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REVIEW

An Information-Motivation-Behavioral Skills (IMB) model of pandemic risk and prevention

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COVID-19 will be with us well into the future, and four years into the pandemic, it continues to cause serious individual and public health consequences and economic impact worldwide. Mindful of the staggering continuing costs of the COVID-19 pandemic, calls are urgently being made to "prepare *now* for the next pandemic." Containing future pandemics will require at the very core widespread, voluntary, and sustained behavior change to prevent spread of pandemic disease. Such efforts must be based upon well-validated behavioral science models of health behavior change articulated to foreseeable future pandemic contexts. We present an Information-Motivation-Behavioral Skills (IMB) Model of Pandemic Risk and Prevention as a conceptual foundation for understanding the determinants and dynamics of pandemic risk and preventive behavior and as a systematic framework for the design, implementation, and evaluation of interventions to promote and maintain pandemic preventive behavior. Our model is highly generalizable across pandemic scenarios. It is currently testable in the context of COVID-19, and can be tested in future localized epidemics and in pandemic simulation studies. The IMB model of Health Behavior Change, upon which our new model is based, is an empirically well validated and supported multivariate model utilized successfully for decades to understand and promote behavior change in multiple health domains. Our introduction of the IMB Model of Pandemic Risk and Prevention aims to contribute to theoretically- and empirically-based efforts to reduce risk and promote prevention in future pandemics and in the continuing COVID-19 pandemic.

Keywords: Next pandemic; COVID19; Information-Motivation-Behavioral Skills Model; prevention; intervention; health behavior change

1. INTRODUCTION

As the presence of COVID-19 morphs into the "new normal," while nonetheless continuing to cause widespread illness and death, increasingly urgent calls are being heard to "Prepare now for the *next* pandemic" (Gates, 2022; Inglesby, 2023; New York Times, 2023), a challenge that requires, among other things, a foundational behavioral science response. Whatever the specific nature of the next pandemic—and there is a very high likelihood that there will be one (Mahase, 2023)—it is certain that pandemic prevention on an individual and a societal level will require voluntary, widespread, sustained behavior change to avert catastrophic spread of disease. Higher levels of international travel, accelerating climate change, intensifying urbanization and deforestation, and increased human-animal contact contribute to the likelihood that future pandemics will become more frequent, and potentially even more serious than the COVID-19 pandemic. Public health responses to COVID-19 and earlier pandemics have not been optimally effective, in part due to their relatively rare and fragmented use of well-tested behavioral science models of the dynamics of risky behavior, and of prevention behavior change. Moreover, the behavioral science models that were employed on occasion were not specifically articulated to pandemic contexts. Preparation for the next pandemic should involve articulation of relevant, well-researched behavioral science models designed from the outset to promote adoption and maintenance of behavior change to curb the spread of pandemic pathogens. This constitutes one of the major foci of this manuscript.

Preparation for the next pandemic should also involve empirical testing of such models in advance. Many opportunities exist, some even now, for testing the assumptions of a pandemic behavior change model, and for creating model-based behavior change interventions and evaluating their outcomes. A model of pandemic behavior change could be applied and evaluated in the context of understanding the dynamics of, and changing, the current very low COVID-19 bivalent booster vaccination uptake in adults, the extremely low COVID-19 vaccine and booster uptake in children (New York Times, 2022), the very infrequent use of antivirals by those with COVID-19 and at risk for complications, or to rapidity increase individuals' prevention behaviors during future outbreaks of new COVID-19 variants. Model testing could also be performed when there is a need to quickly increase preventive behavior in other serious localized or widespread epidemics or pandemics (e.g., Ebola, Monkey Pox, Avian flu), or in experiments that simulate diverse pandemic scenarios. Approaching COVID-19 and future pandemics with empirically validated theoretical models of pandemic behavior change will allow public health responses to be more proactive, immediate, and effective.

This paper articulates the well-tested and supported Information—Motivation—Behavioral Skills (IMB) Model of Health Behavior Change (J. D. Fisher & Fisher, 1992; W. A. Fisher & Fisher, 2003; W. A. Fisher et al., 2014) to the task of understanding—and changing—the dynamics of pandemic risk and prevention behavior. The IMB model has been used successfully to promote health behavior change in diverse health domains—many of which can result in serious or fatal illness—and notably, in decades of work in the context of the HIV pandemic. We present principles of a new, generalized IMB Model of Pandemic Risk and Prevention we believe will apply across diverse pandemic scenarios, differing pandemic risk and preventive behaviors and efforts to change them, and different populations and cultures. We apply these principles in a discussion that aims to advance a behavioral science approach to prevention in future pandemics, and which is of considerable relevance to understanding and controlling the current COVID-19 pandemic.

2. COVID-19 AND THE CHALLENGE OF FUTURE PANDEMIC PREVENTION

COVID-19 has spread rapidly through global populations, often by asymptomatic or pre-symptomatic but infectious hosts, and continues to cause substantial morbidity, mortality, mental health, social, educational, and economic costs (Johns Hopkins University, 2023; World Health Organization, 2023a, 2023b). The COVID-19 pandemic represents a worldwide public health crisis that has, to date, involved an estimated 676,609,955 individual infections and 6,881,955 deaths globally (Johns Hopkins University, 2023; World Health Organization, 2023a, 2023b). To provide a current perspective as of this writing—and to dismiss the idea that COVID-19 is now behind us—in the US, in the 28 days preceding March 16, 2023, there were 959,794 individual infections and 9,451 COVID-19 related deaths (Johns Hopkins University, 2023). Significant numbers of individuals who have ever been infected with COVID-19 continue to suffer from "long COVID", which can persist for months or years, and may include fatigue, fever, respiratory and cardiac symptoms, metabolic, neurological, and digestive and other symptoms, alone or in combination. Nevertheless, as of this writing, public health authorities including the World Health Organization, the US Government, Health Canada, the Government of China, and others have substantially reduced COVID-19 prevention recommendations, including dropping social distancing and masking stipulations, closing down COVID-19 testing sites, shortening self-isolation periods when infected, and eliminating travel restrictions and pre- and post- travel COVID-19 testing requirements, in spite of persisting high levels of incident infection and hospitalization (Health Canada, 2023; Mallapaty, 2022; U.S. Department of Health and Human Services, 2023; World Health Organization, 2023a, 2023b).

While containing and curtailing a pandemic requires sustained health behavior change on multiple levels, the specific behavior changes required depend on the pandemic, the nature of the causal pathogen, how it spreads, and how its spread can be prevented or contained. For COVID-19, preventive behaviors may include social distancing, face mask utilization, COVID-19 testing, acceptance of vaccination and booster vaccination, and self-isolation and securing and utilizing antiviral treatment if infected and at risk for complications (Centers for Disease Control and Prevention, 2023b). Future pandemics will require their own array of preventive behaviors depending on how the relevant pathogen spreads and is contained.

It is certain that prevention of infection will remain the mainstay of control of future pandemics. Prevention of COVID-19 infection and associated morbidity and mortality—not the therapeutic management of COVID-19 disease—remains the core of COVID-19 pandemic control. The COVID-19 pandemic is now in its fourth year, and successive pandemic waves are driven by new viral variants, some of which are less virulent than the original strain but more efficient in immune escape and spread (Landisman & Connors, 2022). Future COVID-19 strains that spread more efficiently and are more deadly remain possible. Nevertheless, despite widespread COVID-19 vaccine availability, vaccine uptake is uneven and often inadequate within and across countries and populations (New York Times, 2023; K. J. Wu, 2022). Vaccine efficacy against new variants remains a challenge, prompting public skepticism and requiring new vaccine formulations that may or may not keep up with emerging variants (Centers for Disease Control and Prevention, 2023a). At present, across North America and Europe, alongside concerning vaccine uptake, it is rare to see people wearing face masks, and use of antivirals among those infected and at risk is infrequent.

To date, in efforts to promote COVID-19 preventive behavior and contain the pandemic, public health entities have deployed a diversity

of strategies based on a mixture of medical science, well-intentioned "best guesses," and political and economic considerations. When behavioral science health promotion concepts have been applied, it has usually been by academics who have done so in research, and not in widespread public health campaigns (Agley et al., 2021; Bedford et al., 2020; Dearan, 2020; Elgersma et al., 2022; Ezati Rad et al., 2021; Mendez-Brito et al., 2021; Michie, 2022; Michie et al., 2020; Michie & West, 2020; Romano, 2020). A reactive vs. proactive, ad hoc, generally atheoretical mixture of public health prevention strategies also characterized public health prevention efforts early in the HIV/AIDS pandemic and had similar, limited impact (W. A. Fisher et al., 2009). It is well-established that relevant, comprehensive, theory-based approaches can be integral to effective health promotion interventions and that some health behavior change theories are empirically stronger than others (e.g., Albarracín et al., 2005; Davis et al., 2015; J. D. Fisher and Fisher, 2000; Michie and West, 2020; West et al., 2020).

At this point in the COVID-19 pandemic, research and public health interventions using well supported models of health behavior change articulated to the pandemic context—which conceptualize the dynamics of pandemic risk and prevention behavior and inform interventions to strengthen pandemic prevention practices—remain essential. Such efforts also represent critical preparation for widespread public health application in the next pandemic. At present, comprehensive, multivariate, theory-based, and rigorously evaluated health behavior change approaches articulated to COVID-19 prevention—and to prevention and containment of the next pandemic—are lacking (Michie & West, 2020; West et al., 2020). Unless future public health pandemic preparedness includes the introduction, testing, adoption, training in, and widespread use of comprehensive, effective pandemic health behavior change models from the outset, an ad hoc, reactive vs. proactive, atheoretical—and not especially effective—approach to future pandemic prevention will again predominate.

3. THE IMB MODEL OF PANDEMIC PREVENTION

This article presents a new, fully articulated Information—Motivation—Behavioral Skills (IMB) model of pandemic prevention. The model aims to understand the determinants and dynamics of risk and preventive behavior in future pandemics, and to promote and maintain pandemic prevention at the individual, interpersonal, and community levels. Since the particulars of pathogen spread in the next pandemic are not known, we illustrate our IMB model approach to pandemic prevention in the context of the COVID-19 pandemic. We hope to stimulate the design, implementation, and evaluation of effective IMB model-based interventions to encourage preventive behaviors that could yet have major impact on the COVID-19 pandemic (e.g., by increasing COVID-19 vaccine and booster vaccine uptake in adults and children). We present our IMB approach to pandemic prevention in the belief it could be used effectively from the very outset of the *next* pandemic.

To date, the percepts of an IMB model approach have been used informally in several studies on COVID-19 risk and prevention. Some of the model's assumptions have been tested and received preliminary correlational and experimental support, although extant research has been characterized by somewhat uneven fidelity to IMB model core constructs (Khanam et al., 2022; Luo, Yao, Hu, et al., 2020; Luo, Yao, Zhou, et al., 2020; Peng et al., 2021; Song et al., 2022; Tjahjadi et al., 2023). This may have occurred, in part, because the IMB model of pandemic prevention had not, until now, been formally articulated, nor had the content of its core constructs been discussed in relation to

COVID-19 or to future pandemics.

The IMB model of pandemic prevention we will present is a testable multivariate model with clearly defined constructs and relationships (See Figure 1). The model focuses on specific constructs assumed to determine pandemic risk and preventive behavior. It asserts that individuals' levels of actionable *information* about pandemic pathogen prevention, their *motivation* to engage in pandemic prevention behavior, and their *behavioral skills* for effectively practicing pandemic prevention actions, determine their initiation and maintenance of pandemic prevention behaviors (Albarracín et al., 2005; W. A. Fisher et al., 2014) (See Figure 1). Note that the proposed relationships among the constructs of the IMB model of pandemic prevention depicted in Figure 1 have been supported using structural equation modelling in the context of HIV risk and prevention, in the context of understanding the dynamics of many other health behaviors (W. A. Fisher et al., 2014), and in preliminary studies in the context of COVID-19 prevention (e.g., Luo, Yao, Hu, et al., 2020; Luo, Yao, Zhou, et al., 2020).

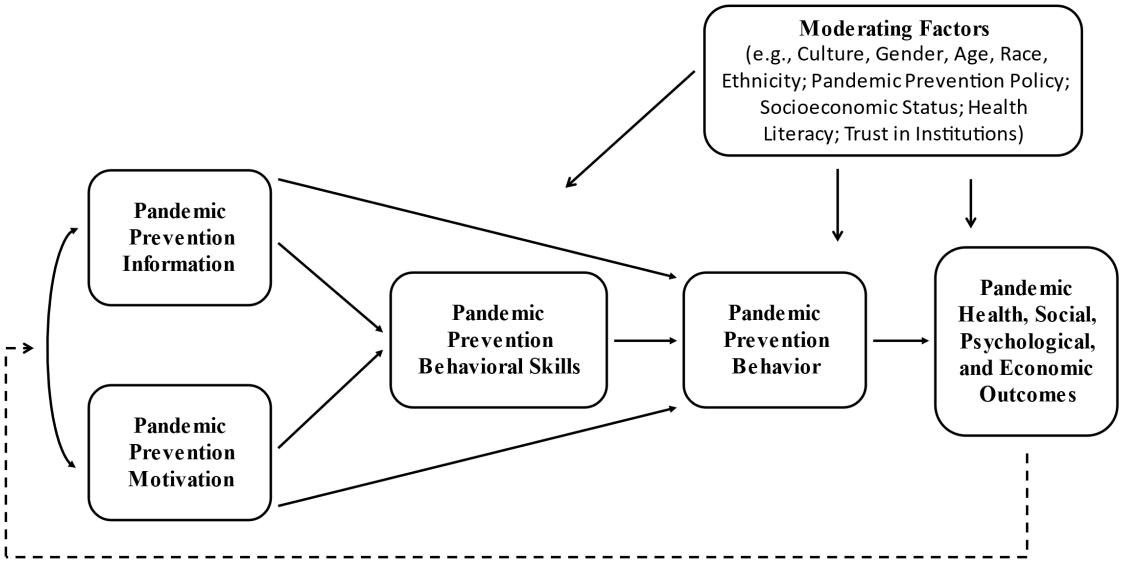
The IMB model of pandemic prevention is mediational in nature (J. D. Fisher & Fisher, 1992). As applied to COVID-19 and to future pandemics, preventive behaviors can be both complicated and novel. For COVID-19, such preventive behaviors have included self-isolating when infected and living in a small space with others alongside significant, competing, job and child-care demands; accessing N-95 masks, COVID-19 vaccination, and COVID-19 testing in the context of shortages of each; and securing and adhering to an antiviral therapy regimen if infected and at risk. In performing such complex and novel behaviors, the effects of pandemic prevention information and pandemic prevention motivation on pandemic preventive behavior will work through, and be limited by, individuals' level of pandemic prevention behavioral skills. For pandemic prevention behaviors that do not involve complex or novel behaviors (e.g., washing one's hands frequently; undergoing readily accessible vaccination at a workplace clinic with employer-granted time off), pandemic prevention information and/or motivation may have direct effects on pandemic prevention behavior (see Figure 1).

The IMB model of pandemic prevention includes a feedback loop such that the health, psychological, social, and economic outcomes of practicing pandemic prevention will affect individuals' subsequent levels of prevention behavior (see Figure 1). For example, some who practice pandemic prevention will remain uninfected, may be positively reinforced by their social contacts for practicing prevention, and may experience economic and health benefits for doing so. These outcomes will feed back through the model to strengthen IMB model components and future pandemic preventive behavior and its maintenance. Others who practice pandemic prevention over time may nevertheless at some point become infected, and/or be socially ostracized for practicing prevention, and/or experience significant economic costs associated with preventive behavior. These outcomes will feed back through the model to negatively influence IMB model constructs and reduce the likelihood of future preventive behavior.

Finally, the IMB model of pandemic prevention specifies moderating factors—including race, ethnicity, socioeconomic status (SES), age, gender, health literacy, and level of trust in government, medicine, and science—that can indirectly (via influence on individuals' pandemic prevention information, motivation, and behavioral skills), or directly (because these elements produce constraints on individuals' ability to practice preventive behavior) affect their pandemic risk and prevention (see Figure 1). Government pandemic prevention policies, availability of relevant health services (e.g., of COVID-19 vaccinations, or COVID-19 test kits or sites) and their economic cost may also moderate levels of risk and prevention behavior.

Figure 1

An Information—Motivation—Behavioral Skills Model of Pandemic Risk and Prevention



4. CONSTRUCTS OF THE IMB MODEL OF PANDEMIC PREVENTION

The sections that follow specify the content of each of the constructs of the IMB model of pandemic prevention. Fidelity to the specified content of IMB model constructs will lead to more valid tests of the IMB model of pandemic risk and prevention, and to stronger, more effective, model-based pandemic prevention behavior change interventions. Next, a systematic process is outlined for testing how the IMB model constructs work together to predict diverse pandemic risk and preventive behaviors in a population, and for designing, implementing, and evaluating theoretically and empirically targeted pandemic prevention interventions.

4.1 Pandemic Prevention Information

Accurate information about how a pandemic pathogen is transmitted and how transmission can be prevented is a necessary foundation for pandemic preventive behavior (Centers for Disease Control and Prevention, 2023b). Actionable prevention information presented in script-like form, that can be relatively easily integrated into the flow of an individual's behavior and is perceived to have low implementation cost, is likely to have the most influence on prevention behavioral performance. It is equally important to recognize that *misinformation* about pathogen transmission and prevention may also be actionable, script-like, seen to be low in implementation cost, and easily integrated into an individual's behavior, and such misinformation is likely to negatively influence pandemic prevention behavior. As the current COVID-19 and future pandemics evolve, accurate information and misinformation about pathogen transmission and prevention will change and will continue to influence risky and preventive behavior. We note that the impact of prevention information and misinformation is likely to be particularly influential early in pandemics when little information of any kind is available to guide preventive behavior. Recall, for example, the impact of information about methods to sterilize one's groceries that led to preventive grocery purification, early in the COVID-19 pandemic.

An additional element relevant to the behavior change potential of pandemic prevention information is the perceived credibility and trustworthiness of the information source. Generally, credible and trusted information sources are preferred, attended to more closely, and lead to greater behavior change (Hovland et al., 1953; Pornpitakpan, 2004). Nevertheless, substantial misinformation can emanate from sources perceived to be credible. Recall incorrect advice from the US Centers for Disease Control (CDC) and the World Health Organization (WHO) early in the COVID-19 pandemic to the public *not to* use face masks. Due to its primacy, such misinformation may have created resistance to subsequent public health recommendations to use masks. It may also have eroded the perceived credibility and impact of subsequent prevention information from public health authorities. Similarly, overt political manipulation of recommendations associated with COVID-19 vaccine trial results (e.g., President Trump's threats to the FDA Director to approve the first COVID-19 vaccine for public use immediately, or be fired; Collins et al., 2020), can erode credibility of vaccine safety and efficacy results. The current relaxation of COVID-19 prevention recommendations by multiple governments (e.g., U.S. Department of Health and Human Services, 2023; Health Canada, 2023; Mallapaty, 2022; World Health Organization, 2022) despite continuing concerning levels of infection, hospitalization, and death may be perceived as based upon political and economic expediency rather than medical science and may also erode trust in authorities charged with protecting public health. Differential perceived credibility may also determine which information sources people seek out and attend to, and thus affect the potential for widespread acceptance of correct information or dangerous misinformation (Rakich, 2020; Schaeffer, 2020). Acceptance of misinformation and conspiracy theories has been associated with risk behavior and rejection of prevention recommendations (Bertin et al., 2020; Eaton & Kalichman, 2020; W. A. Fisher et al., 2013; Sadaf et al., 2013).

Beyond the impact of specific pandemic prevention information and misinformation, individuals may apply cognitively low-effort, often incorrect, heuristic decision rules and naive theories about who is at risk to contract, or transmit, infection. One heuristic involves the assumption that healthy looking people are unlikely to be ill or to infect others with disease (Branswell, 2020). In the context of COVID 19 and, potentially, in future pandemics, this implies that individuals need not practice prevention when interacting with them. However, it is scientifically well established that many infected with COVID-19 are asymptomatic or pre-symptomatic, look well, yet can transmit COVID-19 and other pathogens (Gandhi et al., 2020). People may also heuristically discount the potential to contract serious disease from others they care about and are close to (Misovich et al., 1997; Suls & Wheeler, 2011). Other naive and only partially correct heuristics suggest that "only the elderly die of COVID-19, so if I'm young I need not worry" (Walsh & Semeniuk, 2020). While the elderly do suffer disproportionate COVID-19 mortality, younger individuals are not immune, can become seriously ill and die, and can be asymptomatic, yet transmit COVID-19 to older, more vulnerable, individuals (Jacobs & Sandoval, 2020). Other naive theories promote overly vigilant behavior, e.g., "Hospitals and physician's offices are pandemic hotspots to be avoided at all costs," inclining individuals to fail to seek care even when critically ill with other conditions, or to miss regularly scheduled prevention services (e.g., yearly mammograms) (Feuer, 2020). Novel pandemic-specific heuristics and naive theories are expected to emerge and to operate to precipitate risk behavior in future pandemics.

4.2 Pandemic Prevention Motivation

A second fundamental determinant of pandemic risk and prevention involves individuals' motivation to practice pandemic preven-

tion behaviors. Motivation to practice pandemic preventive behavior involves both *personal* and *social* motivation (Fishbein & Ajzen, 1975; J. D. Fisher & Fisher, 1992; W. A. Fisher et al., 2014).

Personal motivation to practice pandemic prevention rests on individuals' attitudes toward performing specific pandemic prevention behaviors. Attitudes towards performing specific preventive behaviors are a function of an individual's beliefs about the outcomes of practicing these behaviors, and their evaluations of such outcomes (Fishbein & Ajzen, 1975; J. D. Fisher & Fisher, 1992). Positive beliefs about outcomes of pandemic prevention acts (e.g., "If I continue to receive booster COVID-19 vaccination as appropriate, I will remain healthy"), and favorable evaluations of such an outcome (e.g., "Remaining healthy is highly desirable") will be associated with increased pandemic prevention motivation and preventive behavior. If beliefs about the outcomes of pandemic prevention behavior and/or evaluations of such outcomes are negative (e.g., "COVID-19 vaccination can have serious side effects" and "Serious side effects are very worrisome"), prevention motivation will be weaker and preventive behavior less likely. Interventions to change negative beliefs and/or evaluations or to offset their influence by adding positive beliefs and evaluations can increase pandemic prevention motivation and behavior (Ajzen et al., 2007; Fishbein & Ajzen, 1975; Steinmetz et al., 2016).

Available data about specific individuals' or groups' pandemic vulnerability, about disease severity, and about availability of effective therapies and vaccines will affect personal motivation to engage in preventive behavior. Although empirical support for some of these associations is mixed in other contexts (e.g., Brewer et al., 2007; Carpenter, 2010) we believe that in the context of the COVID-19 pandemic and possible future pandemics, data about disease risk, severity, and ability to successfully treat or prevent infection will be linked to personal motivation to practice prevention. For example, to the extent that data about COVID-19 risk, severity, and treatment and prevention is framed and interpreted to indicate the clear and consistent value of sustained preventive behavior (e.g., COVID-19 is contagious, serious, can be difficult to treat, and prevalent in one's age bracket), such data will act to motivate COVID-19 prevention. Note that when data about COVID-19 (or future pandemic) risk, severity, prevalence, and difficulty to treat or prevent disease are framed or interpreted to indicate that one or more of these factors are relatively low, motivation to practice prevention will be lower and risk behavior will increase.

Data about disease risk, severity, and how to prevent COVID-19 (or future pandemic infections) is likely to change over the course of a pandemic and affect motivation to engage in preventive behavior. For example, when safe, effective vaccines are first approved, motivation for vaccine uptake will strengthen. Note, however, that vaccine uptake or the appearance of highly efficacious biological interventions that attenuate illness during a pandemic may reduce performance of other preventive behaviors (e.g., face mask wearing, COVID-19 testing). Data that available vaccines cannot entirely prevent infection, although they do strongly reduce severe disease and hospitalization, may reduce personal motivation to be vaccinated. News that public health authorities have cancelled the COVID-19 emergency designation and relaxed COVID-19 (or other pandemic prevention) mandates and recommendations may have strong demotivating effects on preventive behavior, especially in populations highly motivated to return to pre-pandemic normality. Personal motivation to practice pandemic prevention, based upon perceived outcomes and evaluations of outcomes of preventive behaviors, is expected to be a critical determinant of preventive behavior in future pandemics.

Social motivation to practice pandemic prevention behavior is a function of individuals' perceptions of social support from significant

others for engaging in prevention, and individuals' motivation to comply with these others' wishes (Fishbein & Ajzen, 1975; J. D. Fisher & Fisher, 1992). When individuals perceive significant others to be practicing pandemic prevention, view them as supportive of their own practice of prevention, and are motivated to comply with these others' wishes, social motivation for pandemic prevention will be stronger and preventive behavior more likely. When individuals perceive significant others to not be practicing pandemic prevention, view them as non-supportive of their own preventive practices and/or the individual is unmotivated to comply with significant other's wishes that they practice prevention, social motivation is weaker and prevention less likely. Theory and research suggest that interventions to change individuals' perceptions of, or actual levels of, significant others' support for prevention and/or individuals' motivation to comply with them, or which add pro-prevention referents, will result in increased social motivation and preventive behavior (Ajzen et al., 2007; Miller & Prentice, 2016).

It should be emphasized that across pandemics, personal and social motivation to practice prevention can compete with personal and social motivation to engage in actions *incompatible* with pandemic prevention (Jaccard, 1981). For example, many may possess strong personal and social motivation to practice COVID-19 prevention involving self-isolation if infected– but stronger personal and social motivation to return to their jobs to support their families. Similarly, one may possess strong personal motivation to seek vaccination against COVID-19 but still stronger social motivation to act in accord with important anti-vaccination referent others in their social network. A broad understanding of pandemic prevention motivation must involve research to understand and address personal and social motivation to practice competing behaviors that elevate pandemic risk.

It is an empirical question as to whether personal motivation, social motivation, or both will comprise the dominant determinant(s) of inclination to practice a given pandemic prevention behavior in a population (Ajzen & Fishbein, 1980; Kim et al., 2016). This can be determined through appropriate statistical analysis of data on personal and social motivational determinants of a specific preventive behavior in specific populations. If either personal or social motivation is the dominant determinant of a given pandemic prevention behavior in a particular population, that element should be emphasized in interventions focusing on that behavior and population. However, if both personal and social motivation significantly influence the practice of a given pandemic preventive behavior in a population, both should be emphasized in interventions. It is noted that the potential for social motivation to impact prevention provides a foundation for emphasis on culturally sensitive, community-based interventions to strengthen prevention based on community identification and solidarity.

Additional elements may influence personal and/or social motivation to practice pandemic prevention behaviors. A plateau or decline in pandemic infections may result in a decreased sense of vulnerability and weakened personal motivation to practice prevention, as has often been apparent after peaks of COVID-19 infection, morbidity, and mortality have passed. Subsequent waves of infection and the appearance of new COVID-19 variants which are more contagious and/or which cause more serious disease may affect individuals' relevant beliefs (e.g., about the costs of risky behavior and the benefits of prevention), and their personal motivation to initiate or maintain prevention practices. In an era of relatively widespread COVID-19 vaccine availability (albeit with delays in vaccines articulated to the newest variants), beliefs about vaccine benefits, side effects, and perceptions of social support or opposition to vaccination will impact vaccine hesitancy and

constitute critical personal and social motivational determinants of vaccine uptake. Once again, similar factors are expected to be operating in future pandemics.

4.3 Pandemic Prevention Behavioral Skills

Behavioral skills for pandemic prevention are an additional, foundational factor that determines whether even well-informed and well-motivated individuals will be capable of practicing preventive behaviors effectively. Behavioral skills for pandemic prevention involve individuals' objective ability and subjective self-efficacy to practice the actions necessary to perform, and maintain, specific pandemic prevention behaviors. Pandemic prevention behavioral skills may range from the simple (e.g., hand washing) to more complex and novel (e.g., securing access to scarce vaccines, self-isolation while managing childcare responsibilities). As noted earlier, for pandemic prevention behaviors requiring complex or novel behavioral skills, the effects of pandemic prevention information and pandemic prevention motivation on preventive behavior will work through, and be limited by, individuals' level of relevant behavioral skills. For pandemic preventive behaviors involving simple and familiar actions, pandemic prevention information and motivation can have direct effects on prevention behavior (J. D. Fisher & Fisher, 1992).

In the context of the COVID-19 pandemic, a wide range of relatively complex pandemic prevention behavioral skills have been required. Early in the pandemic, individuals initially needed to possess objective skills and a sense of self-efficacy to make homemade masks or to find a way to obtain scarce N-95 masks, and required skills to keep masks accessible, and to utilize them consistently, comfortably, and properly. Individuals continue to require objective skills and self-efficacy for managing the myriad demands of even briefer periods of recommended self-isolation if infected (e.g., "How do I manage my three children in this small apartment, deal with my partner, who is becoming abusive, and somehow manage to keep my job?"). Correspondingly, individuals must possess the skills and self-efficacy to manage COVID-19 prevention in social and/or work settings that may involve close proximity to unmasked others and elevated infection risk ("My age and medical conditions put me at high risk for complications from COVID-19, and I work on an assembly line in a poorly ventilated space with coworkers who make fun of me wearing a mask. How do I deal with this?"). People must also possess skills and efficacy to access COVID-19 tests and use and interpret them properly, to acquire COVID-19 vaccination, to adhere to two-vaccination schedules and booster vaccination when and if necessary, and to acquire and adhere to antiviral therapy if infected. Paradoxically, the official ending of government-declared COVID-19 emergencies may result in cessation of funding for COVID-19 testing and vaccination and the additional need to overcome financial barriers to access them. The nature of COVID-19 prevention and the requisite behavioral skills will change over the course of the pandemic, and individuals will need to develop new prevention skills and strategies over time (World Health Organization, 2022). The prevention behavioral skill demands of the next pandemic may be similar to the current pandemic, or may be very different, but objective behavioral skills and sense of self-efficacy will again determine whether well-informed and well-motivated individuals will be capable of practicing pandemic preventive behavior effectively.

Additional pandemic prevention behavioral skills that are implicated in the current and future pandemics include the ability to seek out and evaluate the merit of new, or updated, prevention information (Paakkari & Okan, 2020), to recognize conspiracy theories and politically charged misinformation for what they are, and to reinforce oneself and others for appropriate prevention efforts (Guttman,

2019). Other necessary pandemic prevention behavioral skills in the current and likely in future pandemics will involve the ability to manage non-pandemic health concerns ("I have chest pain—how can I safely seek treatment at an emergency room?") in the pandemic context (The Canadian Press, 2020).

4.4 Pandemic Prevention Behaviors

Pandemic prevention behaviors are acts that in and of themselves, if performed properly, can reduce the personal risk of pandemic infection, serious illness, or hospitalization, and/or reduce the risk of infecting others. Some pandemic prevention actions serve both functions. In the context of COVID-19, prevention behaviors include wearing face masks as appropriate, obtaining, and utilizing COVID-19 tests as indicated, practicing self-isolation when appropriate, obtaining and adhering to vaccination and booster schedules, and obtaining, and adhering to antiviral treatment protocols if infected and at risk (Centers for Disease Control and Prevention, 2023a; World Health Organization, 2023a). Those COVID-19 pandemic prevention behaviors that are biomedical in nature (e.g., COVID-19 vaccination, antiviral therapy) are becoming increasingly available, although paradoxically with the end of the COVID-19 public health emergency, they may become increasingly expensive and less accessible to many. Note that currently available COVID-19 vaccines prevent serious illness and hospitalization if one does become infected, but do not necessarily prevent infection and transmission of COVID-19 infection to others. This indicates the benefit of continued COVID-19 preventive behaviors (e.g., wearing a face mask), especially with others who could become seriously ill if infected with COVID-19 (Radcliffe, 2020). Over time, the emergence of new COVID-19 strains may affect vaccine efficacy, dictating the development of new vaccine formulations and acceptance and uptake of booster shots (Centers for Disease Control and Prevention, 2023a). The specific pandemic preventive behaviors that prove essential and effective in future pandemic settings will be a function of the pandemic pathogen in question, but consistent performance of appropriate preventive behaviors will remain essential.

The specific content of the IMB model's information, motivation, and behavioral skills constructs can be articulated to increase COVID-19 preventive behavior or any future pandemic-specific preventive behavior. This can be accomplished in IMB model-based research specifically designed to understand the dynamics of, and to promote the preventive behavior at focus (for details of this process, see the later section on Elicitation Research and its ramifications for the design of effective, targeted interventions). Note that the specific content of each IMB model construct in relation to promoting specific preventive behaviors will vary depending on the pandemic at focus.

4.5 Health, Social, and Economic Outcomes of Pandemic Prevention Behavior

Health, psychological, social, and economic outcomes of pandemic prevention behavior may accrue at the individual, interpersonal, and broader population levels (see Figure 1). At the individual level, such outcomes include one's individual health status (e.g., uninfected, infected, mildly, or severely ill, cured), one's sense of well- being and quality of life, one's social relationships and social support, and one's economic opportunities and outcomes. At the interpersonal level, outcomes may involve the health of one's partner or family, the quality of one's relationships, and the economic wellbeing of the relationship unit. At the population level, pandemic prevention behaviors in the aggregate will affect incidence of infection, illness, hospitalizations and deaths, and available healthcare system capacity, as well as population-wide social and psychological well-being and economic conditions.

4.6 Pandemic Prevention Moderators

The IMB model (see Figure 1) recognizes the influence of moderating factors (J. D. Fisher et al., 2011, 2006) that can directly or indirectly influence individuals' pandemic risk and prevention behavior. For COVID-19 (and likely for future pandemics), moderating factors that can directly impact individuals' pandemic risk and prevention, and thus their COVID-19 health status, include the nature of individuals' employment (e.g., whether they can work alone from home during the pandemic, or must work with others in an office or worksite), and the risk of infection associated with their living arrangements (Blow, 2020; Marmot & Wilkinson, 2005). Population density at work determines risk exposure and ability to practice physical distancing and other preventive behaviors (Blow, 2020). The physical environment in which one lives—in a crowded apartment, dormitory, assisted living setting, prison, homeless shelter, or a more spacious single-family dwelling—can moderate potential risk exposure and possibilities for effective prevention (Tsai & Wilson, 2020).

Race, SES, health disparities, health literacy (Berkman et al., 2011), and medical mistrust (Powell et al., 2019) are all critical moderators with direct effects on individuals' pandemic risk and prevention behavior. A number of these elements (SES, racial-related bias) can directly impact individuals' access to health care services and support. Also, cultures vary in communitarian or individual responsibility (Etzioni, 1995; Lichterman, 1995), men compared to women underestimate their health risk (Finucane et al., 2000), and government pandemic prevention policies have varied markedly across jurisdictions and pandemic stages (Asher, 2020; Carlisle, 2020; Goodman & Carmichael, 2020). These factors can directly impact levels of pandemic prevention behavior. Note that that age and country of residence and (in the US) state of residence were major factors directly affording or limiting access to COVID-19 vaccination during the initial stages of the COVID-19 vaccine rollout (e.g., National Advisory Committee on Immunization, 2020). In future pandemics, direct moderators of prevention behavior may be comprised of some similar and some different elements and will need to be identified and addressed.

The IMB model also recognizes moderating factors that may indirectly impact individuals' pandemic prevention behavior via influence on individuals' levels of pandemic prevention information, motivation, and behavioral skills (Chowkwanyun & Reed, 2020; Yancy, 2020). This may occur due to the targeting, language, accessibility, and other aspects of public health messages, and additional factors. Moderating factors with such indirect effects on individuals' levels of IMB elements may include race, ethnicity, SES, age, gender, cultural characteristics, health literacy, government policies, and individuals' trust in government authorities, in medical institutions, and in science. In future pandemics, the indirect effects of these moderators, and others, on pandemic prevention behavior will need to be addressed.

Beyond the effects of individual moderators, co-occurring moderators have much stronger combined, *syndemic* (synergistic) direct and indirect effects on individual and community levels of IMB model constructs, on individual and community levels of pandemic prevention behavior, on access to pandemic prevention services, and on health outcomes (Singer et al., 2017). Racial minorities and individuals with low SES often have lower health literacy, lower trust in government and healthcare institutions, live and/or work in high-density settings, have less access to prevention mesages, services and supplies, and must continue working and living in high-risk environments during a pandemic. They also likely have a higher prevalence of secondary medical conditions (e.g., diabetes), and thus a higher risk of pandemic morbidity and mortality. All these elements may synergis-

tically, and highly adversely, impact their levels of IMB model pandemic prevention constructs and indirectly impact prevention behavior, and morbidity and mortality. These elements may also directly impact individuals' pandemic prevention and health status. As with other diseases, those most at risk for COVID-19, or the pathogen associated with a future pandemic, may also be less able to practice prevention, and harder to reach with prevention interventions (Blow, 2020; Herrick, 2020; Powell et al., 2019).

4.7 Pandemic Prevention Feedback Loop

The IMB model of pandemic prevention (see Figure 1) specifies a feedback loop such that the health, social, psychological, and economic outcomes of individuals' or populations' prevention behavior feedback recursively through the model (J. D. Fisher et al., 2006; W. A. Fisher et al., 2011). If individuals or populations possess requisite levels of pandemic prevention IMB elements, practice effective prevention behavior, and experience favorable outcomes (e.g., individuals remain relatively healthy, populations experience reduced infection, prevention behavior is socially reinforced, and individual and population economic conditions improve) a virtuous feedback cycle may emerge. Individuals' may become more confident in their prevention information, more motivated to practice prevention, more effective in their prevention behavioral skills, engage in more prevention behavior and its maintenance, and experience lower likelihood of pandemic infection. It is also recognized that inaccurate prevention information, ambivalent motivation to practice prevention, and deficient behavioral skills may result in negative health, social, and economic outcomes. Such negative outcomes may paradoxically reinforce deficits in IMB model constructs and undermine prevention behavior and its maintenance by creating the misguided impression that prevention does not work. Effective pandemic prevention interventions must exploit the potentially virtuous effects and mitigate the potentially deleterious implications of the IMB model's feedback loop in the current COVID-19 pandemic and in future pandemics.

5. DESIGNING, IMPLEMENTING, AND EVALUATING IMB MODEL-BASED PANDEMIC PREVENTION INTERVENTIONS

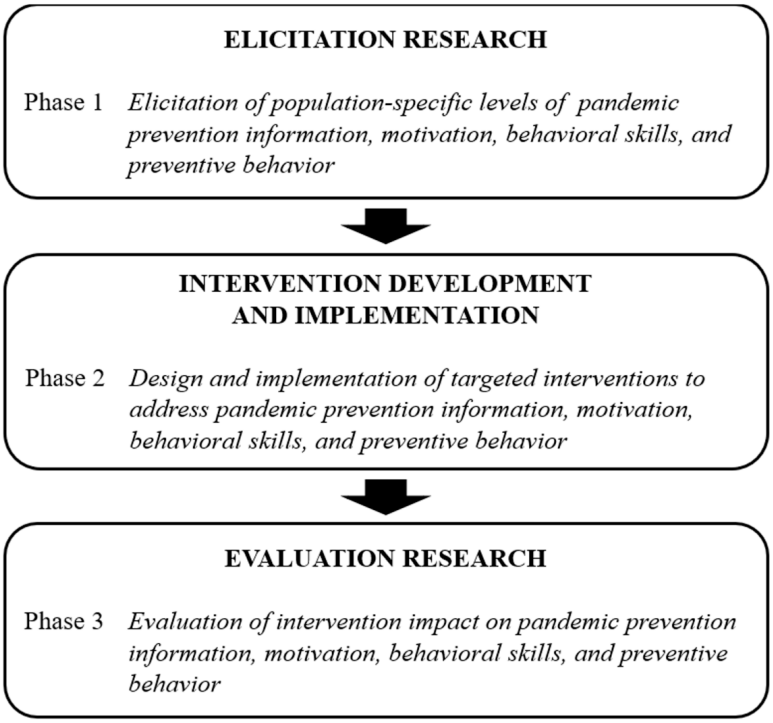
From the perspective of the IMB model, effective pandemic prevention interventions must include content to increase individuals' levels of pandemic prevention information, motivation, and behavioral skills to strengthen their initiation and maintenance of pandemic prevention behavior and yield positive outcomes. As part of the intervention process, specific IMB model moderator elements may also be identified and targeted to mitigate, or strengthen, as necessary, their direct or indirect effects on pandemic prevention and its favorable outcomes.

The IMB approach to pandemic prevention intervention follows a three-phase process (see Figure 2) that has been used successfully for several decades in the design, delivery, and evaluation of effective IMB model-based health behavior change interventions in many health domains (W. A. Fisher et al., 2014).

In the first phase of intervention activity (Fishbein & Ajzen, 1975; J. D. Fisher & Fisher, 1992; W. A. Fisher & Fisher, 2003; W. A. Fisher et al., 2019), *elicitation research* is performed with samples drawn from the target population for the pandemic prevention intervention. Elicitation research aims to illuminate the information, motivation, and behavioral skills determinants and dynamics of a target population's pandemic risk and prevention behavior, and provides an empirical basis for creating tailored pandemic prevention intervention content. Initially, open-ended measures are employed to assess intervention target population members' top-of-the-head, spontaneously accessible pandemic risk and prevention information,

Figure 2

An IMB Model Approach to Theory-Based, Empirically-Targeted Pandemic Prevention Intervention Development and Evaluation.



motivation, and behavioral skills, and their patterns of pandemic risk and prevention behavior. Spontaneously elicited information (and misinformation), motivation (e.g., population members' beliefs about the outcomes of practicing preventive behavior and anticipated social support from important others for practicing it), and population members' perceptions of their behavioral skills for practicing prevention can be described on an aggregate level. These elements can also be compared across those who do, and do not, practice particular pandemic prevention behaviors. Qualitative analyses provide an overview of the pandemic prevention information, motivation, and behavioral skills content associated with the practice of specific pandemic risk and prevention behaviors in a target population.

In the next stage of elicitation research, closed-ended assessments of IMB model constructs are developed based on responses elicited in the open-ended assessment (W. A. Fisher et al., 2019). Closed-ended assessments are employed to quantify individuals' levels of salient pandemic prevention information, motivation, and behavioral skills and their levels of pandemic risk and preventive behavior. Closed-ended elicitation research assessing IMB model constructs can also be used in IMB model testing analyses to identify the strongest IMB model predictors of specific pandemic preventive behaviors in specific populations. This will establish additional, critical empirical guidance for intervention design and emphasis. In sum, both open- and closed-ended elicitation research can identify specific IMB model constructs and content that are deficient and that need to be targeted in interventions to strengthen pandemic prevention.

For COVID-19, a target population for open- and closed-ended elicitation research could involve parents of young children, for whom approved COVID-19 vaccines are available, but rarely utilized. Open ended elicitation research might

identify parents' information weaknesses (misinformation that "Children never get serious cases of COVID-19"), motivational issues ("I'm more worried about vaccine side effects than about my child contracting COVID-19"), and behavioral skills weaknesses ("My partner is very opposed to vaccinating our children and I don't know how to talk with them about this calmly"), that contribute to parental vaccine hesitancy. Close ended research and statistical modeling might then identify personal and social motivation and behavioral skills weaknesses as primary correlates of parental hesitancy to vaccinate children in this target population. The identification of the IMB model constructs and the specific content within them associated with parental vaccine hesitancy creates a theoretical and empirical basis for creation of intervention content aimed at increasing vaccine uptake that respectfully addresses parents' concerns about vaccinating their children.

In addition to identifying IMB model-based elements associated with risky behavior, elicitation research can identify strengths to be capitalized upon to increase prevention. For COVID-19, elicitation research could be used to understand the information, motivation, and behavioral skills determinants and dynamics of face mask use and non-use among personal care workers, who support aged individuals at risk for COVID-19 in assisted living or nursing home settings. Such work could identify specific misinformation among workers (e.g., "I'm feeling healthy, so I don't need to wear a mask today"), specific types of negative personal motivation (e.g., "Wearing a mask makes me look ugly") and negative social motivation (e.g., "My co-workers hassle me when I wear a mask"), as well as specific behavioral skills weaknesses (e.g., "Wearing a mask very quickly becomes uncomfortable") that need to be addressed in interventions to increase face mask use in this target population. At the same time, specific strengths may be identified (e.g., the belief that "I would feel terrible if I infected one of the older adults I care for") that can be leveraged to promote mask use. For an extensive discussion of how elicitation research is performed and how its findings are incorporated into specific intervention content, and detailed examples, see W. A. Fisher et al. (2019).

Thus far we have argued that elicitation research in a particular population can be used to identify population-specific pandemic prevention information, motivation and behavioral skills weaknesses and strengths to target in interventions with a population to increase prevention behavior. Moreover, comparing elicitation research findings for individuals from different groups on the information, motivation, and behavioral skills determinants and dynamics of pandemic risk and prevention can indicate which IMB model-based intervention content can be similar across groups, and which content must differ in different groups to realize the strongest intervention outcomes. In addition to targeting different groups, IMB model-based interventions must also be targeted to specific prevention behaviors. The actionable information, personal and social motivational content, and behavioral skills necessary to practice prevention will differ, for example, for face mask use, for seeking antiviral therapy if infected, for vaccination and booster vaccine uptake in adults, and for deciding to vaccinate one's children. It is clear that for IMB model interventions, "one size does not fit all" (J. D. Fisher & Fisher, 1992). Interventions must also be carefully tailored to the sensitivities and sensibilities of specific groups and populations (e.g., to address the medical mistrust engendered by the historical and ongoing discrimination experienced by African Americans in medical settings).

In addition to providing quantifiable data on populations' pandemic prevention information, motivation, and behavioral skills strengths and weaknesses, closed-ended elicitation research data can also be used to allocate intervention resources and emphasis. Structural equation

modelling (SEM) analyses of the specific interrelations among the three IMB model constructs and a given pandemic risk or preventive behavior can identify how the constructs work together to predict that behavior, and which IMB model constructs may figure most strongly in impacting that behavior in that population. These elements should receive special attention in an intervention. With respect to the IMB model's motivation construct, data analysis can determine whether personal or social motivation (or both) have the strongest relationship with a particular risk or preventive behavior in a population. This can help to prioritize which type of motivation content might best be emphasized in a pandemic prevention intervention effort. In sum, elicitation research is a critical process in developing theoretically- and empirically-guided interventions to strengthen pandemic preventive behavior and lower risk behavior.

In the second, *intervention development and implementation* phase of the IMB model approach to pandemic prevention (J. D. Fisher & Fisher, 1992; W. A. Fisher & Fisher, 2003), theory-based, empirically targeted intervention content is created based on elicitation research findings (see Figure 2). Intervention content creation addresses the IMB model constructs and specific content identified in elicitation research as needing to be strengthened to promote pandemic prevention, or risk dynamics that need to be offset to reduce pandemic risk. Care is taken to ensure the intervention content that is created is culturally sensitive, scientifically accurate, respectfully presented, emanates from credible sources, is optimally engaging, is structured to be script-like and to have relatively low perceived implementation cost, and can be readily integrated in the flow of behavior.

For over thirty years, the IMB approach we have discussed has been used to produce interventions which promote health behavior change and maintenance for diverse health behaviors, intervention settings, and populations worldwide (W. A. Fisher et al., 2014). Behavioral outcomes of IMB model-based interventions have included significant improvements in safer sexual behavior to prevent HIV/AIDS, increased adherence to medication regimens, improved chronic disease self-management, better adherence to post-surgical recovery regimens, increased cancer screening, as well as beneficial changes in other health behaviors. In recent work, an IMB model-based intervention increased medical staff usage of COVID-19 personal protective equipment (Song et al., 2022). In past research, IMB model-based interventions with the strongest information, motivation, and behavioral skills representation were found to have the strongest behavior change impact (see Albarracín et al., 2005; W. A. Fisher et al., 2014). Effective IMB model-based interventions have been delivered by different in person intervenors (e.g., physicians, nurses, lay counselors, social service workers, teachers, and others) in both resource-rich and resource-limited settings (W. A. Fisher et al., 2014). IMB model-based interventions have also been delivered via digital means, including interactive software, medical devices, and health promotion websites (Barak & Fisher, 2003; J. D. Fisher et al., 2011; W. A. Fisher et al., 2014; Orsama et al., 2013), and using multiple media channels. The IMB model is an evidence-based intervention strategy recognized by the CDC (Centers for Disease Control and Prevention, 2023c) and serves as the basis for Canada's national guidelines for sexual and reproductive health education (Barrett et al., 1994; Mckay & Wentland, 2019).

IMB model-based pandemic prevention interventions which include "booster sessions" to respond to challenges which occur in individuals' prevention practice over time and which update, expand, and reinforce individuals' pandemic prevention information, motivation, and skills, may be best able to address emerging prevention challenges as individual engage-

ment with the pandemic continues, and to resist prevention lapses (Metcalf et al., 2005; Y. Wu et al., 2003). Interventions which reinforce individuals' IMB model pandemic prevention constructs at multiple levels and via multiple channels (e.g., at the individual and community levels, and via legacy media, social media, and in multiple day-to-day settings), may be especially effective in maintaining pandemic prevention behavior (Coates et al., 2008; Schensul & Trickett, 2009).

The third phase in the IMB model intervention process (J. D. Fisher & Fisher, 1992; W. A. Fisher & Fisher, 2003) involves rigorous *evaluation research* to assess intervention impact (see Figure 2). To evaluate IMB model-based COVID-19 prevention interventions, for example, one would assess pre- and post-intervention levels of COVID-19 prevention information, motivation, and behavioral skills, COVID-19 preventive behavior, and COVID-19 health status and sense of well-being, measured via biological, psychological, and social markers. In the context of COVID-19 and future pandemics with significant morbidity and mortality, it would be unethical to randomize individuals to a "no treatment" control condition. Research could and should, however, compare outcomes of individuals randomly assigned to an IMB model-based pandemic prevention intervention with those receiving competing pandemic prevention interventions. For individuals receiving an IMB model-based intervention when no alternative intervention is available, one could assess pre-to post-intervention gains in IMB model constructs as determinants of changes in pandemic preventive behavior, and preventive behavior outcomes including health status. Note that the latter is a considerably weaker experimental design than the former.

We have proposed an IMB model theoretical framework for pandemic prevention within which necessary intervention content may be identified, developed, rapidly delivered, and rigorously evaluated in the pandemic setting. While comprehensive elicitation research typically precedes the design of IMB model-based interventions (J. D. Fisher & Fisher, 1992; W. A. Fisher & Fisher, 2003), emergent high morbidity and mortality at the beginning of a pandemic, at specific pandemic peaks, or when changes in effective prevention techniques or practices occur, may dictate rapid development and deployment of initial IMB model-based interventions articulated to specific, especially impactful preventive behaviors and populations at high risk. This may be done based on briefer, more preliminary elicitation research which can quickly identify specific populations' highest priority IMB construct and content needs and prevention behavior challenges. Second generation IMB model-based interventions can incorporate findings of more in-depth elicitation research conducted concurrently with first generation interventions. Such elicitation research would empirically identify in more nuanced ways the IMB intervention content required to promote and maintain critical pandemic prevention behaviors. Second-generation interventions, based on comprehensive elicitation research findings, would provide guidance for individual- and community-level interventions utilizing empirically targeted multi-level mass communication, and targeted digital media. IMB-model based pandemic prevention interventions can be designed to promote the full range of pandemic prevention behaviors and contexts as a pandemic evolves.

6. IMB MODEL-BASED COVID-19 PREVENTION INTERVENTIONS

The COVID-19 public health emergency continues to cause illness and death and requires effective public health, population-wide behavior change interventions delivered via mass media, digital media, and population- and community-based channels. Individual-level COVID-19 pandemic prevention interventions—for example, from a doctor or pharmacist to a patient

or client aimed at increasing vaccination likelihood—must also play a critical role. As we have noted, such interventions—situated in the context of the COVID-19 or a future pandemic setting—should be based upon foundational, well-validated behavioral science models, such as the new IMB model we propose.

At this writing, the COVID-19 pandemic involves worldwide ebbs and flows of infection (Center for Systems Science, 2021; Johns Hopkins University, 2023), substantial first and second generation COVID-19 vaccine accessibility, and widespread perceptions that COVID-19 is "behind us" and preventive precautions are no longer necessary, encouraged by public health authorities' relaxation of prevention recommendations (Health Canada, 2023; Mallapaty, 2022; U.S. Department of Health and Human Services, 2023; World Health Organization, 2022). In this context, unless or until there are significant spikes in infection, or new COVID-19 variants that are highly contagious and cause more serious disease, it will be difficult to motivate face mask use or social distancing in many everyday situations. To protect against COVID-19 variants currently circulating and potentially more contagious and virulent future COVID-19 strains, addressing vaccine hesitancy (Dubé et al., 2013; W. A. Fisher et al., 2013; Larson et al., 2007; Zimet et al., 2013) remains a critical COVID-19 prevention focus. Large segments of many populations—both adults and children—have still not received first generation COVID-19 vaccines or second-generation bivalent vaccines or boosters (New York Times, 2022). Addressing this serious pandemic prevention deficit will be challenging, given findings that substantial proportions of the population do not wish to accept COVID-19 vaccination (New York Times, 2022; Stolberg, 2021).

IMB model-based elicitation research and development and implementation of targeted interventions based on its findings are well-suited to creation of interventions to improve COVID-19 vaccine uptake. Elicitation research can empirically identify specific types of misinformation, personal and social motivational elements (e.g., specific negative beliefs about vaccines, specific anti-vaccination referents), and specific behavioral skills weaknesses that differentiate individuals who accept and those who reject vaccination. Analysis of elicitation research findings can also determine the relative potency of each of the IMB model constructs—pandemic prevention information, motivation, or behavioral skills—in driving vaccine hesitancy, and how individuals' levels and types of relevant information, motivation, and behavioral skills work together to influence vaccine acceptance or rejection. These findings can provide a detailed blueprint for empirically tailored and targeted, theory-based intervention content to mitigate and offset the most powerful elements associated with low vaccine uptake. The resulting interventions have a good chance to be both efficient and effective since they target strong, empirically identified sources of vaccine hesitancy in specific populations.

Suppose, for example, that elicitation research finds that some who reject vaccines believe vaccines do not work because vaccinated individuals can still contract COVID-19. An intervention component could be developed to provide compelling information from sources the target population views as highly credible to the effect that COVID-19 vaccination strongly averts serious illness, hospitalization, long covid, and death, and that the presence of many vaccinated but ill individuals is simply because vaccine uptake among the most vulnerable (e.g., older individuals) is exceptionally widespread. Thus, most vaccinated individuals will not become very ill, but most of the very ill will indeed have been vaccinated—in large part because they were at high risk for complications to begin with. Where referent opposition to vaccination drives COVID-19 vaccine hesitancy, one could use elicitation research to

identify trusted referents, who resonate with a target community, and recruit them to serve as pro-prevention referents who endorse vaccination in interventions.

Where parents are hesitating to vaccinate children based upon the belief that children rarely fall seriously ill with COVID-19, interventions can strengthen the belief that vaccinating children can reduce even the remote likelihood that children will be hospitalized or die from severe COVID-19. This can be paired with an intervention element to strengthen the perception that vaccination will reduce the possibility that one's child will have to stay home from daycare or school, requiring parental days out of work. In all such interventions, the specific IMB model constructs and content most strongly associated with vaccine hesitancy in elicitation work should receive the greatest attention. Evaluation outcome research then can assess intervention-induced changes in such critical IMB model constructs and content, and in vaccination uptake among intervention participants. If an intervention does not sufficiently impact the IMB model elements associated with vaccine hesitancy as well as vaccination uptake *per se*, an iterative process can ensue in which subsequent IMB intervention content targeting these elements is strengthened, which should then enhance vaccine uptake.

The foregoing discussion outlines a systematic, well-researched, highly generalizable approach to understanding and promoting prevention behavior for COVID-19 and foreseeable future pandemics. This approach provides a theoretical and empirical foundation for rapid, coherent, and sequentially organized pandemic prevention interventions. Early in a pandemic, interventions can be based on more limited elicitation research, and should prioritize specific IMB model-based content for target groups likely to have the most immediate, powerful impact on critical prevention actions and on morbidity and mortality. When initial interventions prove effective in one population, brief elicitation research may be used to adapt intervention content carefully and sensitively to other populations. More detailed and nuanced elicitation research should then form the basis of more in-depth "second generation" interventions designed to be implemented after the initial phase of the pandemic and over the long term.

7. CONCLUSION

Too often to date, public health pandemic prevention efforts have been reactive and based on an ad hoc mixture of medical science, political and economic considerations, well-intentioned "best guesses," and infrequent, fragmentary use of isolated health promotion constructs not articulated to pandemic contexts. Such approaches have not been highly effective in stimulating the widespread, voluntary, and sustained behavior change needed to contain and curtail pandemics. The IMB model of Pandemic Prevention, which we introduce in this manuscript, is a conceptual and operational framework articulated to the pandemic setting and based on a very well-researched model of health behavior change. The model can guide understanding of the determinants and dynamics of pandemic risk and prevention behavior and serve as a validated blueprint for the design, implementation, evaluation, and dissemination of effective pandemic prevention interventions. We believe our new model can provide valuable, immediately useful insights into controlling the continuing COVID-19 epidemic, and for curtailing and controlling future pandemics from their very outset.

8. CONFLICTS OF INTEREST

Jeffrey D. Fisher has no known conflict of interest to disclose. William A. Fisher has received consultant and speaker fees from Seqirus and Merck.

9. AUTHOR NOTE

The order of authorship is alphabetical.

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