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Abstract

Background: Understanding the main determinants of COVID-19 vaccine uptake is critical to increasing vaccine coverage. This is particularly important for COVID-19 vaccine uptake, which has been affected by both demand and supply issues.

Aim: To understand the links between vaccine uptake and demand and supply issues in the WHO Eastern Mediterranean and UNICEF Middle East and North Africa regions.

Methods: We collected data through 2 rounds of a repeated cross-sectional phone survey from 11 000 individuals across 16 low- and middle-income countries. We used logit modelling to distil the main characteristics of the 4 vaccination categories (vaccinated, unvaccinated but willing, unvaccinated and undecided, and unvaccinated and unwilling) while also considering vaccine availability. We conducted sub-regional analysis to account for differences in level of development between the low- and middle-income countries.

Results: Despite the increase in vaccination coverage from 60.9% at the end of 2021 to 78.3%

by August 2022, about 9% were not willing and were not vaccinated during the two rounds of interviews. Our modelling analysis revealed that positive beliefs about safety, effectiveness and side effects of the COVID-19 vaccines were associated with increased odds of being vaccinated or willingness to be vaccinated. Those who did not believe in the safety of the vaccines were less likely to be vaccinated than those who believed in the safety of the vaccines (OR: 0.56; 95% CI: 0.46–0.67). By contrast, negative beliefs about the COVID-19 vaccines increased the probability of being unwilling to be vaccinated.

Conclusion: The results from this research offer useful insights into tackling the supply and demand related barriers to COVID-19 vaccination uptake and provides lessons for future health threats.

Keywords: Covid-19 vaccination, vaccine hesitancy, vaccine supply, Eastern Mediterranean Region, vaccination coverage

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Introduction

Demand-side (e.g. willingness to be vaccinated) and supply-side (e.g. vaccine availability and access) factors both play a vital role in ensuring high and equitable vaccination coverage. Shedding light on these factors is important for closing the remaining gaps in vaccination coverage, reducing further outbreaks and spread of disease, and reducing the serious health risks associated with COVID-19 and vaccine-preventable diseases.

Understanding the demand-side and supply-side factors associated with vaccination uptake is particularly important in the WHO Eastern Mediterranean Region (EMR), which includes countries where polio virus is still not eradicated (Afghanistan and Pakistan), and cholera is emerging in some previously cholera-free countries (e.g. Syrian Arab Republic and Lebanon) (1). Significant deficiencies are evident on the supply side (e.g. staffing and facilities) (2) and demand side (e.g. vaccine hesitancy). Some of these issues have been amplified during the COVID-19 pandemic, as governments and partners struggled to achieve high population coverage rapidly, while battling a global shortage of vaccines (3). The extent to which the impact of COVID-19 will continue to affect routine vaccination and other service uptake is a key concern for the future.

To date, a substantial body of literature from the EMR has emerged around the uptake of COVID-19 vaccines. We identified 28 studies from Egypt (4–6), Sudan (7, 8), Pakistan (9–12), Iraq (13), Islamic Republic of Iran (14, 15), Morocco (16), Jordan (17, 18), Palestine (19), and Lebanon (20). Three of the studies covered more than 1 country (21–23). Most of the studies focused on the general population (5, 9–12, 14, 15, 17–23), although some also covered COVID-19 vaccination uptake among medical staff (4, 6–8, 13, 16). One study in State of Palestine included the general population as well as medical professionals (21). When studying the uptake of COVID-19 vaccination, most studies focused on profiling the individuals who were willing to take the vaccine (4–6, 8, 10, 12, 14–23). However, a significant number of studies focused on vaccine hesitancy, defined as delay in acceptance or refusal, despite availability. In most of the studies in our review, profiling of vaccine refusal (4–9, 12, 15–19, 21–23) was separate from profiling of individuals who were unsure or who delayed their decision to be vaccinated (4, 6–9, 15, 16, 18, 19, 23). In 1 of the studies that we identified, the refusers and delayers were grouped together (13). As the vaccination campaigns in the EMR accelerated, a few studies focused on understanding the main characteristics of the adults who were vaccinated (7, 11, 13). All of these studies focused on: (1) socioeconomic and demographic characteristics (e.g. age, sex, income, educational attainment, and location), and (2) knowledge, attitudes, and beliefs about COVID-19 vaccines (e.g. trust in vaccine effectiveness, fear of adverse effects, and health impact of the vaccines), as well as attitudes towards the wider health systems in the country (e.g. trust in the healthcare system). A common feature of all these studies was that they were based on small, one-off, cross-sectional surveys. Almost all these studies used convenience sampling, thus making the results unrepresentative of the country/region and limiting their overall generalizability. All these studies focused on the demand-side correlates of vaccination uptake, and to date, no study has attempted to shed light on the link between the supply-side variables (e.g. vaccine availability) and COVID-19 vaccination uptake.

The objective of this study was to determine if there was a significant association between COVID-19 vaccination status and demographic and socioeconomic factors, and beliefs about

vaccination across the EMR (24, 25). We distinguished 4 vaccination categories: vaccinated; not vaccinated but willing; not vaccinated and undecided; and not vaccinated and not willing. The modelling approach also took into account supply-side factors, such as country characteristics (e.g. availability of healthcare infrastructure) and supply of vaccines.

Methods

Data collection

This study was based on a repeated cross-sectional survey of knowledge, attitudes, and beliefs about COVID-19 in 23 countries and territories in the EMR (26). The survey was conducted in June and July 2021, October and November 2021, and July and August 2022. To use data collected in a single uniform way, we only included data collected for the 16 low- and middle-income countries in the EMR. Data collection was conducted using a structured questionnaire containing 31 items and translated into national languages.

Questions used in the survey were derived from the global question bank provided by the Risk Communication and Community Engagement Collective Service and guided by their conceptual model (27). The decision to focus on the last 2 rounds was made because vaccines had become increasingly available, particularly in the low- and middle-income countries, during rounds 2 and 3. The sample was weighted using the UN population estimates to reflect the actual population by age, sex, and country within the EMR (28).

We used data from UNICEF's procurement repository to explore whether vaccine supply was associated with changes in intention to be vaccinated. We aggregated the total cumulative number of vaccines delivered through the above channels in December 2021 and August 2022, and expressed them as the total number of vaccines per adult, using UN World Population Prospects Data (28). We expressed the total number of vaccine doses per adult population to keep the analysis comparable across countries with differences in eligible populations.

Statistical analyses

We conducted 2 rounds of a repeated cross-sectional survey, with about 11 000 individuals per round in 16 low- and middle-income countries in the EMR. We also conducted a subregional analysis of middle-income and low-income countries. This took into account differences in attitudes towards vaccination, vaccine availability, and the infrastructure capacity to administer the vaccines.

The study focused on 4 vaccination categories: (1) individuals who were vaccinated

(vaccinated); (2) individuals not vaccinated but willing to receive vaccination (willing); (3) individuals not vaccinated and undecided on whether to be vaccinated (undecided); and (4) individuals not vaccinated and not willing to be vaccinated (unwilling). Four binary variables capturing the 4 vaccination categories were derived based on 2 survey questions: (1) Have you received a COVID-19 vaccine? (2) Will you take the COVID-19 vaccine when it is available? Those answering yes to the first question were considered as vaccinated (with at least 1 dose of the vaccine); those answering no to the first question and yes to the second were defined as willing; those answering no to the first question and don't know to the second were defined as undecided; and those answering no to both questions were considered unwilling.

The 4 binary variables were used as dependent variables in a separate logit modelling analysis, which, in addition to the variable capturing vaccination status, included a set of correlates consisting of: socioeconomic and demographic variables (e.g. age, sex, and profession); previous infection with COVID-19; knowledge about COVID-19 transmission (including risk perceptions regarding contracting COVID-19); and beliefs associated with vaccines (e.g. protection offered by the vaccine, and adverse effects associated with the vaccine). As mentioned above, to explore the link between vaccine supply and vaccination status, we used the total number of vaccines per adult (all adults, vaccinated and unvaccinated) at country level, at the time of the 2 survey rounds.

To account for country heterogeneity, country fixed effects were included in the regression analysis. All regressions used the derived weights as described above. The analysis was conducted on a pooled dataset, which, in addition to country fixed effects, included temporal effects (i.e. dummy variables for the different survey rounds). Given the country heterogeneity, the analysis was also conducted on a subregional basis on middle-income and low-income countries. The classification into the country groups was based on the most recent World Bank country income classification (29). Additionally, 3 robustness checks were performed: (1) The analysis was repeated on a joint group of individuals, including those who were undecided and unwilling. (2) A multinomial logit analysis was performed, with the vaccinated individuals as a baseline category. As the order of the vaccination categories did not matter, we opted to use multinomial rather than ordered logit modelling analysis. (3) The pooled dataset analysis was repeated on a round-by-round basis.

All analyses were performed in Stata version 14.0. P **Ethical approval**

The survey tool and protocols were approved by the WHO Regional Ethical Research Committee. Participants were verbally informed about the objective of the survey and their participation, which was purely voluntary. After data were collected, each respondent was assigned a unique ID, while keeping the rest of the personal information completely confidential.

Results

The participants were approximately equally split on a sex basis and among the different age groups (Table 1). The number of respondents who had received at least 1 dose of the COVID-19 vaccine increased over time. The number of those willing and undecided decreased over the 2 survey rounds, but the number who were unwilling to be vaccinated remained stable. Trust in local healthcare providers remained stable over the 2 rounds, but there was a slight reduction in beliefs regarding the effectiveness, protection, and safety of the vaccine. By contrast, the number of respondents who stated “slightly/not at all” regarding their belief in serious vaccine-associated adverse effects changed little between the 2 rounds. The number of respondents without sufficient knowledge about COVID-19 transmission remained high between the 2 rounds. The survey asked respondents if they knew whether COVID-19 could be transmitted through direct contact with people who had the virus but no symptoms.

The descriptive analysis based on the 2 subgroups of countries showed that a little over one-third of respondents in the low-income countries had received at least 1 dose of the COVID-19 vaccine, which was lower than the middle-income countries. Twice as many respondents in the low-income countries were unwilling to be vaccinated, when compared with respondents in the middle-income countries. The number of those unwilling remained stable in low- and middle-income countries.

Figure 1 shows the results of the logit model, using 4 vaccination categories as dependent variables. Figure 1A shows the characteristics of those self-reported as vaccinated. Women were less likely to be vaccinated than men. The probability of vaccination increased with age, when controlling for other covariates. Respondents aged 18–24 years had 0.5 times the odds of being vaccinated compared with those aged > 50 years. Respondents in the health and education professions were the most likely to be vaccinated, which reflected prioritization of these groups in the beginning of the vaccination drive across the region. Respondents who had greater trust and belief that vaccines were safe and offered protection were associated with greater likelihood of receiving at least 1 dose of COVID-19 vaccine.

Figure 1B shows the characteristics of individuals who were willing to be vaccinated. The odds were higher for the younger respondents, possibly reflecting the fact that older individuals were prioritized (or already vaccinated), particularly at the beginning of the vaccination drive. Beliefs about COVID-19 vaccines were important for those willing to be vaccinated; however, they seemed to be less important compared with respondents already vaccinated. Only beliefs in vaccine effectiveness and safety were significantly associated with increased willingness to receive vaccination.

Figure 1C shows the results for the respondents who were undecided, which was a small proportion of the overall sample. Women were more likely than men to be undecided regarding COVID-19 vaccination, and younger women were more likely to be undecided than older women, especially those aged > 50 years. Beliefs about COVID-19 vaccines were not significant for those who were undecided; however, less belief in the safety of the vaccines was correlated with being undecided.

Figure 1D shows the results for respondents who were unwilling to receive COVID-19 vaccination. Sex was not a significant correlate of being unwilling to be vaccinated. However, younger respondents (e.g. aged 18–24 years) were more likely than those aged > 50 years to be unwilling. These respondents had low personal risk perception about contracting COVID-19. Respondents who were unwilling to be vaccinated had significant doubts about vaccine effectiveness, protection and safety.

The EMR includes countries with different levels of economic development; therefore, we repeated the above analysis on subgroups of middle-income (Figure 2) and low-income (Figure 3) countries. The disaggregated analysis suggested that the 4 vaccination categories were maintained when applied to countries with different levels of economic development. In middle-income countries, vaccine supply was positively associated with the likelihood of vaccination willingness. However, in low-income countries, there was a significant negative link between vaccine supply and willingness to be vaccinated; that is, higher supply of vaccines was negatively associated with willingness to be vaccinated. We also conducted an analysis in which individuals undecided and unwilling to be vaccinated were merged into a single category (results available upon request).

Given the interaction between age and sex (and the method used for developing the survey weights for our survey), we repeated the analysis by including an interaction variable for age and sex (available upon request). The analysis showed that compared with younger women aged 18–24 years, older women and men were more likely to be vaccinated. By contrast, compared with younger women aged 18–24 years, older women and men were less willing to be vaccinated. Compared with younger women aged 18–24 years, younger and older men were less likely to be undecided regarding vaccination. The age/sex variable had lower explanatory power when describing those unwilling to be vaccinated. The findings were broadly consistent when repeated on the subgroups of low- and middle-income countries. Importantly, the interaction between age and sex did affect the robustness of the rest of the findings reported above. As an additional check of robustness, we conducted a polynomial logit modelling analysis, whose findings were consistent with the above analysis.

Discussion

To our knowledge, this is the first comprehensive analysis of the main correlates of COVID-19 vaccination status in the EMR, with consideration of 4 vaccination categories. We analysed the correlates of vaccination status over time, the link between vaccination status and vaccine availability, and the vaccination categories according to economic development.

The findings suggest that, despite efforts to increase vaccination coverage across the EMR, about 1 in 10 respondents was unwilling to be vaccinated, and the number unwilling to be vaccinated remained stable between the 2 survey rounds. There is mixed evidence to date regarding the extent of COVID-19 vaccination hesitancy in the general population and how it has evolved over time. A study in the United States of America (USA) found an increase in the number of respondents unwilling to be vaccinated (30). However, the results of those studies could simply be a reflection of the sampling/data collection methods; or more specifically, the datasets were not representative of the population that they aimed to study. Our study used a regionally representative sample and is believed to be the first to suggest that there was a small but persistent group of vaccine refusers, whose unwillingness to be vaccinated did not change over time. The characteristics of these individuals were distinct from those of individuals in the other vaccination categories, suggesting that different strategies will be required for this group. Further research is needed to better understand these implications

We found that some demographic characteristics were associated with vaccination status. In particular and given the priorities of the vaccination drives, older individuals were more likely to be vaccinated. Women were more likely than men to be undecided about whether to be vaccinated. Younger (aged 18–24 years) compared with older individuals were more unwilling to be vaccinated. In the USA, it was shown that a higher likelihood of vaccination was associated with male sex, older age, and higher educational level (31). There is evidence of a link between vaccination status and socioeconomic characteristics in the EMR. A study in the Gaza Strip, for example, found that males and older people had higher odds of being vaccinated against COVID-19 (19), and similar findings emerged from a survey in Jordan (17).

Beliefs about the COVID-19 vaccines were significantly associated with the probability of being vaccinated, willingness to be vaccinated, and unwillingness to be vaccinated. More specifically, positive beliefs about safety, effectiveness, and adverse effects of COVID-19 vaccines were associated with increased odds of being vaccinated or willingness to be vaccinated. By contrast, negative beliefs about COVID-19 vaccines increased the probability of unwillingness to be vaccinated. The findings for the 4 vaccination categories were consistent across the 2 subgroups of low- and middle-income countries.

A large body of evidence from the EMR has also documented the link between vaccination status and beliefs about vaccines. A study among healthcare workers in Egypt found that the reasons for vaccine acceptance revolved around safety and effectiveness, while fear of adverse effects was the main reason for vaccine hesitancy. More specifically, misinformation about fertility was of greater concern among women than men in studies in the EMR (32, 33). Concerns about safety as well as general lack of trust in the vaccines were the main reasons for vaccine hesitancy among healthcare workers in Sudan and Iraq (7, 13). Lack of trust in vaccine effectiveness and fear of adverse effects were the main reasons for vaccine refusal among the general population (5, 14, 18, 22), while belief in the effectiveness and benefits associated with COVID-19 vaccination were the main reasons for vaccine acceptance (14, 16).

Analysis of the entire sample did not find any evidence that vaccine supply was a significant correlate of vaccination status. However, in the subgroup analysis of low-income countries, there was a negative link between vaccine supply and willingness to be vaccinated. This finding could be explained by the slow pace of vaccine supply in the low-income countries and concerns that this may have caused among people willing to be vaccinated. By the time that the third round of the survey was carried out, the low-income countries averaged 0.9 vaccinations per adult, compared with 2.3 in the middle-income countries. In effect, a perceived norm of low vaccination may have been established, which potentially deterred some people who were previously willing to be vaccinated. Although our survey did not include questions on concerns about vaccine supply, previous research has demonstrated that concerns over supply significantly reduced willingness to be vaccinated in low- and middle-income countries, as well as in some high-income countries during the initial vaccination drives (34).

Our study had the following strengths: First, it was based on a regionally representative weighted sample of the adult population in the EMR; thus, the findings can be generalized to the entire region as well as the 2 subregions (low- and middle-income countries). This was an important strength compared with other studies that have attempted to answer similar questions using samples that were not representative of the countries studied, or used data collection methods that excluded sections of the population (34). Second, we used an array of methodological approaches and checks to validate the robustness of our findings. Thirdly, while there was significant self-reporting bias associated with the telephone-based survey, the administrative data suggested that our measure of self-reported vaccination status was only 10% higher than official administrative data.

Our study also had some limitations. First, given the nature of the surveys and the analysis, we could only establish associations rather than causality between the main variables of interest. Second, some of the beliefs around vaccines may have changed over time as conditions

changed (e.g. access to different vaccine brands, global reporting of adverse effects, and policy changes). As more people were vaccinated without incident and communities obtained more social proof of safety (e.g. evidence that their health was not affected), some of the fears around the vaccines were allayed. However, we would need a longitudinal survey to address change in social beliefs over time. Third the vaccine supply variable only captured the total number of vaccinations per adult population cumulatively disbursed at the periods the survey was conducted in November/December 2021 and July/August 2022.

Conclusion

There are significant policy implications from our research. An uninterrupted supply of vaccines (mostly procured through the global COVAX facility) is crucial for further increase in vaccination coverage. This is particularly the case among the low-income and conflict-affected countries in the EMR, where vaccination coverage is still low. Where vaccination policy prioritizes some subpopulations (e.g. older people, and individuals with chronic disease), this analysis could help tailor interventions to the context (e.g. low income, and conflict) and other psychological characteristics beyond demographics (e.g. how people think and feel). Segmentation of the data to focus on specific subgroups, such as those who are unvaccinated and undecided, in relation to their fear of adverse effects, and other negative beliefs, could help increase vaccination willingness and coverage in the EMR. This approach has proven particularly relevant for countries whose vaccination coverage has been low. For example, initially low vaccination rates of women in the region were addressed by tailoring programmes to their specific needs (35).

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Conclusions tirées d'une analyse de modélisation pour la vaccination contre la COVID-19 dans la Région de la Méditerranée orientale

Résumé

Contexte : Il est essentiel de comprendre les principaux déterminants de l'adoption des vaccins contre la COVID-19 pour augmenter la couverture vaccinale. Cette démarche est

particulièrement importante dans le cas de ces vaccins, dont l'utilisation a été affectée par les problèmes de demande et d'approvisionnement.

Objectif : Comprendre les liens entre l'adoption des vaccins et les problèmes de demande et d'approvisionnement dans la Région OMS de la Méditerranée orientale et dans la Région UNICEF du Moyen-Orient et de l'Afrique du Nord.

Méthodes : Les données ont été recueillies au cours de deux phases d'une enquête téléphonique transversale répétée menée auprès de 11 000 personnes dans 16 pays à revenu faible et intermédiaire. Nous avons recouru à une modélisation logit pour déterminer les principales caractéristiques des quatre catégories de personnes vaccinées (les vaccinés, les non vaccinés mais disposés à recevoir le vaccin, les non vaccinés et indécis, et les non vaccinés et non disposés à le recevoir), tout en examinant la disponibilité des vaccins. Nous avons effectué une analyse infrarégionale pour tenir compte des écarts de développement entre les pays à revenu faible et ceux à revenu intermédiaire.

Résultats : Malgré une augmentation de la couverture vaccinale, qui est passée de 60,9 % fin 2021 à 78,3 % en août 2022, près de 9 % des participants n'étaient pas disposés à se faire vacciner et n'étaient pas vaccinés au cours des deux séries d'entretiens. Notre analyse de modélisation a révélé que des croyances positives quant à l'innocuité, à l'efficacité et aux effets secondaires des vaccins contre la COVID-19 étaient associées à des probabilités plus élevées d'être vacciné ou disposé à l'être. Les personnes qui ne croyaient pas en l'innocuité des vaccins avaient moins de chances d'être vaccinées que celles qui y croyaient (OR : 0,56 ; IC à 95 % : 0,46-0,67). En revanche, le fait d'avoir des croyances négatives à l'égard des vaccins contre la COVID-19 augmentait la probabilité de ne pas vouloir se faire vacciner.

Conclusion : Les résultats obtenus dans le cadre de cette recherche fournissent des informations utiles afin de surmonter les obstacles liés à l'approvisionnement et à la demande qui freinent l'adoption des vaccins contre la COVID-19. Ces données permettent également de tirer des enseignements quant aux futures menaces pour la santé.

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WHO EMRO | Insights from a modelling analysis of COVID-19 vaccination in the Eastern Mediterranean R

الخلاصة

: إنَّ فَهم المحددات الرئيسية للإقبال على لقاحات كوفيد -19 أمر بالغ الأهميةالخلفية
لزيادة التغطية باللقاحات . ويكتسي هذا الأمر أهمية خاصة فيما يخص الإقبال على لقاحات
كوفيد -19 ، الذي تأثر بمشكلات العرض والطلب على حدٍّ سواء .

: هدفت هذه الدراسة الى فهم الروابط بين الإقبال على اللقاحات ومشكلات العرضالأهداف
والطلب في إقليم منظمة الصحة العالمية لشرق المتوسط وإقليم اليونيسف في الشرق الأوسط
وشمال أفريقيا .

: جمعنا البيانات من خلال جولتين من المسح الهاتفي المستعرض المتكرر لعددطرق البحث
11000 فرد في 16 بلدًا من البلدان المنخفضة والمتوسطة الدخل . واستخدمنا نموذج " لوجيت "
لاستخراج الخصائص الرئيسية لفئات التطعيم الأربعة (المطعمين، وغير المطعمين ولكنهم
راغبون في التطعيم، وغير المطعمين ولم يقرروا بعد الحصولَ على التطعيم، وغير المطعمين
ولا يرغبون في التطعيم) ، مع مراعاة توافر اللقاحات . وأجرينا تحليلًا دون إقليمي
لمراعاة الاختلافات في مستوى التنمية بين البلدان المنخفضة والمتوسطة الدخل .

: رغم زيادة التغطية بالتطعيم من 60,9% في نهاية عام 2021 إلى 78,3% بحلولالنتائج
أغسطس/ آب 2022 ، لم يكن نحو 9% راغبين في التطعيم ولم يحصلوا عليه خلال جولتَي
المقابلات . وكشف تحليل النمذجة الذي أجريناه عن أن المعتقدات الإيجابية بشأن مأمونية
لقاحات كوفيد -19 وفعاليتها وآثارها الجانبية ارتبطت بزيادة أرجحية الحصول على
التطعيم أو الرغبة في الحصول عليه . أما الذين لم يصدقوا مأمونية اللقاحات فقد كانوا
أقل إقبالًا على التطعيم من الذين صدَّقوا مأمونية اللقاحات (نسبة الأرجحية : 0,56 ،
فاصل الثقة 95%: 0,46–0,67). وعلى النقيض من ذلك، زادت المعتقدات السلبية بشأن لقاحات
كوفيد -19 من احتمال عدم الرغبة في الحصول على التطعيم .

: تقدم نتائج هذا البحث رؤى مفيدة بشأن التصدي للعقبات المرتبطة بالعرضالاستنتاجات
والطلب، التي تحول دون الإقبال على التطعيم ضد كوفيد -19 ، وتقدم دروسًا بشأن التهديدات
الصحية المستقبلية .

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