.org/10.1093/eurpub/ckq117.

[45] Wroe AL, Bhan A, Salkovskis P, Bedford H. Feeling bad about immunising our children. Vaccine 2005;23:1428–33, http://dx.doi.org/10.1016/j.vaccine.2004.10.004.

[46] Hilton S, Petticrew M, Hunt K. Parents' champions vs. vested interests: Who do parents believe about MMR? A qualitative study. BMC Public Health 2007;7:42, http://dx.doi.org/10.1186/1471-2458-7-42.

[47] Brown KF, Long SJ, Ramsay M, Hudson MJ, Green J, Vincent CA, et al. UK parents' decision-making about measles–mumps–rubella (MMR) vaccine 10 years after the MMR-autism controversy: a qualitative analysis. Vaccine 2012;30:1855–64, http://dx.doi.org/10.1016/j.vaccine.2011.12.127.

[48] Uwemedimo OT, Findley SE, Andres R, Irigoyen M, Stockwell MS. Determinants of influenza vaccination among young children in an inner-city community. J Community Health 2011;37:663–72, http://dx.doi.org/10.1007/s10900-011-9497-9.

[49] Jackson C, Cheater FM, Harrison W, Peacock R, Bekker H, West R, et al. Randomised cluster trial to support informed parental decision-making for the MMR vaccine. BMC Public Health 2011;11:475, http://dx.doi.org/10.1186/1471-2458-11-475.

[50] Macdonald V, Dore GJ, Amin J, van Beek I. Predictors of completion of a hepatitis B vaccination schedule in attendees at a primary health care centre. Sex Health 2007;4:27, http://dx.doi.org/10.1071/SH06008.

[51] Nyhan B, Reifler J, Richey S, Freed GL. Effective messages in vaccine promotion: a randomized trial. Pediatrics 2014;133:e835–42, http://dx.doi.org/10.1542/peds.2013-2365.

[52] Becker MH, Maiman LA. Sociobehavioral determinants of compliance with health and medical care recommendations. Med Care 1975;13:10–24.

[53] Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process 1991;50:179–211.

[54] Ajzen I, Fishbein M. Attitudes and the attitude-behavior relation: reasoned and automatic processes. Eur Rev Soc Psychol 2000;11:1–33, http://dx.doi.org/10.1080/14792779943000116.