Factors affecting healthcare worker COVID-19 vaccination acceptance and uptake: a living behavioural science evidence synthesis (v3, Jun 18th, 2021)

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Research Questions: How can behavioural science help inform messaging to and broader supports for healthcare workers to encourage vaccination for COVID-19? How can behavioural science help address vaccine-related concerns from equity-seeking groups?

New in this update (version 3, 18th Jun, 2021)

- 30 studies were added including 2 Canadian studies, with 28 measuring COVID-19 vaccination acceptance and 2 measuring actual uptake in healthcare workers (HCWs).
- 4/30 studies based their surveys on the Health Belief Model (a well-tested behavioural model that identifies how perceptions about the severity and vulnerability of disease, and benefits, barriers, and cues to action influence behaviour) which complement our understanding of a subset of key aspects of vaccine acceptance/uptake.
- 5/30 studies (UK & USA) found that COVID-19 vaccination acceptance/uptake was generally higher in respondents identifying as White versus those identifying as Black, although none of these studies sought to explicitly explain any differences or similarities in terms of barriers/enablers of vaccination acceptance.

Key overall findings

- We identified 94 studies assessing factors associated with vaccination acceptance and uptake among HCWs; 8 studies were conducted in Canada. Most (*k*=68) collected data since COVID-19 vaccines have been approved (Nov, 2020 – Apr, 2021 in this update).
- Across North American studies, a median of 69% of HCWs reported being willing to accept a COVID-19 vaccine (*k*=27; IQR=45-81%). Of those, 76% of Canadian HCW respondents were willing (*k*=8; IQR=62-80%). In studies conducted outside of North America, 64% of HCWs were willing to accept a vaccine for COVID-19 (*k*=61, IQR=49-79%).
- 6 studies measured actual COVID-19 vaccination uptake among HCWs with 80% of HCWs being vaccinated (k=6; IPQ=73-85%), however, none were conducted in Canada.
- We categorised all identified **BARRIERS** and **ENABLERS** to vaccine acceptance/uptake in HCWs using the **Capability**, **Opportunity**, and **Motivation**-Behaviour (COM-B) model and the *Theoretical Domains Framework* to inform how different strategies might be leveraged to address different types of predominant issues.
    1. **Capability**-related factors identified mostly concerned *Knowledge* (or lack thereof) but only in a relatively few studies.
    2. **Opportunity**-related factors identified included *Environmental context and resources* and *Social influences* (which remains an especially important factor among HCWs, consistent with data from the <u>general public</u>).
    3. **Motivation**-related factors identified included *Beliefs about consequences* (including concerns and erroneous beliefs about COVID-19 vaccine safety, efficacy, and necessity were common across studies and associated with lower

vaccination acceptance), *Beliefs about capabilities*, *Social/professional role and identity* (with lower acceptance rates among non-physician HCWs, although the extent to which this applies to Canadian HCWs is unclear given limited available data), *Reinforcement* (in particular having a history of getting other vaccinations), and *Emotion*.

- The top 5 most frequent **BARRIERS** to HCW vaccination acceptance/uptake include:
    1. Concerns about COVID-19 vaccine safety (*k*=34)
    2. COVID-19 vaccine acceptance rates differ among HCWs in different roles (*k*=23)
    3. Concerns about COVID-19 vaccine efficacy (*k*=12)
    4. Concerns about COVID-19 vaccine development (*k*=10)
    5. Mistrust in government/public health response to COVID-19 (*k*=10)
- The top 5 most frequent **ENABLERS** to HCW vaccination acceptance/uptake include:
    1. Historical seasonal influenza vaccination (*k*=27)
    2. Concerns about becoming infected with COVID-19 (*k*=10)
    3. Working directly with COVID-19+ patients during the pandemic (*k*=8)
    4. Having access to and trust in reputable information sources (*k*=6)
    5. Positive attitudes/high perceived benefit of COVID-19 vaccines (*k*=6)
- 16 studies assessed whether vaccine acceptance in HCWs was associated with race and ethnicity; 15 studies found some evidence that racialized (e.g., Black, Latinx, Asian) respondents were less likely to express vaccine acceptance vs. White respondents. However, only 1 study explicitly explored barriers/enablers of vaccination acceptance based on race/ethnicity, identifying *Social influences* (consistent with the importance of trusted others across all HCWs) and *Beliefs about consequences* (namely indicating that concerns specifically about vaccine development were more common among Black, Latinx, and Asian vs. White respondents while concerns over safety were identified across groups).
- While there is an increasing number of published Canadian research looking at vaccination acceptance in HCWs, more Canadian research would help to better serve and support HCWs from equity-seeking groups.

Key implications
- Across 8 of 14 Theoretical Domains Framework domains, we identified 20 **BARRIERS** and **ENABLERS** which may have implications for COVID-19 vaccine interventions.
- Based on these data, there is considerable evidence for **Motivation**-related factors associated with COVID-19 vaccination acceptance and uptake which may help influence

vaccination messaging, campaigns, and program design. However, we also need to support motivated individuals who may experience barriers to access which may be outside their control (**Opportunity**-related factors).

- Addressing these key and recurring barriers and enablers in HCWs should involve multiple approaches at multiple levels. A one-size-fits-all approach is unlikely to address the range of barriers and enablers expressed by HCWs. Behavioural strategies for addressing **Capability**-related barriers/enablers differ from those addressing **Opportunity** or **Motivation**. There would likely be benefit in leveraging approaches that empathise with the safety (and possible side effects), efficacy, and development concerns transparently from trusted sources that likely differ for different groups of HCWs, using modalities beyond information provision and without relying only on numeracy-based risk information. Strategies shown to be effective in supporting vaccination acceptance/uptake in HCWs for other vaccines [1] should be carefully considered in terms of how they address **Capability**-, **Opportunity**-, or **Motivation**-related barriers currently known for COVID-19 vaccines.

- Ultimately, COVID-19 vaccination behaviour in HCWs is a multifaceted issue which likely requires a multilevel and multifaceted approach to address the needs and concerns of individuals and groups.

Introduction: Leveraging behavioural science to provide a new lens on HCW COVID-19 vaccination

Recent breakthroughs in vaccine development have been crucial for curbing the COVID-19 pandemic. As of Jun 17, 2021, it is estimated almost 3.8 million people have died from COVID-19, including almost 26,000 Canadians (cf. Johns Hopkins COVID tracker). As vaccine programs continue to be steadily being rolled out across Canada, addressing vaccination acceptance and uptake among high-priority groups such as frontline healthcare (HCWs) remains an urgent public health challenge. It is therefore crucial to better understand the factors associated with vaccination acceptance and uptake among HCWs generally and among HCWs from equity-seeking groups (e.g., those experiencing racial, ethnic, and socioeconomic disparities/marginalization). This is especially important given the disproportionate health, economic, and emotional impact COVID-19 has had on equity-seeking groups in Canada.

A behavioural science approach does not imply an individual-focus, nor does it put the onus of responsibility on individuals. Rather, framing COVID-19 vaccination uptake as a behaviour allows us to draw upon decades of research aimed at understanding factors that affect what people think, feel, decide, and ultimately do. Such an approach fully recognizes that what individuals, groups, communities, and populations do is shaped by the past and present experiences, resources, and constraints afforded or not by the social and physical contexts in which they live and work. These experiences and affordances (or lack thereof) ultimately serve to shape the Capability, Opportunity, and Motivation that drive the behaviour of individuals and groups (cf. COM-B model [2]).

Capability-, Opportunity- and Motivation-related factors of individuals are shaped by the multiple social, cultural, historical, community, governmental, clinical, and environmental levels that influence acceptance and uptake of COVID-19 vaccination. We drew upon the overarching COM-B model to situate 14 key behavioural factors that can drive vaccination intention and uptake (**Figure 1**). These 14 factors are reflected in the Theoretical Domains Framework (TDF), a synthesis of decades of research and evidence of the key, modifiable factors that influence behaviour [3–5]. TDF factors are linked to specific behaviour change techniques [6] that can be used to address particular barriers and enablers to vaccination, thus linking barriers to solutions. Using these approaches can enable exploration of whether different factors influence vaccine acceptance in different equity-seeking groups which may point to strategies and programs that address the needs and concerns of these groups. Such approaches have been used extensively to understand and address behaviour change in other health-related contexts but have yet to be fully leveraged to address COVID-19 vaccination acceptance and uptake [7].

As part of a living behavioural science evidence synthesis (LBSES), we will use perspectives from the COM-B model and TDF to help identify factors affecting vaccination acceptance and uptake among HCWs both globally and in Canada, and in particular those serving equity-seeking groups.

Living Behavioural Science Evidence Synthesis Objectives
1. Identify rates of vaccination acceptance in HCWs globally and in Canada.
2. Identify rates of vaccination uptake in HCWs globally and in Canada.
3. Identify factors associated with COVID-19 vaccination acceptance and uptake among HCWs globally and in Canada.
4. Identify factors associated with COVID-19 vaccination acceptance and uptake among HCWs serving equity-seeking groups globally and in Canada.

Figure 1. Potential drivers of vaccination acceptance and uptake based on the COM-B model and Theoretical Domains Framework, embedded within social and structural factors
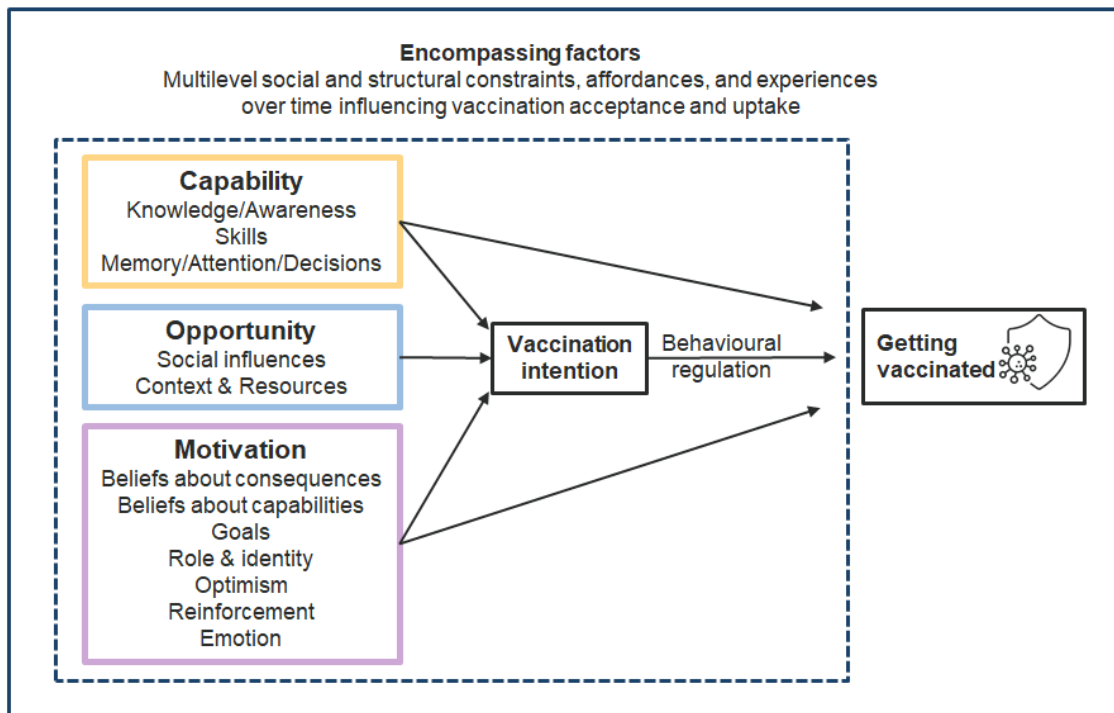
Methods

Data sources

We identified 5 databases that have been capturing published peer-reviewed papers, preprints, published reports, and unpublished datasets relating to our research questions. The first database is run by the McMaster Health Forum who produces a monthly Living Evidence Profile looking at COVID-19 vaccine rollout which includes acceptance/uptake. This Profile is searched manually for relevant papers. The second database is run by Kristin Konnyu (Brown University, USA) who is co-author on this report. This database includes weekly searches of MEDLINE (via PubMed) and the Cochrane Register of Clinical Trials (PROSPERO registration: CRD42021253533). Two researchers have been independently undertaking level 1 (title and abstract) and level 2 (full-text) screening (screening team includes co-authors Crawshaw, Konnyu, Castillo, and van Allen). Discrepancies during screening are being resolved via consensus meetings. Data extraction is being undertaken by Crawshaw, Konnyu, Castillo, and van Allen. The following links represent the most recent publically-available reports based on the databases detailed above:

- *Rapid Evidence Review: What are the barriers and facilitators to individuals' willingness to be vaccinated for COVID-19?* [8]; *Understanding and promoting COVID-19 vaccine uptake among marginalized communities in RI* [9] **(Database managed by Kristin Konnyu, co-author on this report. Manually searched up until May 24, 2021).**
- *COVID-19 Rapid Evidence Profile #24: What is known about strategies for encouraging vaccine acceptance and addressing vaccine hesitancy or uptake?* [10] (**Most recent search: Nov 18, 2020**).
- *Evidence Synthesis Briefing Note: COVID-19 Vaccine Uptake Among Health Care Workers* [11] (**Most recent search: Jan 22, 2021**).
- *Evergreen Rapid Review on COVID-19 Vaccine Knowledge, Attitudes, and Behaviours – Update* 6 [12] (**Most recent search: May 1, 2021**).
- *COVID-19 Living Evidence Profile #1: What is known about anticipated COVID-19 vaccine roll-out elements?* [13] **(Most recent search: Apr 20, 2021).**

Inclusion criteria

- *Population:* HCWs in general and particularly those from equity-seeking groups (HCW role could be self-identified).
- *Outcome:* Studies had to include a measure (self-report and/or objective) of COVID-19 vaccination willingness/intention/hesitancy/acceptance (referred to as **vaccination**

acceptance hereafter), and/or uptake. Vaccination acceptance and uptake had to relate to HCWs being vaccinated themselves.
- *Time:* Onset of the COVID-19 pandemic (Jan 2020) onwards.
- *Design:* Qualitative and survey (observational) data; cross-sectional, prospective and cohort designs.

Exclusion criteria
- *Population:* General public samples only (we are capturing these data as part of another LBSES focusing on the general public, see Gen Pub LBSES v2).
- *Outcome:* Studies that only included a measure of vaccination knowledge. Vaccination acceptance and uptake in relation to vaccinating others (e.g., family members, patients).

Data extraction

Data sources were manually screened and cross-referenced for relevant studies (version 1 final search date: Feb 3, 2021; version 2 final search date: Apr 20, 2021; version 3 final search date: May 24, 2021). A standardised data extraction form (**Appendix 1**) was used to extract relevant data relating to study characteristics, behavioural specification (based on the AACTT tool [14]), factors affecting vaccination acceptance and uptake based on the COM-B model and TDF, and equity-related data. Factors affecting COVID-19 vaccination were distilled into key barriers and enablers. Recommendations were based on key barriers/enablers were drawn from the team's expertise in behavioural science, rather than data (although future planned LBSES will explore this further). Equity-related data were extracted separately with a particular focus on studies conducted in Canada. A list of equity-related factors was created based on factors identified in the PROGRESS framework [15], intersecting categories of privilege and oppression [16], and those considered part of an equity approach by PHAC. '*k*' refers to the number of studies. Where available, we have captured key statistical analyses (odds ratios (OR); adjusted odds ratios (ORa)) on the factors associated with higher or lower vaccination acceptance and uptake.

Results

Study characteristics

A total of 94 studies (including 30 studies that were added for version 3 update) met our inclusion criteria [17–110]. **Appendix 2** provides an overview of the 94 studies. 67 were published peer-reviewed papers, 23 were preprints, 3 were published reports, and 1 study was an unpublished dataset. 68/94 studies collected data in the period since COVID-19 vaccine approval (from Nov, 2020 onwards). 89/94 studies used cross-sectional survey designs. 88/94 studies measured COVID-19 vaccination acceptance; 8/94 studies measured uptake, and 2 qualitative studies did not report quantitative data on vaccination acceptance/uptake [24,48].

32/94 studies were conducted exclusively in North America of which 7 were conducted exclusively in Canada [28,33,52,76,78,89,99]. 1 study collected data from Canada, France, and Belgium [102]. 62 studies were conducted outside of North America: Israel [32,110]; China [38,94,103,108]; Italy [30,31,64]; Taiwan [61]; Mexico [25]; Saudi Arabia [22,85,98]; Turkey [41,55,60,106,109]; Greece [66,79]; Greece and Cyprus [87]; Germany [23,45,56,73]; UK [17,46,100,105]; Lebanon [107]; Slovenia [83]; Poland [59,97]; Columbia [21]; Palestine [86]; Egypt [35,50,90]; Ghana [18]; India [96], Hong Kong [63,104]; France [29,40,81]; Cameroon [37]; Indonesia [47]; Democratic Republic of Congo [74]; Nepal [80]; Vietnam [51]; Zambia [26]; [50]; Malta [42,43]; Iraq [20]; Uganda [54]; Palestine [68]; Libya [34]; Pakistan [88]; multicounty (Europe) [82]; multicountry (Asia) [27]; multicountry (Arabian Gulf) [19].

58/94 studies recruited broad HCW samples. 36/94 studies recruited specific professions/specialities: medical students [54,65,90]; skilled nursing facility staff [48]; dental professionals/students [69,110]; paediatricians [41]; intensive care staff [56]; physicians [21]; nurses [86]; long-term care home staff [100]; non-physicians [28,39], nursing home/assisted living staff [101], continuing care workers [89], pharmacy professionals [78], personal support workers [99], nurses/trainee nurses [63,67,82,104], lab medical professionals [26], physicians/trainee physicians [42]; ophthalmology residents [59]; emergency medical services personnel [73]; doctor and nurses [94]; school nurses [49]. 9/94 studies recruited mixed samples including HCWs, general public, and patients [20,34,44,57,61,70,76,83,109].

Objective 1: COVID-19 vaccination acceptance rates among HCWs

Among North American studies, the median average of HCWs willing to accept a COVID-19 vaccine was 69% (*k*=27; IQR=45-81%) (**Figure 2**). In Canada specifically, 76% of HCWs were willing to accept a COVID-19 vaccine (*k*=8; IQR=62-80%). In studies conducted outside of North

America, 64% of HCWs were willing to accept a vaccine for COVID-19 (k=61, IQR=49-79%) (**Figure 3**). Among studies conducted in the period since COVID-19 vaccine approval (from Nov, 2020 onwards) (k=64), 64% (IQR=46-80%) of HCWs were willing to accept a COVID-19 vaccine.

Objective 2: COVID-19 vaccination uptake rates among HCWs

6/94 studies measured uptake of COVID-19 vaccines [36,46,57,77,92,100], however, none were conducted in Canada. Among these studies, 80% of HCWs received the vaccine (k=6; IPQ=73-85%). Data from the Government of Canada website is currently no longer reporting on COVID-19 vaccination uptake among HCWs.

Figure 2. Box-and-whisker plots showing mean % vaccination acceptance rates among HCWs over time (May, 2020 - Mar, 2021) for North American studies (k=27)
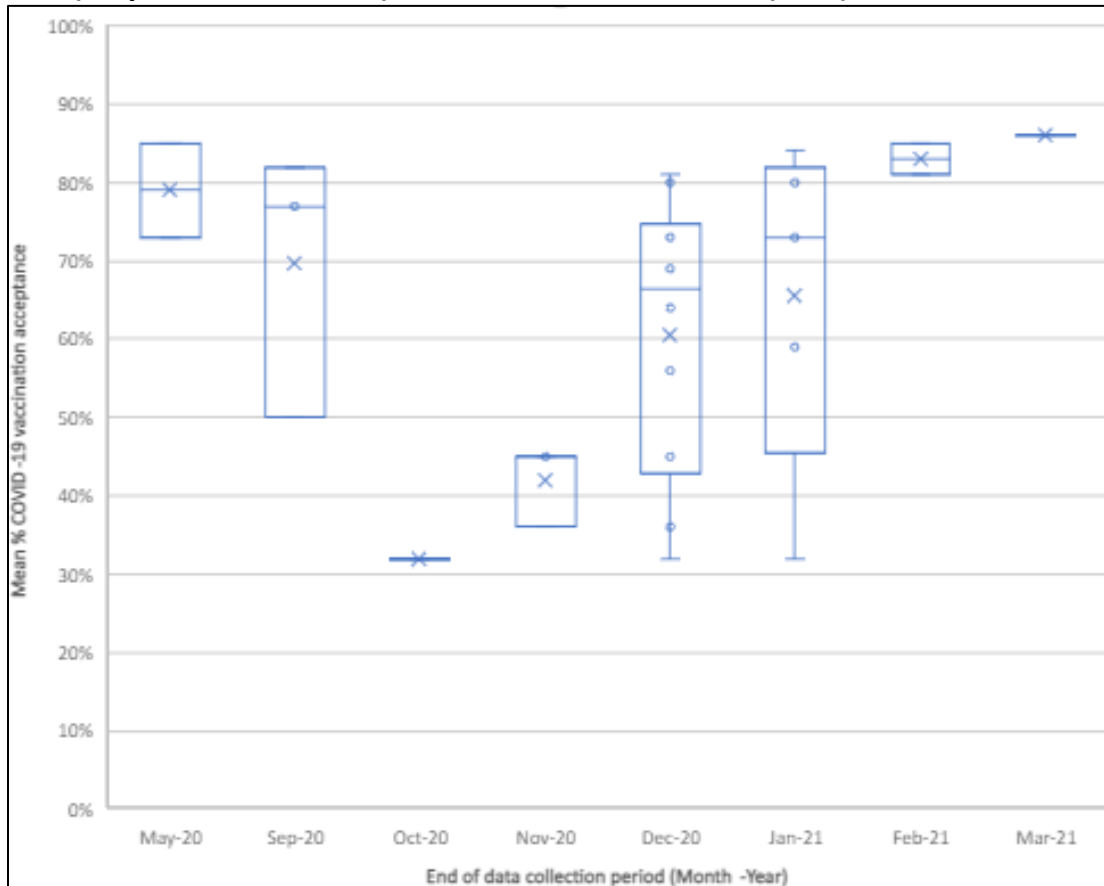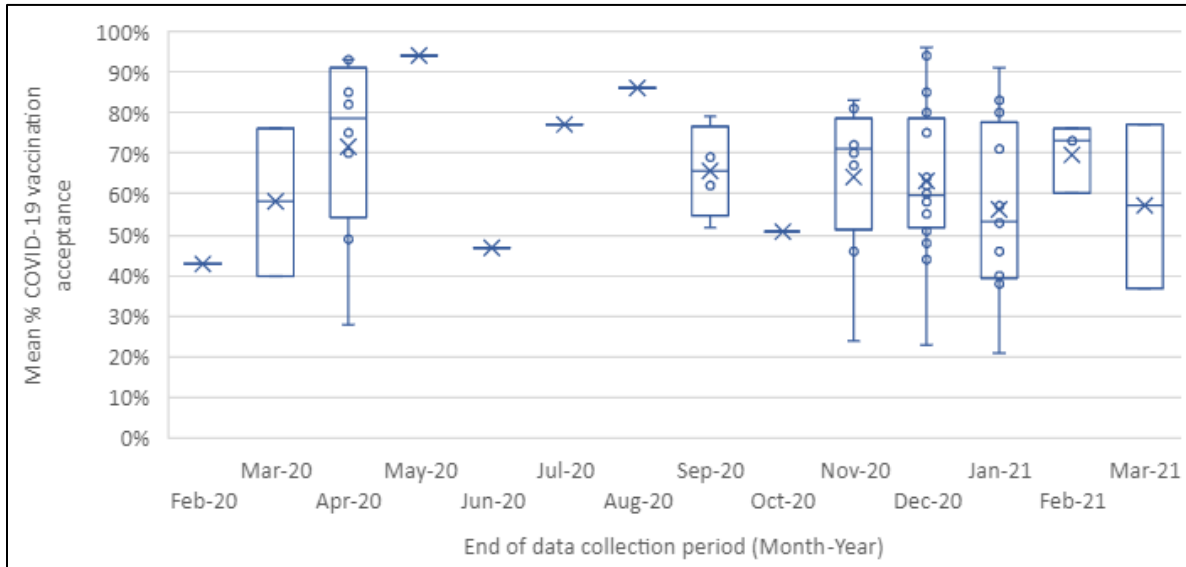
Figure 3. Box-and-whisker plots showing mean % vaccination acceptance rates among HCWs over time (Feb, 2020 - Mar, 2021) for studies conducted outside of North America (*k*=61)

Objective 3: Factors associated with higher and lower COVID-19 vaccination acceptance and uptake among HCWs

83/94 studies provided evidence on the potential factors influencing COVID-19 vaccine acceptance and uptake in HCWs which were mapped using the COM-B (Capability, Opportunity, and Motivation- Behaviour) model and the TDF. 16/94 studies assessed COVID-19 acceptance among certain equity-seeking groups [17,36,39,44,46,58,62,72,77,84,91–93,95,101,105], with 1 study performing analysis looking at determinants based on HCW race/ethnicity [44] (**see Objective 4**).

8 (of a possible 14) TDF domains appear to be important determinants of COVID-19 vaccine acceptance in HCWs (**Figure 4**):

- **Capability** (Knowledge [*k*=11]) (**Table 2**).
- **Opportunity** (Environmental context and resources [*k*=11]; Social influences [*k*=21]) (**Table 3**).
- **Motivation** (Beliefs about consequences [*k*=60]; Beliefs about capabilities [*k*=3]; Social/professional role and identity [*k*=44]; Reinforcement [*k*=32]; Emotion [*k*=9]) (**Table 4**).

Compared to our LBSES focusing on COVID-19 vaccination in the general public, aside from Goals (general public only) and Beliefs about capabilities (HCW only), identical domains were

identified. As such, our findings indicate that drivers of vaccination acceptance remain consistent to date, even in light of authorised vaccines (since Nov 2020) and regardless of whether we are focusing on the general public or HCWs. Domains that do not seem to be important determinants of COVID-19 vaccine acceptance and uptake among HCWs include: Skills; Behavioural regulation; Memory, attention and decision processes; Goals; and Optimism. **Figure 5** and **Figure 6** depict the 20 most frequent barriers and enablers (coded in at least 3 studies each) across domains. 5/8 frequently identified barriers and 11/12 frequently identified enablers focus on motivation-related factors.

Figure 4. Frequency of Capability, Opportunity and Motivation factors associated with COVID-19 vaccination acceptance and uptake among healthcare workers across *k*=94 studies up to May 24th, 2021
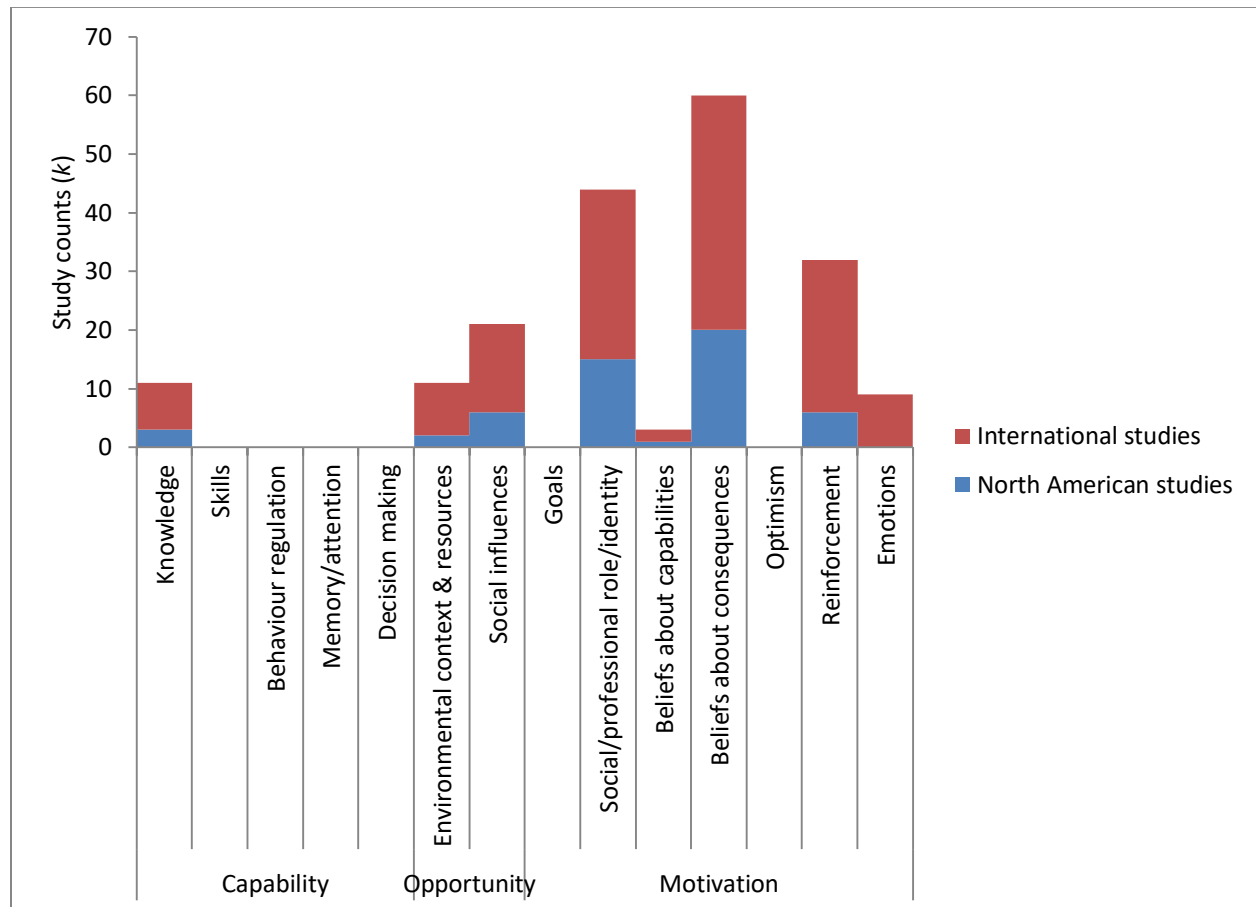
Capability-related factors associated with higher and lower COVID-19 vaccination acceptance and uptake among HCWs

While Capability encompasses Knowledge, Skills, Behavioural regulation, and Memory, attention and decision processes, to date only Knowledge-related factors have been assessed and identified in this literature (**Table 2**). A lack of knowledge about COVID-19 vaccines was cited as a barrier in 10 studies [42,43,48,62,64,68,82,99,105,107]. One study tested the relationship statistically between HCW knowledge and vaccination acceptance, where HCWs with 'high' knowledge about COVID-19 vaccines had 1.86 times greater odds of accepting a COVID-19 vaccine versus those with 'low' knowledge [82]. Despite decision-making (e.g., how do the decisions HCWs make about the behaviour influence whether they do it or not?) being a key Capability-related domain, no studies attempted to measure decision-making. However, it is likely that future studies collecting data on both vaccination acceptance and uptake may delve deeper into the actual decision-making process (e.g., framing effects, memory [111], which may also tap into other domains such as Beliefs about consequences (e.g., how HCWs weighed up beliefs about vaccine necessity vs. concerns about possible adverse effects). A qualitative study added to version 3 of this report highlighted that 'complex information, conflicting and changing guidance, overwhelming amounts of material, and poor provision of information in other languages contributed to a lack of trust, confusion, and ultimately vaccine hesitancy' [105].

Table 2. Capability-related factors associated with COVID-19 vaccination acceptance and uptake among HCWs

TDF Domain (Definition)
Knowledge (What do HCW know & how does that influence what they do? Do they have the procedural knowledge (know how to do it)?)
Vaccination acceptance • *k*=11 → **BARRIER:** Insufficient knowledge/education/understanding about COVID-19 [90] and COVID-19 vaccines [42,43,48,62,64,68,82,99,105,107] *Vaccination uptake* • No studies yet identified linking knowledge directly to vaccination uptake data

Opportunity-related factors associated with higher and lower COVID-19 vaccination acceptance and uptake among HCWs

Opportunity consists of Environmental context and resources, and Social influences (**Table 4**). 10 studies identified factors related to HCWs' environmental context and access to resources which were associated with vaccination acceptance. A Canadian study found that vaccination acceptance was higher among HCWs if financial support (e.g., paid sick leave) was provided which highlights a key issue at the healthcare organization level [28]. 10 studies, including one conducted in Canada [89], found mistrust towards governments and public health bodies was associated with lower vaccination acceptance. One Chinese study found that vaccination intention of social contacts was a barrier to vaccination acceptance among HCWs [38]. One study looking at vaccination uptake in a long-term care home reported that common reasons for staff not receiving the vaccine included staff being off-site during vaccination sessions (37%) which reflects an organizational barrier that some HCWs may face [100].

Social influence factors are increasingly being identified since version 1 of this report. Perceptions about trust/mistrust among public health agencies and their overall performance in handling the COVID-19 pandemic are prominent in HCWs, in line with data on vaccination acceptance in the general public.

Table 3. Opportunity-related factors associated with COVID-19 vaccination acceptance and uptake among HCWs

TDF Domain (Definition)
Environmental Context and Resources (What in HCWs environment influence what they do and how do they influence?)
Vaccination acceptance   • *k*=6 → **ENABLER:** Access to and trust in reputable scientific/non-scientific information sources about COVID-19 and COVID-19 vaccines (e.g., cues to action) [20,22,30,31,51,108]   • *k*=1 → **ENABLER:** Receiving financial support during the pandemic (e.g., paid sick days) [28]   • *k*=1 → **BARRIER:** Limited availability and accessibility of COVID-19 vaccines [107]   *Vaccination uptake*   • *k*=1 → **BARRIER:** Common reasons for staff not receiving the vaccine included staff being off-site during vaccination sessions [100]
TDF Domain (Definition)
Social influences

(What do others do? What do others think of what HCWs do or what they should do? Who are they and how does that influence what they do?)

Vaccination acceptance
- *k*=10 → **BARRIER:** State/government/public health agency/media mistrust [18,37,44,48,65,82,87,89,102,107]
  - **Equity-seeking group data** → Black, Latinx, and Asian expressed more distrust in companies making vaccines than White respondents [44]
- *k*=5 → **BARRIER:** Negative influences of social contacts [38,55], family members [107], and political figures [96] in relation to COVID-19 vaccination acceptance [102]
- *k*=2 → **ENABLER:** Trust in how hospital management has handled the pandemic [82,87]

Vaccination uptake
- No studies yet identified linking ocial influences directly to vaccination uptake data

Motivation-related factors associated with higher and lower COVID-19 vaccination acceptance and uptake among HCWs

One of the most frequently identified determinants of HCWs willingness to receive a COVID-19 vaccine was their beliefs about consequences, specifically beliefs related to vaccine safety, efficacy, and necessity. Safety concerns centered on the risk of possible adverse events (e.g., side effects) (*k*=34) and the speed at which vaccines were being developed (*k*=10); two Canadian studies reported these associations [28,89]. One study added to version 3 of this report found that safety concerns about the AstraZeneca COVID-19 vaccine specifically was associated with lower acceptance [81].

12 studies found that HCWs questioned to efficacy of COVID-19 vaccines. Moreover, beliefs about the necessity of COVID-19 vaccines (e.g., not feeling at risk because they feel in good health) were also found to be associated with lower vaccination acceptance in 6 studies including one from Canada [28]. From the Emotion domain, general fear about COVID-19 was associated with higher vaccination acceptance among HCWs [40,50,55,82,97].

One consistent finding was that vaccination acceptance was lower in non-physicians such as nurses [18,23,25,30–32,39,40,68,72–74,77,79,81,83,87,89,93,96,103,106], although none of these data were Canadian. Data from the SafeCare-BC report found 30% of healthcare assistants were 'unsure' about vaccination and nurses were the highest HCW group that would decline vaccination (20% of nurses) [89]. It may be that certain HCW groups have specific needs and concerns that need to be addressed.

8 studies found that HCWs providing direct care to patients generally and to COVID-19 patients specifically was associated with vaccination acceptance. Interestingly, a Canadian study found that perceived professional responsibility was associated with higher vaccination acceptance which could potentially be leveraged at the healthcare organization level [28]. Captured in the Reinforcement domain, past vaccination behaviour (e.g., seasonal influenza vaccine) was found to be consistently associated with higher acceptance of a COVID-19 vaccine, including data from one Canadian study [28].

Similar barriers described above were also identified among studies measuring vaccination uptake itself (**Table 4**). Tulloch et al. and Schrading et al. reported that concerns about vaccine development and vaccine safety were reasons for non-uptake [92,100]. Oliver et al. reported that concerns about vaccine safety continued to predict lower vaccine receipt (ORa=0.39, 95% CI: 0.28-0.55) [77]. Interestingly, a qualitative study found that among HCW that had already been vaccinated, many stated that what convinced them to get the vaccine was the perceived positive impact on their residents or family. For example, one nurse stated: *"I got vaccinated because I don't want my patients to have to keep visiting family through a window"* (p5) [24].

In terms of the domain Social/professional role and responsibility domain, two studies measured factors associated with COVID-19 vaccination uptake. Oliver et al. found that a role in nursing (ORa=0.37, 95% CI: 0.21-0.65), administration (ORa=0.46, 95% CI: 0.26-0.78), or allied and other health professionals (ORa=0.48, 95% CI: 0.27-0.81) remained significant for decreased odds of vaccine receipt compared to physicians and advanced practice providers [77]. Additionally, Hall et al. found that uptake was lower among certain hospital staff, namely those working as a porter, security, or in estates (ORa=0.61, 95% CI: 0.42-0.90) or midwife (ORa=0.74, 95% CI: 0.57-0.97) [46].

Table 4. Motivation-related factors associated with COVID-19 vaccination acceptance and uptake among HCWs

TDF Domain (Definition)
Beliefs about consequence   (What are the good and bad things that can happen from what HCWs do and how does that influence whether they'll do it in the future?)
Vaccination acceptance   • *k*=34 → **BARRIER:** Concerns about vaccine safety (e.g., side-effects) [17,22,28,38,39,42,43,48,50,56,59,60,62,65,69,71,77,78,81–83,85,86,88,89,92,93,95,101,102,104–107]   • *k*=12 → **BARRIER:** Beliefs about vaccine efficacy [22,44,50,60,78,82,88,96,98,104,106]

and in particular efficacy against COVID-19 variants of concern [105]

- o **Equity-seeking group data** → Black, Latinx, and Asian respondents reported greater concern about perceived vaccine efficacy than White respondents [44]
- *k*=10 → **BARRIER:** Concerns about rushed vaccine development [22,28,32,39,44,60,71,89,95,105]
  - o **Equity-seeking group data** → Black, Latinx, and Asian respondents reported greater concern about rushed vaccine development than White respondents [44]
- *k*=6 → **BARRIER:** Beliefs that vaccine not necessary (e.g., feel in good health, already protected) [28,37,60,86,90,104]
- *k*=10 → **ENABLER:** Concerns about being infected by COVID-19 (e.g., perceived susceptibility to COVID-19 and its severity) [27,31,38,40,51,54,58,61,103,108]
- *k*=6 → **ENABLER:** Positive attitudes and confidence towards COVID-19 vaccines (e.g., perceived benefit) [20,41,51,55,63,74]
- *k*=5 → **ENABLER:** Belief that getting vaccinated will protect family specifically [24,28,53,64,67]
- *k*=3 → **ENABLER:** Belief that getting vaccinated will protect patients specifically [28,64,67]

Vaccination uptake
- *k*=2 → **BARRIER:** Concerns about vaccine **safety** (e.g., side-effects) [77,92]
- *k*=1 → **BARRIER:** Concerns about **rushed vaccine development** [100]
- *k*=1 → **ENABLER:** Belief that getting vaccinated will protect family and patients [24]

TDF Domain (Definition)
Social/Professional Role and Identity   (How does their role/responsibility (in various settings) influence whether they do or not? How does who they are as a HCW influence whether they do something or not? Is the behaviour something they are supposed to do or is someone else responsible?)

Vaccination acceptance
- *k*=23 → **BARRIER:** Vaccine acceptance lower among nursing professionals vs. physicians [18,23,25,30–32,39,40,68,72–74,77,79,81,83,87,89,93,96,103,106] or dietary, housekeeping, and administrative staff [101]
- *k*=8 → **ENABLER:** Working directly patients generally [58,62,95] and with COVID-19 patients specifically [23,32,33,35,104]
- *k*=3 → **ENABLER:** When getting vaccinated seen as a professional [28] or collective/prosocial responsibility [27,63]
- *k*=3 → **ENABLER:** Belief that vaccination for COVID-19 should be mandatory for HCWs [41,66,85]

- k=1 → **ENABLER:** Pharmacists who are managers/owners were more likely to accept a vaccine than pharmacy technicians [78]
- k=1 → **ENABLER:** An increase in the unemployment rate within the dental sector coincides with a rise in willingness for a COVID-19 vaccine [110]
- k=1 → **ENABLER:** Paediatric physicians more likely to accept free 80% effective vaccine vs. physicians in administrative roles [21]
- k=1 → **ENABLER:** Being a pharmacy student vs. medicine student was a significant predictor of COVID-19 vaccine acceptance [90]

Vaccination uptake
- k=1 → **BARRIER:** Vaccine acceptance lower among nursing, administration, or allied and other health professionals vs. physicians [77]
- k=1 → **BARRIER:** Less likely to be vaccinated if worked as a porter, security, or in estates or midwife [46]
- k=1 → **ENABLER:** Working directly patients generally was associated with uptake [36]

TDF Domain (Definition)
Reinforcement
(How have their experiences (good and bad) of doing it in the past influence whether or not they do it? Are there incentives/rewards?)

Vaccination acceptance
- k=27 → **ENABLER:** Historical seasonal influenza vaccination [17,20,21,23,28,30,35,40–43,54,55,60,62,66,68,81–83,85,89,97,102,104,105]
- k=2 → **ENABLER:** Members of families/close social network having being infected with COVID-19 [18,90]
- k=1 → **ENABLER:** Engaging with COVID-19 infection behaviours (i.e. personal protective behaviour) throughout the pandemic [61]
- k=2 → **BARRIER:** previously tested positive for COVID-19 themselves were more hesitant towards vaccination [72,105]

Vaccination uptake
- k=2 → **ENABLER:** Historical seasonal influenza vaccination [46,77]

TDF Domain (Definition)
Emotion
How do they feel (affect) about what they do and do those feelings influence what they do?

Vaccination acceptance
- k=5 → **ENABLER:** Fear about the consequences of contracting COVID-19 [40,50,55,82,97]
- k=3 → **ENABLER:** Psychological distress (stress, depression, anxiety) was associated with

higher vaccine acceptance [63,97,109]
- k=1 → **ENABLER:** Fearing injections was independent predictor of COVID-19 vaccine acceptance [86]
- k=1 → **ENABLER:** Job satisfaction was associated with higher vaccine acceptance [94]

Vaccination uptake
- No studies yet identified linking emotion directly to vaccination uptake data

TDF Domain (Definition)

Beliefs about capabilities

(Do HCWs think they can (are they confident that they can) and how does that influence whether they do it or not? What increases or decreases their confidence?)

Vaccination acceptance
- k=3 → **ENABLER:** Self-efficacy/confidence in overcoming any challenges or difficulties in getting vaccinated [89,94,108]

Vaccination uptake
- No studies yet identified linking beliefs about capabilities directly to vaccination uptake data

Figure 5. Frequency of BARRIERS identified within the literature (only including barriers identified in ≥ 3 studies)
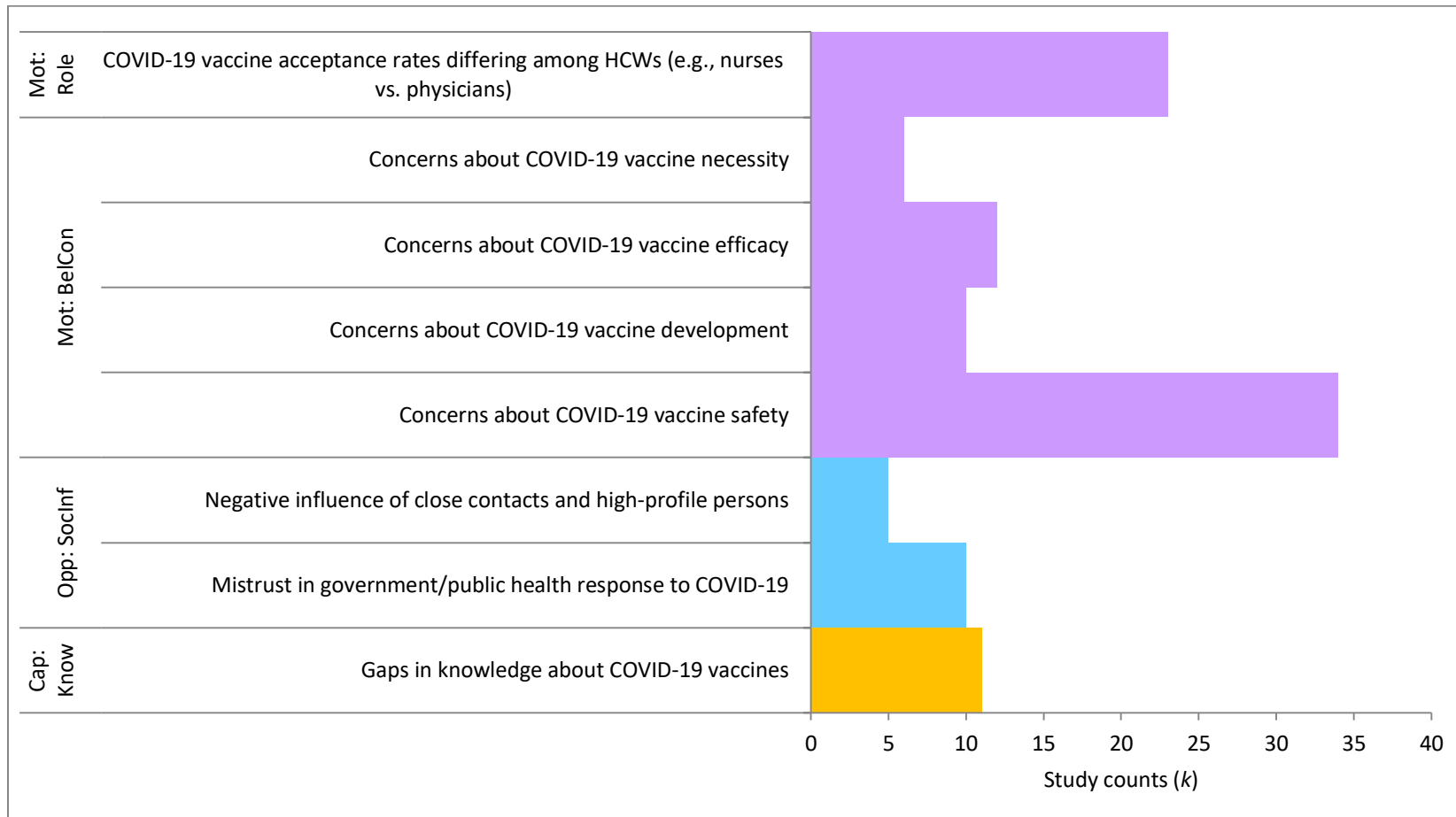
Figure 5 notes: BelCon = Beliefs about consequences; Cap = capability; Know = knowledge; Mot = motivation; Opp = opportunity; Role = Social/professional role and identity.

Figure 6. Frequency of ENABLERS identified within the literature (only including barriers identified in ≥ 3 studies).

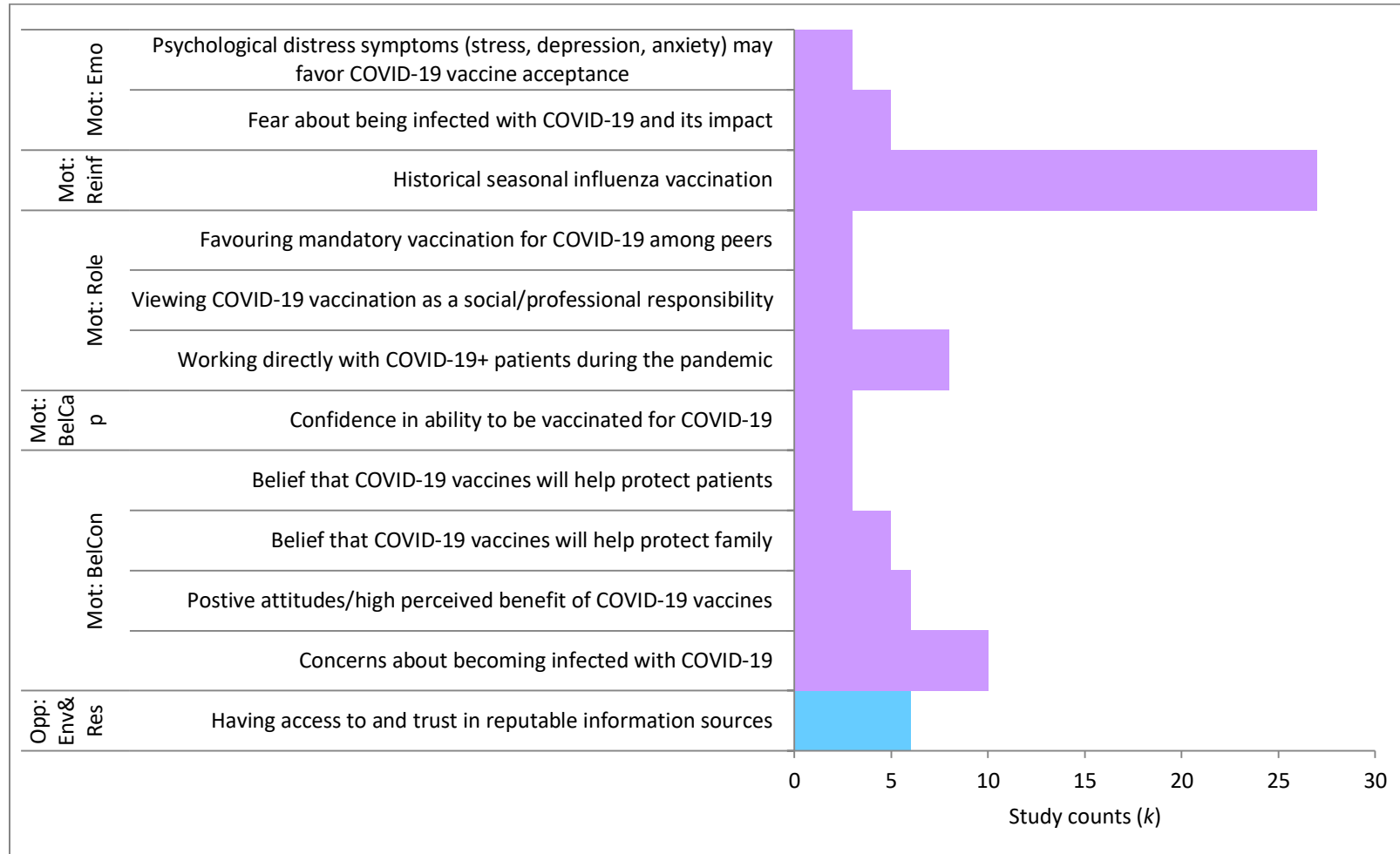Figure 6 notes: BelCap = beliefs about capabilities; BelCon = Beliefs about consequences; Cap = capability; Emo: emotion; Env&Res = environmental contact and resources; Know = knowledge; Mot = motivation; Opp = opportunity; Reinf = reinforcement; Role = Social/professional role and identity.

Objective 4: Equity-related factors associated with higher and lower COVID-19 vaccination acceptance and uptake in HCWs

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Equity-related factors and COVID-19 vaccination acceptance and uptake in Canada

Four Canadian studies [28,52,78,89] investigated equity-related factors associated with COVID-19 vaccination acceptance. One Canadian report [99] and one study [33] did not assess equity-related factors in relation to vaccination acceptance.

Race, ethnicity and indigeneity
- Desveaux et al. found interaction effect between race/ethnicity and employment setting such that Filipino HCWs working in continuing care and Caribbean HCWs working in acute care had lower vaccination acceptance vs. European ethnicity [28].
- The SafeCare-BC report noted that those who identified as East/South Asian were more likely than Latino and Black respondents to accept a vaccine. Indigenous respondents were more likely to respond "not sure" [89].
- Among respondents in the SafeCare-BC report who provided reasons for uncertainty or unwillingness to get vaccinated, East/Southeast Asian respondents were most likely to cite concerns over side effects while White and indigenous respondents were the most likely to cite mistrust in government and pharmaceutical companies' recommendations [89].
- Desveaux et al. found that mistrust was associated with lower vaccine acceptance but did not find an interaction between mistrust and race, ethnicity and indigeneity [28].

Equity-related factors and COVID-19 vaccination acceptance and uptake outside of Canada

16 studies (all conduced since vaccine approval, Nov 2020) assessed COVID-19 acceptance and/or uptake among certain equity-seeking groups [17,36,39,44,46,58,62,72,77,84,91–93,95,101,105]. Only 1 study to date assessed determinants based on race/ethnicity [44] (**see Tables 2-4**). 11 studies were conducted in the USA and 5 were conducted in the UK [17,46,58,100,105], therefore applicability to Canada is uncertain. 12 studies measured COVID-19 vaccination acceptance [17,39,44,58,62,72,84,91,93,95,101,105] and 4 measured vaccine uptake [36,46,77,92].

COVID-19 vaccination acceptance and uptake in HCWs from equity-seeking groups

6 studies [17,39,72,91,101,105] found that White respondents were more likely to accept a COVID-19 vaccine. Savoia et al. surveyed essential workers (61% HCWs) and explicitly examined the impact of past experiences with discrimination and found that those with a history of racial discrimination, more than other types of discrimination, are less accepting of COVID-19 vaccine [91]. 3 studies [72,93,95] found that some racialized groups expressed more acceptance than others. For example, Shaw found that Asian respondents (73.8%) and White (58.4%) respondents were more likely to express vaccine acceptance than other groups [93]. Similar findings were reported in Moniz et al. [72]. Shekhar et al. found that vaccine acceptance was lower among Black and Latinx HCWs and that Black, Native American, Hawaiin, and Pacific Islander HCWs would rather wait to review vaccine safety data before accepting the vaccine [95]. 1 study found that race, ethnicity and indigeneity were not associated with accepting a COVID-19 vaccine [84]. Kociolek et al. found respondents identifying as Black more had higher hesitancy (OR=3.20, 95% CI: 2.90-3.60) vs. non-Black respondents and that HCWs identifying as Hispanic/Latinx had higher hesitancy (OR=1.70, 95% CI: 1.50-2.00) vs. non-Hispanic/Latinx respondents [58]. Kuter et al. reported intention to receive a COVID-19 vaccine varied by race/ethnicity: Asian (74%), White (70%), Hispanic (54%), Black (30%), and multiple/other races (59%). The likelihood of intending to be vaccinated was lower among HCWs identifying as Black (OR=0.23, 95% CI: 0.19-0.27), Hispanic (OR=0.51, 95% CI: 0.39-0.67), and those reporting multiple/other races (OR=0.58, 95% CI 0.47-0.73) versus those identifying as White [62]. Grumbach et al. reported likeliness of vaccine uptake relative to White respondents was 0.24 (0.10-0.60) for Black respondents, 0.50 (0.31-0.79) for Latinx respondents, 0.37 (0.27-0.51) for Asian respondents, 0.28 (0.15-0.53) for respondents of other races, and 0.49 (0.29-0.82) for respondents of multiple races [44]. We were able to map determinants of vaccination acceptance to the TDF according to race/ethnicity; Beliefs about consequences and Social influence were represented (**see Tables 2-4**).

Hall et al. found that HCW participants were less likely to have been vaccinated if they were from Black, Asian, or minority ethnic groups, especially if they were Black (ORa=0.26, 95% CI: 0.21-0.32) or lived in areas of higher deprivation (ORa=0.75, 95% CI: 0.65-0.87) [46]. Similarly, Schrading et al. reported that the non-Hispanic Black HCWs had the lowest vaccine uptake rate of all participants (65%) [92]. Oliver et al. found that COVID-19 vaccination uptake was lower among Black (58%) compared with White (91%) HCWs; and lower among Hispanic (69%) compared with non-Hispanic (84%) HCWs. Identifying as Black was associated with a decreased vaccine uptake (ORa=0.38, 95% CI: 0.24-0.59). Based on free responses/thematic analysis, the

theme of mistrust was identified in only 8% of statements. However, statements aligning with the theme of mistrust in the vaccine were more frequently cited among HCWs who identified as Black, and Black HCWs provided reasons for hesitancy more frequently than other racial/ethnic groups. Participants highlighted the historical medical experimentation on minority groups, political involvement in the COVID-19 pandemic response overall and in the development and distribution of the vaccine [77]. 1 study added to version 3 of this report found that HCWs identifying as White had higher vaccination uptake vs. HCWs identifying as Black or African American (OR=4.55, 95% CI: 3.74-5.52) [36].

Discussion

Key implications
This is the third update of our LBSES looking at factors affecting COVID-19 vaccination acceptance and uptake among HCWs. A total of 94 studies (including 30 new studies added to version 3 of this report), 8 in Canada, were identified up to May 24, 2021.

Across 8 of 14 domains from the Theoretical Domains Framework, we have identified 20 **BARRIERS** and **ENABLERS** which may have implications for COVID-19 vaccine interventions. Addressing these key and recurring barriers and enablers in HCWs should involve multiple approaches at multiple levels; therefore, a one-size-fits-all approach is unlikely to address the range of barriers and enablers expressed by HCWs. In **Table 4,** we provide a non-exhaustive list of recommendations based on general principles from behaviour science which may help form the basis for behaviour-focused interventions to increase COVID-19 vaccination among HCWs. The next step here would be to supplement these recommendations with learning from past vaccination campaign interventions [1] and interventions/trials conducted during the COVID-19 pandemic.

Table 5. Identified BARRIERS and ENABLERS to COVID-19 vaccination acceptance and uptake among HCWs along with recommendations based on behavioural science principles

Domain	Barriers/Enabler	Recommendations based on behavioural science principles
BARRIERS		
Capability: *Knowledge*	Gaps in knowledge about COVID-19 vaccines (*k*=11)	Address knowledge gaps through educational campaigns tailored to different groups of HCWs, disseminated from trusted sources that likely differ for

		different groups of HCWs; one-size-fits-all knowledge dissemination unlikely to reach those who may benefit most.
Opportunity: *Social Influences*	Mistrust in government/public health response to COVID-19 (*k*=10)	Help rebuild trust through transparent communication about COVID-19 vaccination and community engagement and cultural understanding, especially HCWs from equity seeking groups. Acknowledging past harms against racialized groups that validates feelings of mistrust and aims to rebuild trust by addressing inequities.
	Negative influence of close contacts and high-profile persons (*k*=5)	Recognize the importance of people's social circles and prominent public figures and the influence they can have on intention and behaviour. Work within trusted circles and engage meaningfully.
Motivation: *Beliefs about consequences*	Concerns about COVID-19 vaccine safety (*k*=34)	Reassure and be transparent about vaccine risks using trusted sources and communication modalities that leverage risk communication tools and approaches that go beyond numerical risk and benefit data.
	Concerns about COVID-19 vaccine development (*k*=10)	Reiterate how it was possible to develop and approve COVID-19 vaccines relatively rapidly while maintaining all the same checks and balances to ensure a rigorous vaccine development process.
	Concerns about COVID-19 vaccine efficacy (*k*=12)	Ensure that the effectiveness of vaccines against COVID-19 and its variants of concern are clear and continue to be updated as evidence accrues. Communicate efficacy using evidenced benefit communication approaches that do not only rely on numeracy. Clarify benefits where known across outcomes

		of importance including infection, severity, side effect, hospitalization and/or death.
	Concerns about COVID-19 vaccine necessity (*k*=6)	Reassure the need for vaccines, emphasizing the protection of one's self and others to build towards community immunity.
Motivation: *Social/professional role and identity*	COVID-19 vaccine acceptance rates differing among HCWs (e.g., nurses vs. physicians) (*k*=23)	One-size-fits-all approaches are unlikely to generalize across different group of HCWs. Working within professional circles (both formal and informal) and leveraging trusted members of each group may help to address their needs and concerns.
ENABLERS		
Opportunity: *Environmental context and resources*	Having access to and trust in reputable information sources (*k*=6)	Identify and make available reputable and trustworthy sources of information sources more accessible to help counter misinformation about COVID-19 vaccines.
Motivation: *Beliefs about consequences*	Concerns about becoming infected with COVID-19 (*k*=10)	Reiterate the seriousness of being infected by COVID-19 and potential longer-term consequences (e.g., 'long-covid').
	Positive attitudes/high perceived benefit of COVID-19 vaccines (*k*=6)	Emphasize the benefit of vaccines, both from a medical standpoint (e.g., drawing on the benefit of previous vaccines for infectious diseases (e.g., polio)) and personal/social standpoint (e.g., returning to 'normal', seeing family without restrictions).
	Belief that COVID-19 vaccines will help protect family (*k*=5)	Leverage the prosocial nature of vaccination which will help protect others.
	Belief that COVID-19 vaccines will help protect	Leverage the prosocial nature of vaccination which will help protect

	patients (k=3)	others in a work context.
Motivation: *Beliefs about capabilities*	Confidence in ability to be vaccinated for COVID-19 (*k*=3)	Encourage confidence in ability to be vaccinated, minimize barriers to access which may impact perceived capability and show similar others being vaccinated to help model and build confidence.
Motivation: *Emotion*	Fear about being infected with COVID-19 and its impact (*k*=5)	Whilst being careful not to stoke fear, reiterate the seriousness of COVID-19 and its societal consequences (e.g., lockdowns).
	Psychological distress symptoms (stress, depression, anxiety) may favor COVID-19 vaccine acceptance (*k*=3)	Acknowledge that some psychological disorder-thinking (stress, depression, anxiety) may influence personal protective behaviours such as vaccination (although there must be caution with this).
Motivation: *Social/professional role and identity*	Working directly with COVID-19+ patients during the pandemic (*k*=8)	Encourage those not working in a clinical setting that COVID-19 still poses risks.
	Viewing COVID-19 vaccination as a social/professional responsibility (*k*=3)	Instill the notion of vaccination as a professional and social responsibility, normalize such behaviour.
	Favoring mandatory vaccination for COVID-19 among peers (*k*=3)	Consider mandatory vaccination (although there must be caution with this and if considered, in conjunction with approaches that support addressing other barriers/enablers so as not to undermine trust).
Motivation: *Reinforcement*	Historical seasonal influenza vaccination (*k*=27)	Leverage successful interventions to increase seasonal influenza vaccination which may be applicable to COVID-19.

Future directions for research in this area

Although some behavioural domains did not yet emerge as factors associated with COVID-19 vaccine acceptance in HCWs, there may be opportunity for considering a greater breath of possible barriers and enablers which could be guided by frameworks such as the TDF. Only one study [28] to date had used the TDF to inform their survey design, which resulted in key insights into barriers and enablers to vaccination acceptance among Canadian HCWs, many of which extended what is known. There was some evidence indicating that knowledge was associated with vaccination acceptance among HCWs. Knowledge, or lack thereof, is often seen as a key barrier to behaviour change which is reflected in the abundance of strategies and programs that focus solely on education and providing information. Whilst knowledge is undoubtedly important, it is usually insufficient as a stand-alone strategy, therefore, additional evidence-based, modifiable barriers must also be considered (cf. recent brief from Ontario COVID-19 Science Advisory Table [112]). There is a need for more research, and in particular Canadian research, to be conducted among equity-seeking groups to help better inform how best to support greater vaccination. Assessing barriers and enablers to vaccine acceptance that racialized groups experience may provide valuable insights into factors driving observed disparities, especially when considered alongside the COM-B related barriers/enablers that each racialized group experience to better support each group.

Future directions for this LBSES

Given that COVID-19 vaccines have been rolling out over the past 8 months, we expect to see more research to investigate drivers of actual uptake (8/94 studies so far), in addition to factors associated with vaccination acceptance. From a behavioural science perspective, this will provide an opportunity to assess whether the same factors associated with vaccine acceptance (intention) are also associated with actual vaccination uptake (behaviour) and whether vaccine intention predicts behaviour. Evidence from other behavioural literatures suggests a gap between intention and action and measures for bridging this gap offer opportunities for ensuring individuals who do develop strong intentions and acceptance for the COVID-19 vaccine translate their strong intention into vaccination [112]. From an equity-seeking group perspective, future versions of this LBSES will continue to assess what is driving observed differences in vaccination acceptance and uptake. Moreover, we will connect with Canadian researchers who are spearheading the important work of nuancing observed differences to vaccine acceptance to better account for how the lived experiences of equity-seeking groups may impact barriers and enablers to vaccine acceptance.

Future planned LBSES

- Identify which **strategies/techniques** are effective in supporting COVID-19 vaccination acceptance and uptake among HCWs.
- Identify **alignment and gaps** between experienced barriers/enablers and currently tested strategies among HCWs, and any lack of data for certain equity-seeking groups.
- Summarize **actionable implications** in general for HCWs and in particular among HCWs serving equity-seeking groups.

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References

1   Schumacher S, Salmanton-García J, Cornely OA, *et al.* Increasing influenza vaccination coverage in healthcare workers: a review on campaign strategies and their effect. *Infection* 2021;**49**:387–99. doi:10.1007/s15010-020-01555-9

2   Michie S, Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci* 2011;**6**.

3   Atkins L, Francis J, Islam R, *et al.* A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implement Sci* 2017;**12**. doi:10.1186/s13012-017-0605-9

4   Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci* 2012;**7**.

5   Michie S, Johnston M, Abraham C, *et al.* Making psychological theory useful for implementing evidence based practice: a consensus approach. *BMJ Qual Saf* 2005;**14**.

6   Michie S, Richardson M, Johnston M, *et al.* The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med* 2013;**46**. doi:10.1007/s12160-013-9486-6

7   The British Psychological Society Covid-19 Behavioural Science and Disease Prevention Taskforce. Optimising vaccination uptake for Covid-19. British Psychological Society 2021.

8   Konnyu K, Benitez G. What are the barriers and facilitators to individuals' willingness to be vaccinated for COVID-19? Center for Evidence Synthesis in Health, Department of Health, Policy and Practice, Brown University 2020. https://www.brown.edu/public-health/cesh/news/2021/01/what-are-barriers-and-facilitators-individuals%E2%80%99-willingness-be-vaccinated-covid-19

9   Konnyu K, Benitez G. Understanding and promoting COVID-19 vaccine uptake among marginalized communities in RI. Center for Evidence Synthesis in Health, Department of Health, Policy and Practice, Brown University 2021. https://www.brown.edu/public-health/cesh/news/2021/05/understanding-and-promoting-covid-19-vaccine-uptake-among-marginalized-communities-ri

10 McMaster Health Forum. What is known about strategies for encouraging vaccine acceptance and addressing vaccine hesitancy or uptake? McMaster Health Forum 2020.

11 Ontario Ministry of Health. COVID-19 Vaccine Uptake Among Health Care Workers. Ontario Ministry of Health 2021.

12 Public Health Agency of Canada. Evergreen Rapid Review on COVID-19 Vaccine Knowledge, Attitudes, and Behaviors – Update 6. Public Health Agency of Canada 2021.

13   McMaster Health Forum. COVID-19 Living Evidence Profile #1: What is known about anticipated COVID-19 vaccine roll-out elements? McMaster Health Forum 2021.

14   Presseau J, McCleary N, Lorencatto F, *et al.* Action, actor, context, target, time (AACTT): a framework for specifying behaviour. *Implement Sci* 2019;**14**:102. doi:10.1186/s13012-019-0951-x

15   O'Neill J, Tabish H, Welch V, *et al.* Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. *J Clin Epidemiol* 2014;**67**:56–64. doi:10.1016/j.jclinepi.2013.08.005

16   Etherington N, Rodrigues IB, Giangregorio L, *et al.* Applying an intersectionality lens to the theoretical domains framework: a tool for thinking about how intersecting social identities and structures of power influence behaviour. *BMC Med Res Methodol* 2020;**20**:169. doi:10.1186/s12874-020-01056-1

17   Abuown A, Ellis T, Miller J, *et al.* COVID-19 vaccination intent among London healthcare workers. *Occup Med* Published Online First: 18 May 2021. doi:10.1093/occmed/kqab057

18   Agyekum MW, Afrifa-Anane GF, Kyei-Arthur F, *et al.* Acceptability of COVID-19 vaccination among health care workers in Ghana. *medRxiv* 2021;:2021.03.11.21253374. doi:10.1101/2021.03.11.21253374

19   Ali KF, Whitebridge S, Jamal MH, *et al.* Perceptions, Knowledge, and Behaviors Related to COVID-19 Among Social Media Users: Cross-Sectional Study. *J Med Internet Res* 2020;**22**:e19913. doi:10.2196/19913

20   Al-Metwali BZ, Al-Jumaili AA, Al-Alag ZA, *et al.* Exploring the acceptance of COVID-19 vaccine among healthcare workers and general population using health belief model. *J Eval Clin Pract* 2021;**n/a**. doi:10.1111/jep.13581

21   Alvarado-Socarras JL, Vesga-Varela AL, Quintero-Lesmes DC, *et al.* Perception of COVID-19 Vaccination Amongst Physicians in Colombia. *Vaccines* 2021;**9**. doi:10.3390/vaccines9030287

22   Barry M, Temsah M-H, Alhuzaimi A, *et al.* COVID-19 vaccine confidence and hesitancy among healthcare workers: a cross-sectional survey from a MERS-CoV experienced nation. *medRxiv* 2020;:2020.12.09.20246447. doi:10.1101/2020.12.09.20246447

23   Bauernfeind S, Hitzenbichler F, Huppertz G, *et al.* Brief report: attitudes towards Covid-19 vaccination among hospital employees in a tertiary care university hospital in Germany in December 2020. *Infection* Published Online First: 20 May 2021. doi:10.1007/s15010-021-01622-9

24   Berry SD, Johnson KS, Myles L, *et al.* Lessons learned from frontline skilled nursing facility staff regarding COVID-19 vaccine hesitancy. *J Am Geriatr Soc* 2021;**n/a**. doi:10.1111/jgs.17136

25   Castañeda-Vasquez DE, Ruiz-Padilla JP, Botello-Hernandez E. Vaccine Hesitancy against SARS-CoV-2 in Health Personnel of Northeastern Mexico and its Determinants. *J Occup Environ Med* 2021;**Publish Ahead of**

Print.https://journals.lww.com/joem/Fulltext/9000/Vaccine_Hesitancy_against_SARS_CoV_2_in_ Health.97927.aspx

26   Chawe A, Mfune RL, Syapiila PM, *et al.* Knowledge, attitude and practices of COVID-19 among medical laboratory professionals in Zambia. *Afr J Lab Med* 2021;**10**.https://ajlmonline.org/index.php/ajlm/article/view/1403/1889

27   Chew NWS, Cheong C, Kong G, *et al.* An Asia-Pacific study on healthcare workers' perceptions of, and willingness to receive, the COVID-19 vaccination. *Int J Infect Dis* 2021;**106**:52–60. doi:10.1016/j.ijid.2021.03.069

28   Desveaux L, Savage RD, Tadrous M, *et al.* Beliefs associated with Intentions of Non-Physician Healthcare Workers to Receive the COVID-19 Vaccine in Ontario, Canada. *medRxiv* 2021;:2021.02.19.21251936. doi:10.1101/2021.02.19.21251936

29   Detoc M, Bruel S, Frappe P, *et al.* Intention to participate in a COVID-19 vaccine clinical trial and to get vaccinated against COVID-19 in France during the pandemic. *Vaccine* 2020;**38**:7002–6. doi:10.1016/j.vaccine.2020.09.041

30   Di Gennaro F, Murri R, Segala FV, *et al.* Attitudes towards Anti-SARS-CoV2 Vaccination among Healthcare Workers: Results from a National Survey in Italy. *Viruses* 2021;**13**. doi:10.3390/v13030371

31   Di Giuseppe G, Pelullo CP, Della Polla G, *et al.* Surveying willingness toward SARS-CoV-2 vaccination of healthcare workers in Italy. *Expert Rev Vaccines* 2021;:1–9. doi:10.1080/14760584.2021.1922081

32   Dror AA, Eisenbach N, Taiber S, *et al.* Vaccine hesitancy: the next challenge in the fight against COVID-19. *Eur J Epidemiol* 2020;**35**:775–9. doi:10.1007/s10654-020-00671-y

33   Dzieciolowska S, Hamel D, Gadio S, *et al.* Covid-19 vaccine acceptance, hesitancy, and refusal among Canadian healthcare workers: A multicenter survey. *Am J Infect Control* Published Online First: 28 April 2021. doi:10.1016/j.ajic.2021.04.079

34   Elhadi M, Alsoufi A, Alhadi A, *et al.* Knowledge, attitude, and acceptance of healthcare workers and the public regarding the COVID-19 vaccine: a cross-sectional study. *BMC Public Health* 2021;**21**:955. doi:10.1186/s12889-021-10987-3

35   Fares S, Elmnyer MM, Mohamed SS, *et al.* COVID-19 Vaccination Perception and Attitude among Healthcare Workers in Egypt. *J Prim Care Community Health* 2021;**12**:21501327211013304. doi:10.1177/21501327211013303

36   Fossen MC, Bethany MD, Modak SR, *et al.* Who's vaccinated? A closer look at healthcare workers' coronavirus disease 2019 (COVID-19) COVID-19 vaccine hesitancy and demographics. *Infect Control Hosp Epidemiol* 2021;:1–2. doi:10.1017/ice.2021.192

37   Fouogue JT, Noubom M, Kenfack B, *et al.* Poor knowledge of COVID-19 and unfavourable perception of the response to the pandemic by healthcare workers at the Bafoussam Regional Hospital (West Region - Cameroon). *medRxiv* 2020;:2020.08.20.20178970. doi:10.1101/2020.08.20.20178970

38   Fu C, wei Z, Pei S, *et al.* Acceptance and preference for COVID-19 vaccination in health-care workers (HCWs). *medRxiv* 2020;:2020.04.09.20060103. doi:10.1101/2020.04.09.20060103

39   Gadoth A, Halbrook M, Martin-Blais R, *et al.* Assessment of COVID-19 vaccine acceptance among healthcare workers in Los Angeles. *medRxiv* 2020;:2020.11.18.20234468. doi:10.1101/2020.11.18.20234468

40   Gagneux-Brunon A, Detoc M, Bruel S, *et al.* Intention to get vaccinations against COVID-19 in French healthcare workers during the first pandemic wave: a cross-sectional survey. *J Hosp Infect* 2021;**108**:168–73. doi:10.1016/j.jhin.2020.11.020

41   Gönüllü E, Soysal A, Atıcı S, *et al.* Pediatricians' COVID-19 experiences and views on the willingness to receive COVID-19 vaccines: a cross-sectional survey in Turkey. *Hum Vaccines Immunother* 2021;:1–8. doi:10.1080/21645515.2021.1896319

42   Grech V, Bonnici J, Zammit D. Vaccine hesitancy in Maltese family physicians and their trainees vis-à-vis influenza and novel COVID-19 vaccination. *Early Hum Dev* 2020;:105259. doi:10.1016/j.earlhumdev.2020.105259

43   Grech V, Gauci C, Agius S. Vaccine hesitancy among Maltese Healthcare workers toward influenza and novel COVID-19 vaccination. *Early Hum Dev* 2020;:105213–105213. doi:10.1016/j.earlhumdev.2020.105213

44   Grumbach K, Judson T, Desai M, *et al.* Association of Race/Ethnicity With Likeliness of COVID-19 Vaccine Uptake Among Health Workers and the General Population in the San Francisco Bay Area. *JAMA Intern Med* Published Online First: 30 March 2021. doi:10.1001/jamainternmed.2021.1445

45   Grüner S, Krüger F. The intention to be vaccinated against COVID-19: stated preferences before vaccines were available. *Appl Econ Lett* 2020;:1–5. doi:10.1080/13504851.2020.1854445

46   Hall VJ, Foulkes S, Saei A, *et al.* COVID-19 vaccine coverage in health-care workers in England and effectiveness of BNT162b2 mRNA vaccine against infection (SIREN): a prospective, multicentre, cohort study. *The Lancet* 2021;**397**:1725–35. doi:10.1016/S0140-6736(21)00790-X

47   Harapan H, Wagner AL, Yufika A, *et al.* Acceptance of a COVID-19 Vaccine in Southeast Asia: A Cross-Sectional Study in Indonesia. *Front Public Health* 2020;**8**:381–381. doi:10.3389/fpubh.2020.00381

48   Harrison J, Berry S, Mor V, *et al.* "Somebody Like Me": Understanding COVID-19 Vaccine Hesitancy Among Staff in Skilled Nursing Facilities. *J Am Med Dir Assoc* Published Online First: 20 March 2021. doi:10.1016/j.jamda.2021.03.012

49   Hoke AM, Keller CM, Calo WA, *et al.* School Nurse Perspectives on COVID-19. *J Sch Nurs* 2021;:1059840521992054. doi:10.1177/1059840521992054

50   Hussein AAM, Galal I, Makhlouf NA, *et al.* A national survey of potential acceptance of COVID-19 vaccines in healthcare workers in Egypt. *medRxiv* 2021;:2021.01.11.21249324. doi:10.1101/2021.01.11.21249324

51   Huynh G, Tran T, Nguyen H, *et al.* COVID-19 vaccination intention among healthcare workers in Vietnam. Asian Pac. J. Trop. Med. 2021;**14**:159–64.

52   Institut national de santé publique du Québec. Preliminary opinion on priority groups for COVID-19 vaccination in Quebec. Institut national de santé publique du Québec. 2020.

53   Jain V, Doernberg SB, Holubar M, *et al.* Healthcare personnel knowledge, motivations, concerns and intentions regarding COVID-19 vaccines: a cross-sectional survey. *medRxiv* 2021;:2021.02.19.21251993. doi:10.1101/2021.02.19.21251993

54   Kanyike AM, Olum R, Kajjimu J, *et al.* Acceptance of the coronavirus disease-2019 vaccine among medical students in Uganda. *Trop Med Health* 2021;**49**:37. doi:10.1186/s41182-021-00331-1

55   Kaplan AK, Sahin MK, Parildar H, *et al.* The willingness to accept the COVID-19 vaccine and affecting factors among healthcare professionals: A cross-sectional study in Turkey. *Int J Clin Pract* 2021;**n/a**:e14226. doi:10.1111/ijcp.14226

56   Karagiannidis C, Spies C, Kluge S, *et al.* Impfbereitschaft unter intensivmedizinischem Personal: Ängsten entgegenwirken. *Med Klin - Intensivmed Notfallmedizin* 2021;**116**:216–9. doi:10.1007/s00063-021-00797-1

57   King WC, Rubinstein M, Reinhart A, *et al.* COVID-19 vaccine hesitancy January-March 2021 among 18-64 year old US adults by employment and occupation. *medRxiv* 2021;:2021.04.20.21255821. doi:10.1101/2021.04.20.21255821

58   Kociolek LK, Elhadary J, Jhaveri R, *et al.* Coronavirus disease 2019 vaccine hesitancy among children's hospital staff: A single-center survey. *Infect Control Hosp Epidemiol* 2021;**42**:775–7. doi:10.1017/ice.2021.58

59   Konopińska J, Obuchowska I, Lisowski Ł, *et al.* Intention to Get COVID-19 Vaccinations among Ophthalmology Residents in Poland: A Cross-Sectional Survey. *Vaccines* 2021;**9**. doi:10.3390/vaccines9040371

60   Kose S, Mandiracioglu A, Sahin S, *et al.* Vaccine hesitancy of the COVID-19 by health care personnel. *Int J Clin Pract* 2020;**n/a**:e13917. doi:10.1111/ijcp.13917

61   Kukreti S, Lu M-Y, Lin Y-H, *et al.* Willingness of Taiwan's Healthcare Workers and Outpatients to Vaccinate against COVID-19 during a Period without Community Outbreaks. *Vaccines* 2021;**9**. doi:10.3390/vaccines9030246

62   Kuter BJ, Browne S, Momplaisir FM, *et al.* Perspectives on the receipt of a COVID-19 vaccine: A survey of employees in two large hospitals in Philadelphia. *Vaccine* 2021;**39**:1693–700. doi:10.1016/j.vaccine.2021.02.029

63   Kwok KO, Li K-K, WEI WI, *et al.* Influenza vaccine uptake, COVID-19 vaccination intention and vaccine hesitancy among nurses: A survey. *Int J Nurs Stud* 2021;**114**:103854. doi:10.1016/j.ijnurstu.2020.103854

64   Ledda C, Costantino C, Cuccia M, *et al.* Attitudes of Healthcare Personnel towards Vaccinations before and during the COVID-19 Pandemic. *Int J Environ Res Public Health* 2021;**18**:2703. doi:10.3390/ijerph18052703

65   Lucia VC, Kelekar A, Afonso NM. COVID-19 vaccine hesitancy among medical students. *J Public Health* Published Online First: 26 December 2020. doi:10.1093/pubmed/fdaa230

66   Maltezou HC, Pavli A, Dedoukou X, *et al.* Determinants of intention to get vaccinated against COVID-19 among healthcare personnel in hospitals in Greece. *Infect Dis Health* Published Online First: 31 March 2021. doi:10.1016/j.idh.2021.03.002

67   Manning ML, Gerolamo AM, Marino MA, *et al.* COVID-19 vaccination readiness among nurse faculty and student nurses. *Nurs Outlook* Published Online First: 2021. doi:10.1016/j.outlook.2021.01.019

68   Maraqa B, Nazzal Z, Rabi R, *et al.* COVID-19 vaccine hesitancy among health care workers in Palestine: A call for action. *Prev Med* 2021;**149**:106618. doi:10.1016/j.ypmed.2021.106618

69   Mascarenhas AK, Lucia VC, Kelekar A, *et al.* Dental students' attitudes and hesitancy toward COVID-19 vaccine. *J Dent Educ* 2021;**n/a**. doi:10.1002/jdd.12632

70   McCabe SD, Hammershaimb EA, Cheng D, *et al.* Unraveling Attributes of COVID-19 Vaccine Hesitancy in the U.S.: A Large Nationwide Study. *medRxiv* 2021;:2021.04.05.21254918. doi:10.1101/2021.04.05.21254918

71   Meyer MN, Gjorgjieva T, Rosica D. Trends in Health Care Worker Intentions to Receive a COVID-19 Vaccine and Reasons for Hesitancy. *JAMA Netw Open* 2021;**4**:e215344–e215344. doi:10.1001/jamanetworkopen.2021.5344

72   Moniz MH, Townsel C, Wagner AL, *et al.* COVID-19 Vaccine Acceptance Among Healthcare Workers in a United States Medical Center. *medRxiv* 2021;:2021.04.29.21256186. doi:10.1101/2021.04.29.21256186

73   Nohl A, Afflerbach C, Lurz C, *et al.* Acceptance of COVID-19 Vaccination among Front-Line Health Care Workers: A Nationwide Survey of Emergency Medical Services Personnel from Germany. *Vaccines* 2021;**9**. doi:10.3390/vaccines9050424

74   Nzaji MK, Ngombe LK, Mwamba GN, *et al.* Acceptability of Vaccination Against COVID-19 Among Healthcare Workers in the Democratic Republic of the Congo. *Pragmatic Obs Res* 2020;**11**:103.

75   O'Brien EC, Xu H, Cohen LW, *et al.* Recent changes in COVID-19 Vaccine Hesitancy among Healthcare Workers. *medRxiv* 2021;:2021.03.01.21252457. doi:10.1101/2021.03.01.21252457

76   Ogilvie GS, Gordon S, Smith LW, *et al.* Intention to receive a COVID-19 vaccine: Results from a population-based survey in Canada. *medRxiv* 2021;:2021.02.03.21251007. doi:10.1101/2021.02.03.21251007

77   Oliver K, Raut A, Pierre S, *et al.* Factors associated with COVID-19 vaccine receipt at two integrated healthcare systems in New York City: A Cross sectional study of healthcare workers. *medRxiv* 2021;:2021.03.24.21253489. doi:10.1101/2021.03.24.21253489

78   Ontario College of Pharmacists. COVID-19 Vaccine Administration Participation Readiness Survey Summary. Ontario College of Pharmacists 2021.

79   Papagiannis D, Malli F, Raptis DG, *et al.* Assessment of Knowledge, Attitudes, and Practices towards New Coronavirus (SARS-CoV-2) of Health Care Professionals in Greece before the Outbreak Period. *Int J Environ Res Public Health* 2020;**17**. doi:10.3390/ijerph17144925

80   Parajuli J, Mishra P, Sharma S, *et al.* Knowledge and attitude about COVID 19 among health care workers working in seti provincial Hospital. *Concern* 2020;**3**:5.

81   Paris C, Bénézit F, Geslin M, *et al.* COVID-19 vaccine hesitancy among healthcare workers. *Infect Dis Now* Published Online First: 5 May 2021. doi:10.1016/j.idnow.2021.04.001

82   Patelarou E, Galanis P, Mechili EA, *et al.* Factors influencing nursing students' intention to accept COVID-19 vaccination – A pooled analysis of seven countries. *medRxiv* 2021;:2021.01.22.21250321. doi:10.1101/2021.01.22.21250321

83   Petravić L, Arh R, Gabrovec T, *et al.* Factors Affecting Attitudes towards COVID-19 Vaccination: An Online Survey in Slovenia. *Vaccines* 2021;**9**. doi:10.3390/vaccines9030247

84   Piltch-Loeb R, Savoia E, Goldberg B, *et al.* Examining the effect of information channel on COVID-19 vaccine acceptance. *medRxiv* 2021;:2021.01.18.21250049. doi:10.1101/2021.01.18.21250049

85   Qattan AMN, Alshareef N, Alsharqi O, *et al.* Acceptability of a COVID-19 Vaccine Among Healthcare Workers in the Kingdom of Saudi Arabia. *Front Med* 2021;**8**:83. doi:10.3389/fmed.2021.644300

86   Rabi R, Maraqa B, Nazzal Z, *et al.* Factors affecting nurses' intention to accept the COVID-9 vaccine: A cross-sectional study. *Public Health Nurs* 2021;**n/a**. doi:10.1111/phn.12907

87   Raftopoulos V, Iordanou S, Katsapi A, *et al.* A comparative online survey on the intention to get COVID-19 vaccine between Greek and Cypriot healthcare personnel: is the country a predictor? *Hum Vaccines Immunother* 2021;:1–8. doi:10.1080/21645515.2021.1896907

88   Rehman K, Hakim M, Arif N, *et al.* COVID-19 vaccine acceptance, barriers and facilitators among healthcare workers in Pakistan. *Res Sq* 2021.

89   SafeCare-BC. Briefing Note: COVID-19 Vaccine Survey. SafeCare-BC 2020.

90   Saied SM, Saied EM, Kabbash IA, *et al.* Vaccine hesitancy: Beliefs and barriers associated with COVID-19 vaccination among Egyptian medical students. *J Med Virol* 2021;**n/a**. doi:10.1002/jmv.26910

91   Savoia E, Piltch-Loeb R, Goldberg B, *et al.* Predictors of COVID-19 Vaccine Hesitancy: Socio-demographics, Co-Morbidity and Past Experience of Racial Discrimination. *medRxiv* 2021;:2021.01.12.21249152. doi:10.1101/2021.01.12.21249152

92   Schrading WA, Trent SA, Paxton JH, *et al.* Vaccination rates and acceptance of SARS-CoV-2 vaccination among U.S. emergency department health care personnel. *Acad Emerg Med* 2021;**28**:455–8. doi:10.1111/acem.14236

93   Shaw J, Stewart T, Anderson KB, *et al.* Assessment of US Healthcare Personnel Attitudes Towards Coronavirus Disease 2019 (COVID-19) Vaccination in a Large University Healthcare System. *Clin Infect Dis* Published Online First: 25 January 2021. doi:10.1093/cid/ciab054

94   She R, Chen X, Li L, *et al.* Factors associated with behavioral intention of free and self-paid COVID-19 vaccination based on the social cognitive theory among nurses and doctors in China. *Infect Control Hosp Epidemiol* 2021;:1–25. doi:10.1017/ice.2021.201

95   Shekhar R, Sheikh AB, Upadhyay S, *et al.* COVID-19 Vaccine Acceptance among Health Care Workers in the United States. *Vaccines* 2021;**9**. doi:10.3390/vaccines9020119

96   Singhania N, Kathiravan S, Pannu AK. Acceptance of coronavirus disease 2019 vaccine among health-care personnel in India: a cross-sectional survey during the initial phase of vaccination. *Clin Microbiol Infect Off Publ Eur Soc Clin Microbiol Infect Dis* 2021;:S1198-743X(21)00143-9. doi:10.1016/j.cmi.2021.03.008

97   Szmyd B, Karuga FF, Bartoszek A, *et al.* Attitude and Behaviors towards SARS-CoV-2 Vaccination among Healthcare Workers: A Cross-Sectional Study from Poland. *Vaccines* 2021;**9**. doi:10.3390/vaccines9030218

98   Temsah M-H, Barry M, Aljamaan F, *et al.* Adenovirus and RNA-based COVID-19 vaccines: perceptions and acceptance among healthcare workers. *medRxiv* 2020;:2020.12.22.20248657. doi:10.1101/2020.12.22.20248657

99   The Canadian PSW Network. COVID-19 Vaccination Survey. The Canadian PSW Network 2021.

100   Tulloch JSP, Lawrenson K, Gordon AL, *et al.* COVID-19 vaccine hesitancy in care home staff: a survey of Liverpool care homes. *medRxiv* 2021;:2021.03.07.21252972. doi:10.1101/2021.03.07.21252972

101   Unroe KT, Evans R, Weaver L, *et al.* Willingness of Long-Term Care Staff to Receive a COVID-19 Vaccine: A Single State Survey. *J Am Geriatr Soc* 2021;**69**:593–9. doi:10.1111/jgs.17022

102   Verger P, Scronias D, Dauby N, *et al.* Attitudes of healthcare workers towards COVID-19 vaccination: a survey in France and French-speaking parts of Belgium and Canada, 2020. *Eurosurveillance* 2021;**26**:2002047.

103   Wang J, Feng Y, Hou Z, *et al.* Willingness to receive SARS-CoV-2 vaccine among healthcare workers in public institutions of Zhejiang Province, China. *Hum Vaccines Immunother* 2021;:1–8. doi:10.1080/21645515.2021.1909328

104   Wang K, Wong ELY, Ho KF, *et al.* Intention of nurses to accept coronavirus disease 2019 vaccination and change of intention to accept seasonal influenza vaccination during the coronavirus disease 2019 pandemic: A cross-sectional survey. *Vaccine* 2020;**38**:7049–56. doi:10.1016/j.vaccine.2020.09.021

105   Woolf K, McManus IC, Martin CA, *et al.* Ethnic differences in SARS-CoV-2 vaccine hesitancy in United Kingdom healthcare workers: Results from the UK-REACH prospective nationwide cohort study. *medRxiv* 2021;:2021.04.26.21255788. doi:10.1101/2021.04.26.21255788

106   Yigit M, Ozkaya-Parlakay A, Senel E. Evaluation of COVID-19 vaccine acceptance of healthcare providers in a tertiary Pediatric hospital. *Hum Vaccines Immunother* 2021;:1–5. doi:10.1080/21645515.2021.1918523

107   Youssef D, Abbas LA, Berry A, *et al.* Determinants of Acceptance of Coronavirus Disease-2019 (COVID-19) Vaccine Among Lebanese Health Care Workers Using Health Belief Model. *Res Sq* Published Online First: 6 May 2021. doi:10.21203/rs.3.rs-294775/v1

108   Yu Y, Lau JTF, She R, *et al.* Prevalence and associated factors of intention of COVID-19 vaccination among healthcare workers in China: application of the Health Belief Model. *Hum Vaccines Immunother* 2021;:1–9. doi:10.1080/21645515.2021.1909327

109   Yurttas B, Poyraz BC, Sut N, *et al.* Willingness to get the COVID-19 vaccine among patients with rheumatic diseases, healthcare workers and general population in Turkey: a web-based survey. *Rheumatol Int* 2021;**41**:1105–14. doi:10.1007/s00296-021-04841-3

110   Zigron A, Dror AA, Morozov NG, *et al.* COVID-19 Vaccine Acceptance Among Dental Professionals Based on Employment Status During the Pandemic. *Front Med* 2021;**8**:13. doi:10.3389/fmed.2021.618403

111   Jacobson Vann JC, Jacobson, RM, Coyne-Beasley, T, Asafu-Adjei, JK, Szilagyi P. Patient reminder and recall interventions to improve immunization rates. *Cochrane Database Syst Rev* Published Online First: 2018. doi:10.1002/14651858.CD003941.pub3

112   Presseau J, Desveaux L, Allen U. Behavioural science principles for supporting COVID-19 vaccine confidence and uptake among Ontario health care workers. *Sci Briefs Ont COVID-19 Sci Advis Table* 2021;**2**:12.

Appendices
Appendix 1. Data abstraction forms

Study characteristics	Behaviour specs	Key findings/themes by COM-B and TDF do	
Author:	Action(s):	Capability	
Year:	Actor(s):		Knowledge:
URL:	Context(s):		Skills:
Design:	Target:		Behaviour regulation:
Publication status:	Time:		Memory/attention:
Countries/provinces:			Decision making:
Data collection date range:		Opportunity	
			Environmental context & resources:
			Social influences:
		Motivation	
			Intention (capture % intention/hesitant/confident where available)
			Goals:
			Social/professional role/identity:
			Beliefs about capabilities:
			Beliefs about consequences:
			Optimism:
			Reinforcement:
			Emotions:
		Other	Specify:
		%/Mean vaccine intention and/or hesitancy	

Equity seeking groups	TDF/COM-B Key findings/themes					
Race/ethnicity/indigeneity groups included:	Group A:		Group B:		Group C:	
	Capability		Capability		Capability	
		Knowledge:		Knowledge:		Knowledge:
		Skills:		Skills:		Skills:
		Behaviour regulation:		Behaviour regulation:		Behaviour regulation:
		Memory/attention:		Memory/attention:		Memory/attention:
		Decision making:		Decision making:		Decision making:
	Opportunity		Opportunity		Opportunity	
		Environmental context & resources:		Environmental context & resources:		Environmental context & resources:
		Social influences:		Social influences:		Social influences:
	Motivation		Motivation		Motivation	
		Intention (capture % intention/hesitant/confident where available)		Intention (capture % intention/hesitant/confident where available)		Intention (capture % intention/hesitant/confident where available)
Other notes:		Goals:		Goals:		Goals:
		Social/professional role/identity:		Social/professional role/identity:		Social/professional role/identity:
		Beliefs about capabilities:		Beliefs about capabilities:		Beliefs about capabilities:
		Beliefs about consequences:		Beliefs about consequences:		Beliefs about consequences:
		Optimism:		Optimism:		Optimism:
		Reinforcement:		Reinforcement:		Reinforcement:
		Emotions:		Emotions:		Emotions:
	Other	Specify:	Other	Specify:	Other	Specify:
		%/Mean vaccine intention and/or hesitancy		%/Mean vaccine intention and/or hesitancy		%/Mean vaccine intention and/or hesitancy

Appendix 2. Evidence of COVID-19 vaccination acceptance and uptake among healthcare workers (*k*=94)

Author	Publication status	Country	Design	Sample	Sample size	Data collection period	Mean % vaccine acceptance [actual uptake]	COM-B model factors (*TDF domains*)
North American studies (*k*=32), listed in order of end of data collection period								
Hoke et al.	Published	USA	CS	HCWs (school nurses)	350	May, 2020	85%	N/A
INSPQ	Published (report)	Quebec, Canada	CS	Gen pub (inc. HCWs)	NR	Apr - May, 2020 & Sep, 2020	73%	N/A
Manning et al.	Published	USA	CS	HCWs (nurse faculty and student nurses)	1212,	Aug 10 - Sep 14, 2020	50%	Motivation (*Beliefs about consequences*)
Ogilvie et al.	Preprint	Canada	CS	Gen pub (inc. HCWs)	4,058	Aug 20 - Sep 27, 2020	82%	N/A
Lucia et al.	Published	USA	CS	HCWs (medical students)	168	Sep 14-30, 2020	77%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences*)

Gadoth et al.	Preprint	USA	CS	HCWs (non-physicians)	609	Sep 24 - Oct 16, 2020	32%	Opportunity (*Environmental context and resources*) Motivation (*Social/professional role and identity; Beliefs about consequences*)
Verger et al.*	Published	Canada data only	CS	HCWs	1,055	Oct-Nov, 2020	45%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences; Reinforcement*)
Shekhar et al.	Published	USA	CS	HCWs	3,479	Oct 7 - Nov 9, 2020	36%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Unroe et al.	Published	USA	CS	HCWs (nursing home and assisted living staff)	8,243	Nov 14-17, 2020	45%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
O'Brien et al.	Preprint	USA	Coh	HCWs	998	Oct - Dec, 2020	69%	N/A
Mascarenhas et al.	Published	USA	CS	HCWs (dental students)	245	Dec, 2020	56%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences*)

SafeCare-BC	Published (report)	British Columbia, Canada	CS	HCWs (continuing care workers)	1,503	Dec, 2020	57%	Opportunity (*Social influences*) Motivation (*Social/professional role and identity; Beliefs about consequences; Beliefs about capabilities; Reinforcement*)
Shaw et al.	Published	USA	CS	HCWs	5,287	Nov 23 - Dec 5, 2020	58%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Kuter et al.	Published	USA	CS	HCWs	12,034	Nov 13 - Dec 6, 2020	64%	Capability (*Knowledge*) Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Jain et al.	Preprint	USA	CS	HCWs	2,135	Nov 16 - Dec 8, 2020	69%	Motivation (*Beliefs about consequences*)
Meyer et al.	Published	USA	CS	HCWs	16,158	Dec 4-22, 2020	53-80%	Motivation (*Beliefs about consequences*)
Savoia et al.	Preprint	USA	CS	Gen pub (inc. HCWs)	1,616	Dec 13-23, 2020	NR	N/A
Piltch-Loeb et al.	Preprint	USA	CS	Gen pub (inc. HCWs)	1,627	Dec 13-23, 2020	39%	N/A

Harrison et al.	Published	USA	Qual	HCWs (skilled nursing facility staff)	58 staff (5 focus groups)	Dec 17-23, 2020	NR (Qual data)	Capability (*Knowledge*) Opportunity (*Social influences*) Motivation (*Beliefs about consequences*)
Dzieciolowska et al.	Published	Canada	CS	HCWs	2,761	Dec 15-28, 2020	81%	Motivation (*Social/professional role and identity*)
Canadian PSW Network	Unpublished dataset	Canada	CS	HCWs (personal support workers)	562	Jan 5, 2021	64%	Capability (*Knowledge*)
Desveaux et al.	Preprint	Ontario, Canada	CS	HCWs (non-physicians)	8,634	Jan 4-12, 2021	80%	Opportunity (*Environmental context and resources*) Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Grumbach et al.	Published	USA	CS	Gen pub & HCWs samples	3,161 (Gen pub); 1,803 (HCWs)	Nov 27, 2020 - Jan 15, 2021	66% (Gen pub); 84% (HCWs)	[Determinants broken down among equity-seeking groups, see Objective 4] Opportunity (*Social influences*) Motivation (*Beliefs about consequences*)

Berry et al.	Published	USA	Qual	HCWs	193 staff from 50 facilities participated in 26 meetings	Dec 30, 2020 - Jan 15, 2021	NR (Qual data)	Motivation (*Beliefs about consequences*)
Schrading et al.	Published	USA	CS	HCWs	1,542	Jan 4, 2021	**[86%]**	Motivation (*Beliefs about consequences*)
Kociolek et al.	Published	USA	CS	HCWs	4,448	Dec 21, 2020 - Jan 13, 2021	59%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Ontario College of Pharmacists	Published (report)	Canada	CS	HCWs (pharmacy professionals)	6,677	Jan 12-21, 2021	79%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Oliver et al.	Preprint	USA	CS (inc. FTR)	HCWs	1,933	Dec 23, 2020 - Feb 16, 2021	**[81%]**	Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)

McCabe et al.	Preprint	USA	CS	Gen pub (inc. HCWs)	34,470	Dec 4, 2020 - Feb 9, 2021	81%	Motivation (*Social/professional role and identity*)
Moniz et al.	Preprint	USA	CS	HCWs	11,387	Feb 1-15, 2021	85%	Motivation (*Social/professional role and identity; Reinforcement*)
Fossen et al.	Published	USA	CS	HCWs	3,401	Mar, 2021	**[71%]**	Motivation (*Social/professional role and identity*)
King et al.	Preprint	USA	Coh	Gen pub (inc. HCWs)	732,308	Jan 6 - Mar 31, 2021	86% **[78%]**	Motivation (*Social/professional role and identity*)

Author	Publication status	Country	Design	Sample	Sample size	Data collection period	Mean % vaccine acceptance [actual uptake]	COM-B model factors (*TDF domains*)
International studies (*k*=45), listed in order of end of data collection period								
Papagiannis et al.	Published	Greece	CS	HCWs	461	Feb 10-25, 2020	43%	Motivation (*Social/professional role and identity*)
Zigron et al.	Published	Israel	CS	HCWs (dental professionals)	506	Mar - Apr, 2020	85%	Motivation (*Social/professional role and identity*)
Fu et al.	Preprint	China	CS	HCWs	352	Mar 17-18, 2020	76%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences*)
Wang et al.	Published	Hong Kong	CS	HCWs (nurses)	806	Feb 26 - Mar 31, 2020	40%	Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Ali et al.	Published	Multiple (Arabian Gulf)	CS	Gen pub (inc. HCWs)	1,250	Mar 28 - Apr 4, 2020	75%	N/A
Harapan et al.	Published	Indonesia	CS	Gen pub (inc. HCWs)	264	Mar 25 - Apr 6, 2020	67-93%	N/A

Dror et al.	Published	Israel	CS	Gen pub (inc. HCWs)	829	Mar 26 - Apr 9, 2020	61-78%	Opportunity (*Environmental context and resources*) Motivation (*Social/professional role and identity; Beliefs about consequences*)
Detoc et al.	Preprint	France	CS	Gen pub (inc. HCWs)	1,421	Mar 26 - Apr 20, 2020	82%	N/A
Fouogue et al.	Preprint	Cameroon	CS	HCWs	464	Apr 14-29, 2020	49%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences*)
Kwok et al.	Published	Hong Kong	CS	HCWs (nurses)	1,205	Mar - Apr, 2020	63%	Motivation (*Social/professional role and identity; Beliefs about consequences; Emotion*)
Nzaji et al.	Published	Democratic Republic of Congo	CS	HCWs	613	Mar 20 - Apr 30, 2020	28%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Parajuli et al.	Published	Nepal	CS	HCWs	230	Apr – May, 2020	94%	N/A
Chawe et al.	Published	Zambia	CS	HCWs (lab medical professionals)	208	Jun 10-29, 2020	47%	N/A
Gagneux-Brunon et al.	Published	France	CS	HCWs	2,047	Mar 26 - Jul 2, 2020	77%	Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement; Emotion*)

Grüner et al.	Published	Germany	CS	Gen pub (inc. HCW)	213	May 18 - Aug 2, 2020	86%	N/A
Grech & Bonnici	Published	Malta	CS	HCWs	1,002	Sep 11-19, 2020	52%	Capability (*Knowledge*) Motivation (*Beliefs about consequences; Reinforcement*)
Grech & Gauci	Published	Malta	CS	HCWs (physicians and their trainees)	123	Sep, 2020	62%	Capability (*Knowledge*) Motivation (*Beliefs about consequences; Reinforcement*)
Wang et al.	Published	China	CS	HCWs	3,726	Sep 15-20, 2020	79%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Kose et al.	Published	Turkey	CS	HCWs	1,138	Sep 17-20, 2020	69%	Motivation (*Beliefs about consequences; Reinforcement*)
Maltezou et al.	Published	Greece	CS	HCWs	1,521	Sep 1 - Oct 31, 2020	51%	Motivation (*Social/professional role and identity; Reinforcement*)
Verger et al.*	Published	France and Belgium data only	CS	HCWs	1,623	Oct-Nov, 2020	46%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences; Reinforcement*)
She et al.	Published	China	CS	HCWs (doctors and nurses)	2,064	Oct - Nov, 2020	75% doctors, 68% nurses	Opportunity (*Social influences*) Motivation (*Belief about capabilities; Emotion*)

Yu et al.	Published	China	CS	HCWs	2,254	Oct - Nov, 2020	75% nurses; 68% doctors	Opportunity (*Environmental context and resources; Social influences*) Motivation (*Beliefs about consequences; Beliefs about capabilities*)
Di Gennaro et al.	Published	Italy	CS	HCWs	1,723	Oct 1 – Nov 1 2020	67%	Opportunity (*Environmental context and resources*) Motivation (*Social/professional role and identity; Reinforcement*)
Temsah et al.	Preprint	Saudi Arabia	CS	HCWs	2,007	Nov 1-12, 2020	9-24% (depending on type of COVID-19 vaccine)	Motivation (*Beliefs about consequences*)
Barry et al.	Preprint	Saudi Arabia	CS	HCWs	1,512	Nov 4-14, 2020	70%	Opportunity (*Environmental context and resources*) Motivation (*Beliefs about consequences*)
Gönüllü et al.	Published	Turkey	CS	HCWs (paediatricians)	506	Nov 1-15, 2020	83%	Motivation (*Social/professional role and identity; Beliefs about consequences*)

Di Giuseppe et al.	Published	Italy	CS	HCWs	811	Sep 14-Nov 30, 2020	81%	Opportunity (*Environmental context and resources*) Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Ledda et al.	Published	Italy	CS	HCWs	787	Sep - Dec, 2020	75%	Capability (*Knowledge*) Motivation (*Beliefs about consequences*)
Castañeda-Vasquez et al.	Published	Mexico	CS	HCWs	43	Oct - Dec, 2020	94%	Motivation (*Social/professional role and identity*)
Kaplan et al.	Published	Turkey	CS	HCWs	1,574	Dec, 2020	85%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences; Reinforcement; Emotion*)
Patelarou et al.	Preprint	Multiple (Europe)	CS	HCWs (nursing students)	2,249	Dec, 2020	44%	Capability (*Knowledge*) Opportunity (*Social influences*) Motivation (*Beliefs about consequences; Reinforcement; Emotion*)
Karagiannidis et al.	Published	Germany	CS	HCWs (intensive care staff)	2,305	Dec 3-12, 2020	64%	Motivation (*Beliefs about consequences*)

Qattan et al.	Published	Saudi Arabia	CS	HCWs	673	Dec 8-14, 2020	51%	Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Raftopoulos et al.	Published	Greece & Cyprus	CS	HCWs	2,238	Dec 1-15, 2020	48%	Opportunity (*Social influences*) Motivation (*Social/professional role and identity*)
Elhadi et al.	Published	Libya	CS	Gen pub (inc. HCW)	2,215	Dec 1-18, 2020	80%	N/A
Al-Metwali et al.	Published	Iraq	CS	Gen pub (inc. HCWs)	1,680	Dec 1-19, 2020	62%	Opportunity (*Environmental context and resources; Social influences*) Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Yigit et al.	Published	Turkey	CS	HCWs	343	Dec 15-20, 2020	55%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Abuown et al.	Published	UK	CS	HCWs	514	Dec 1-21, 2020	59%	Motivation (*Beliefs about consequences; Reinforcement*)
Chew et al.	Published	Multiple (Asia)	CS	HCWs	1,720	Dec 12-21, 2020	96%	Motivation (*Social/professional role and identity; Beliefs about consequences*)
Bauernfeind et al.	Published	Germany	CS	HCWs	2,454	Dec 12-21, 2020	60%	Motivation (*Social/professional role and identity; Reinforcement*)

Petravić et al.	Published	Slovenia	CS (inc. FTR)	Gen pub (inc. HCWs)	12,042 (2,068 were HCWs)	Dec 17-27 2020	59%	Opportunity (*Social influences*) Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Kukreti et al.	Published	Taiwan	CS	HCWs & patient samples	500 (HCWs); 238 (patients)	Sep 24 - Dec 31, 2020	23% (HCWs); 31% (patients)	Motivation (*Beliefs about consequences; Reinforcement*)
Youssef et al.	Preprint	Lebanon	CS	HCWs	1,800	Dec 10-31, 2020	58%	Capability (*Knowledge*) Opportunity (*Environmental context and resources; Social influences*) Motivation (*Beliefs about consequences*)
Fares et al.	Published	Egypt	CS	HCWs	385	Dec, 2020 - Jan, 2021	21%	Opportunity (*Social influences*) Motivation (*Social/professional role and identity; Reinforcement*)

Alvarado-Socarras et al.	Published	Columbia	CS	HCWs (physicians)	1,066	Jan, 2021	Free vaccine that was 60% effective: acceptance rate=77% Free vaccine that was 80% effective: acceptance rate=91%	Motivation (*Social/professional role and identity; Reinforcement*)
Konopinska et al.	Published	Poland	CS	HCWs (ophthalmology residents)	126	Jan, 2021	71%	Motivation (*Beliefs about consequences*)
Hussein et al.	Preprint	Egypt	CS	HCWs	496	Dec 1, 2020 - Jan 1, 2021	46%	Motivation (*Beliefs about consequences; Emotion*)
Maraqa et al.	Published	Palestine	CS	HCWs	1,159	Dec 25, 2020 - Jan 6, 2021	38%	Capability (*Knowledge*) Motivation (*Social/professional role and identity; Reinforcement*)
Rabi et al.	Published	Palestine	CS	HCWs (nurses)	639	Jan 1-7, 2021	40%	Opportunity (*Social influences*) Motivation (*Beliefs about consequences; Emotion*)
Szmyd et al.	Published	Poland	CS	HCWs	1,971	Dec 22, 2020 - Jan 8, 2021	83%	Motivation (*Beliefs about consequences; Reinforcement; Emotion*)

Yurttas et al.	Published	Turkey	CS	Gen pub, patient & HCWs samples	320	Jan 4-13, 2021	53%	Motivation (*Emotion*)
Nohl et al.	Published	Germany	CS	HCWs (emergency medical services personnel)	1,296	Dec 4, 2020 - Jan 15, 2021	57%	Motivation (*Social/professional role and identity*)
Saied et al.	Published	Egypt	CS	HCWs (medical students)	2,133	Jan 8-15, 2021	54%	Capability (*Knowledge*) Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)
Singhania et al.	Published	India	CS	HCWs	754	Jan 20-24, 2021	80%	Opportunity (*Social influences*) Motivation (*Social/professional role and identity; Beliefs about consequences*)
Hall et al.	Published	UK	Coh	HCWs	29,378	Dec 7, 2020 - Feb 5, 2021	**[89%]**	Motivation (*Social/professional role and identity; Reinforcement*)
Tulloch et al.	Preprint	UK	CS	HCWs (long-term care home staff)	2,128	Jan 21-28, 2021	**[51%]**	Opportunity (*Environmental context and resources*) Motivation (*Beliefs about consequences*)

Huynh et al.	Published	Vietnam	CS	HCWs	410	Jan - Feb, 2021	76%	Opportunity (*Environmental context and resources*) Motivation (*Beliefs about consequences*)	
Rehman et al.	Preprint	Pakistan	CS	HCWs	436	Jan 31 - Feb 9, 2021	60%	Motivation (*Beliefs about consequences*)	
Agyekum et al.	Preprint	Ghana	CS	HCWs	234	Jan 16 - Feb 15, 2021	39%	Opportunity (*Social influences*) Motivation (*Social/professional role and identity; Reinforcement*)	
Paris et al.	Published	France	CS	HCWs	1,965	Feb 9-18, 2021	73%	Motivation (*Social/professional role and identity; Beliefs about consequences; Reinforcement*)	
Woolf et al.	Preprint	UK	Coh & Qual	HCWs	Coh: 11,584	Dec - Mar, 2021	77%	Capability (*Knowledge*) Opportunity (*Social influences*) Motivation (*Beliefs about consequences; Reinforcement*)	
Kanyike et al.	Published	Uganda	CS	HCW (medical students)	600	Mar 15-21, 2021	37%	Motivation (*Beliefs about consequences; Reinforcement*)	

Appendix 2 notes: Greyed boxes in the data collection period column represent studies conducted from Nov 2020 onwards. COM-B model = Capability, Opportunity, and Motivation-Behaviour model; Coh = cohort study; CS = cross-sectional survey; Exp = experimental study design; Gen pub = general public; FTR = free-text responses; HCW = healthcare worker, N/A = studies that did not capture these factors; NR = not reported; Qual = qualitative; TDF = Theoretical Domains Framework. * = Verger et al. collected data from Canada, France, and Belgium so was included in both North America and International sections.