NOTE: The following protocol was approved by CDC on 4/13/2021. It is being made available for the public's and researchers' awareness. In summary, the aim of the project described in the protocol is to develop and evaluate a surveillance tool using text- and web-based reporting for adverse event monitoring following COVID-19 vaccinations among adults receiving their COVID-19 vaccination through Kaiser Permanente Southern California.

# Development and Implementation of a Text- and Internet-Based Monitoring System for Adverse Events Following COVID-19 Vaccination: A Pilot in Kaiser Permanente Southern California


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## BACKGROUND AND SIGNIFICANCE

Post-licensure vaccine evaluations are required to build a comprehensive understanding of the safety of COVID-19 vaccines, particularly adverse events (AE). With pregnant women and many individuals with co-morbidities being excluded from clinical trials, post-authorization evaluations will be the primary method for SARS-CoV-2 vaccine safety assessments in these patient populations. Previous methods for monitoring of vaccine safety have relied on passive surveillance systems. The caveats of passive adverse event reporting systems are well recognized and include underreporting (particularly for non-medically attended AEs), biased reporting and the inability to establish rates, which could result in delayed detection of adverse events.[1-3]

Text- and web-based reporting systems can provide near real-time information on adverse events with a high degree of granularity, and, by incorporating automation and interoperability into their design, they can be scalable.[4-8] Although text- and web-based reporting tools have been used for post-licensure vaccine monitoring previously, an in-depth analysis of their acceptability and participation across population sub-groups has been limited by the lack of availability of demographic and clinical data.

We conducted a brief review of the literature to identify common challenges identified with adverse events following immunization (AEFI) monitoring systems (**Appendix A**). A total of 10 evaluation studies of monitoring systems for AEFI were identified.[9-20] Eight studies involved active monitoring using telephone or internet-based approaches and two studies evaluated national or regional surveillance systems.[12-20] Of the eight studies involving active follow-up, three assessed a single communication,[13, 16-18] and the remaining studies included surveys at regular intervals. The sample size of study populations ranged from 270 to 4850, and most studies used convenience sampling techniques by recruiting participants at the vaccination visit or relying on opt-in strategies online rather than sending direct invitations. All studies asked participants about AEFIs since getting vaccinated and two studies included additional survey questions on absenteeism.[13, 20]

Identified challenges of the 10 identified studies included: i) the inability to link AEFI data collected by telephone or internet-based surveys to clinical records[13, 14]; ii) in-person recruitment leading to workload concerns on staff at vaccination sites[13]; iii) incorrect contact details being entered at recruitment[13]; and iv) convenience sampling leading to study populations which lack diversity or are unrepresentative of the general population.[11, 13, 15, 16]

The studies identified in the brief literature search also noted several factors associated with higher response rates: i) reminder messages [16]; ii) participation via text message compared with e-mail, although text messaging may also be associated with proportionally higher drop-out rates[9, 10]; iii) individuals with higher

education levels and of older age [11]; and iv) participation via web-based surveys compared with telephone surveys.[15]

The US Centers for Disease Control and Prevention (CDC) have developed a smartphone-based reporting tool, 'v-safe', for capturing adverse events following COVID-19 vaccinations. However, this tool does not have the capability to link adverse event data with individual-level demographic and clinical information such as co-morbidities, medications and vaccine type, limiting the interpretation of responses. Furthermore, by relying on an opt-in mechanism for recruitment, participation is heavily reliant on promotion of the program in the facility, or widespread community knowledge of the program which are likely to vary. This approach further limits the ability to compare the characteristics of v-safe participants to the 'true denominator' of total vaccinated individuals. Additionally, signing up to v-safe requires scanning a QR code on in-facility handouts, which both limits the reach to sub-populations that may not have access to a smartphone, and increases the likelihood of missing people who do not read the in-facility material.

Kaiser Permanente (KP) is one of the largest private integrated health care systems in the US. With high quality individual-level data stored regionally across all levels of care, KP has the unique ability to integrate text- and web-based survey data on adverse events with clinical records, including demographic characteristics, hospital admission data, prescriptions and laboratory data. In July 2020, KP Information Technology (KPIT) and KP Community Health developed an text- and web-based Voluntary Symptom Reporting (VSR) tool which was designed with the intent to supplement passive surveillance systems using active symptom monitoring of COVID-19 among KP members. A pilot study was initiated across the KP Washington region on August 27th, 2020.

Building upon the infrastructure of this VSR tool, KP Southern California (KPSC) has an opportunity to design a text- and web-based active reporting tool for adverse event monitoring following COVID-19 vaccination in partnership with the CDC and the Vaccine Safety Datalink (VSD). We plan to take advantage of the existing infrastructure and lessons learned from the VSR tool to develop a successful COVID-19 vaccine side effect monitoring surveillance tool.

## STUDY SETTING

We aim to collect data on every individual aged at least 18 years who receives their COVID-19 vaccination at KPSC and has provided contact details to Kaiser Permanente. We plan for the first medical centers to roll out the COVID-19 Vaccine Side Effect Monitoring System to be those closest in mileage to our research department building for ease of logistics.

## STUDY AIMS

The overall objective of this project is to develop and evaluate a surveillance tool using text- and web-based reporting for adverse event monitoring following COVID-19 vaccinations among adults receiving their COVID-19 vaccination through KPSC.

The specific aims of this pilot study are separated into three overall objectives:

1. To design the Kaiser Permanente COVID-19 Vaccine Side Effect Monitoring System (or "KP Side Effect Monitor" as abbreviated name): a data collection tool for adverse events following vaccination using text- and web-based surveys that can be linked with clinical records and VSD study IDs.
2. To pilot the KP Side Effect Monitor among adults after receiving COVID-19 vaccinations.
3. To evaluate the monitoring tool during the pilot by:
    - Assessing participation (as a measure of overall acceptability) by describing the characteristics of participants who consent to take part and actively report using the tool relative to invitees who choose not to take part.
    - Identifying opportunities for improvement related to system interoperability, flexibility, data security, scalability, timeliness, data quality, stability, simplicity, and data quality.

Following the completion of these three aims, we plan to discuss the implementation of KP Side Effect Monitor at other participating KP VSD sites, for a larger surveillance study to monitor the safety of COVID-19 vaccine.

# RESEARCH DESIGN AND METHODS

## Summary

This study will involve developing and piloting the KP Side Effect Monitor for reporting adverse events following COVID-19 vaccination directly from study participants.

The Research Design and Methods section of this protocol has been organized around the specific tasks necessary to complete the aims and objectives of the study.

**Aim 1. Developing the KP Side Effect Monitor:** Design a data collection tool for adverse events reported following COVID-19 vaccinations using text- and web-based surveys.

1. Design participant-facing features of the monitoring tool, including timing and wording of survey questions, branding, and legal/compliance requirements.
2. Develop the underlying data infrastructure.
3. Develop scalable real-time data visualization methods.

**Aim 2. Piloting the monitoring system in KPSC:** Conduct a pilot in KPSC of the KP Side Effect Monitor among adults after receiving COVID-19 vaccinations.

1. Recruit a pilot population, starting at a single KPSC site.
2. Collect and manage data for five weeks.
3. Develop educational awareness and communication strategy.
4. Address challenges as they arise.

**Aim 3. Evaluating the monitoring system:** The analysis will involve conducting a prospective, descriptive study that will assess participation and other system attributes of the KP Side Effect Monitor in the pilot population recruited over a 2 week period.

1. Assess participation in the KP Side Effect Monitor.
2. Assess data quality by describing data collected by the Side Effect Monitor and validating against clinical records.
3. Assessing the interoperability of the system, and, in particular the ability to link KP Side Effect Monitor responses with VSD files.
4. Assess the other attributes of the system according to standard criteria for evaluating surveillance systems and digital health interventions.
5. Produce a collaborative report of study findings, including any challenges encountered, lessons learned and plans for expansion.

## Aim 1: Designing the KP Side Effect Monitor and developing the underlying data systems

### Recruitment and consent procedure

**Figure 1** outlines the flow of communication with study participants using the KP Side Effect Monitor, from invitation to survey completion for the first survey. In brief, there are two main channels to opt in to take part in the system:

1) QR code recruitment: On the day of their vaccination, participants can opt into the system by scanning a QR code printed on informational flyers and posters using a smartphone device. Participants who choose to opt in using this method will first be required to sign on to their Kaiser Permanente online account, to confirm their eligibility to enter the program (participants must be aged at least 18 years to take part). Alternatively, if they do not have an account with kp.org, they will be asked to provide their date of birth and gender.

Receiving a digital invitation following their vaccination: Approximately one day following their vaccination, participants who have not been recruited in the clinic and are determined eligible will be sent an invitation to sign up for the KP Side Effect Monitor via text, e-mail or via their online KP account. Individuals will be eligible to receive this digital invitation if they are aged 18 years or above, have received a COVID-19 vaccination on a given day at Kaiser Permanente Southern California and have not explicitly opted out of digital communication services at the time of their vaccination. For those receiving a digital invitation, invites will be sent via online Kaiser Permanente account, text message or e-mail according to the communication information available. From our recent pilot study of the VSR tool we observed that secure portal message invitations through a participant's online account were associated with enhanced participation compared with text message and e-mail invitations alone. Therefore, if participants are registered online with Kaiser Permanente, this route will be prioritized for the initial invitation. Therefore, invites will be sent out according to the following criteria:

- Secure message invite: Participants who have registered online with kp.org.
- Text message invite: Participants for whom e-mail contact information is not available, and a mobile number is available.
- E-mail invite: Participants for whom mobile contact information is not available, and a valid e-mail address is available.
- 50:50 split for e-mail or text message: Participants who have **both** e-mail and mobile contact information available. A random 50% of these individuals will receive a text message and 50% will receive an e-mail invitation.
- Reminder invites: After 24 hours, if members have not responded, a reminder message will be sent through an alternative invitation channel.

The invitation methods described above will ultimately guide individuals to a webpage which will describe the system and ask for their consent to take part (**Figure 2**). The information page will have a series of frequently asked questions (FAQs) around survey timing and data security, as well as clear messaging on the use of the data for reporting purposes. Participants will be informed that KP Side Effect Monitor is for monitoring purposes only, and if they are experiencing health concerns following their vaccination, we advise them to contact their healthcare provider. Alternatively, in addition to the online consent option, for participants who receive invites via text message, they may consent directly via text by replying "YES" to the consent text message. If they require additional information about the system, they have the option of texting "HELP" to receive a link to the information page.

If participants consent, they will provide their preferred contact method for receiving the survey throughout the 5-week follow-up period. Participants will be provided with an option to respond to survey questions via text message directly (by responding "Yes" or "No" to survey questions), or to receive a link to complete the survey securely on a web browser. The information provided during the consent process will clearly explain the risk of third parties accessing text messages, both in transmission and whilst they are stored on mobile phones. Participants are also asked which channel they would like to receive the links to the online survey: text, e-mail, or portal message through their online account. Participants will be able to opt out of the study at any time.

## Survey questions

If participants consent, they will be asked to respond to questions related to their current health at regular intervals for up to 5 weeks. **Table 1** outlines the questions, timing, and participant population for each survey.

Immediately after providing consent, participations will be taken to the initial survey question (or they will receive a text message with the first survey question if they provided consent directly via text). The first question will ask whether participants have been previously infected with COVID-19. Participants will then be asked about local reactions to the vaccine. Next, participants will be asked whether they have experienced systemic reactions to the vaccine. Following this, if they indicated that they have experienced any symptoms, participants will be asked whether their symptoms caused them to seek care from a healthcare professional. The final three questions will be asked again for 14 days, at daily intervals for the first week then on every other day for days 8 through 14. At week 3, 4 and 5, weekly surveys will include one question on whether they have experienced any new or worsening symptoms. If they respond "Yes", they will be asked whether they have received care from a healthcare professional because of their symptoms. The final message will thank individuals for their participation and will remind them that the survey is for reporting purposes only. The survey cycle will restart when

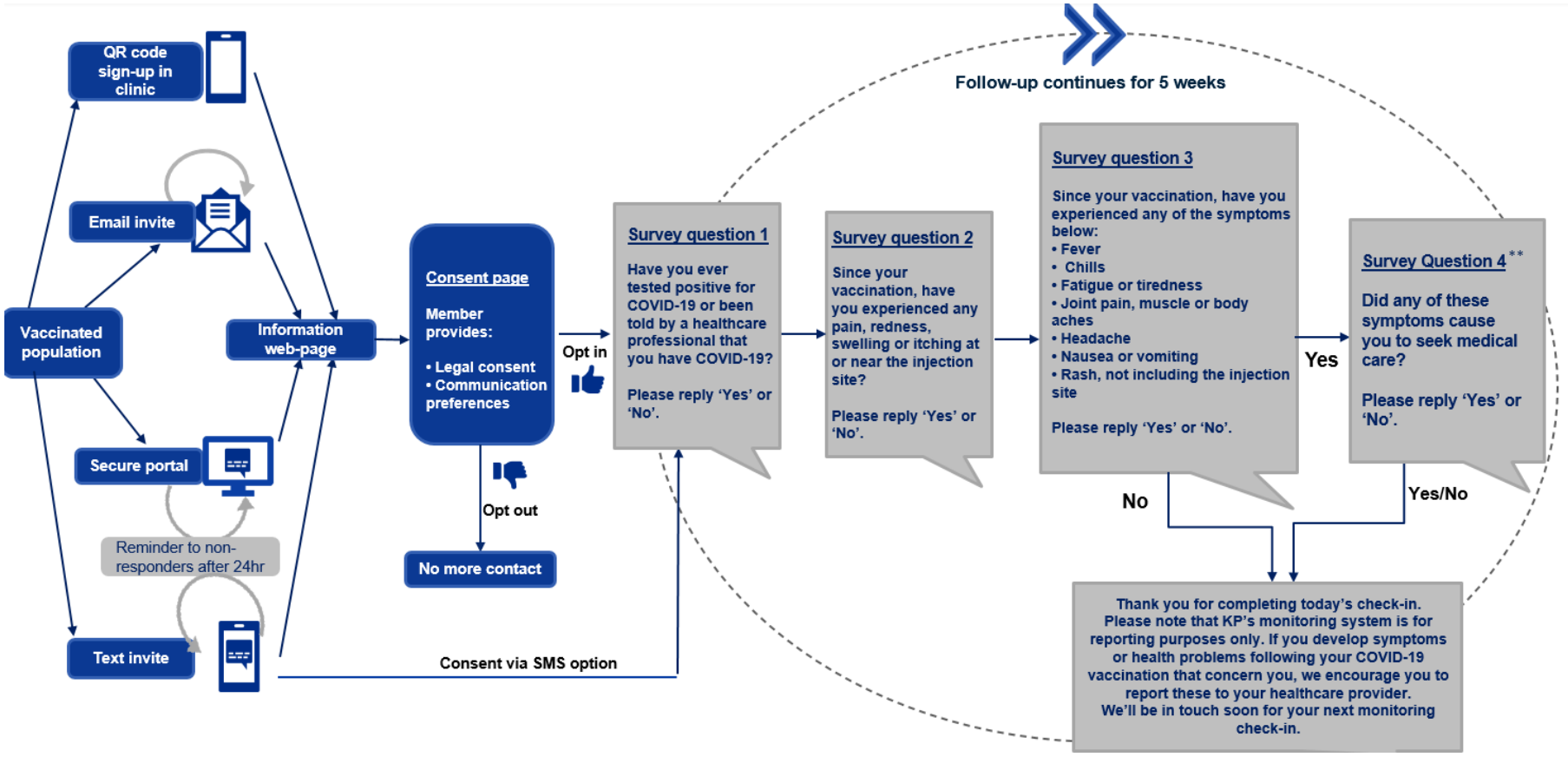
KPSC medical records indicate that study participants have been vaccinated with a second dose, if required. This will mean that participants will no longer receive follow-up survey questions related to their first dose.

When participants reach the end of the survey, there will be clear messaging explaining that the KP Side Effect Monitor is for reporting purposes only, and that their answers will not be provided directly to their care teams. Participants are reminded that they should contact their healthcare provider if they experience vaccine side effects that concern them.

Surveys will be sent at alternating times each day according to a timed schedule within daylight hours. For participants choosing to complete the surveys online, links will not expire throughout the follow-up period, and therefore participants will be allowed to return to previous links and re-submit answers during a different session.

Due to the unknown nature of vaccines, the survey questions can be adapted. We plan to offer the survey in Spanish and English initially, with the aim to increase the languages offered throughout the pilot phase, starting with Mandarin. The surveys will be sent out in the preferred language which is recorded on each participant's medical records. Participants can change their language preferences at any time throughout the survey.

**Figure 1.** Draft design of text- and web-based recruitment and survey pages included in the initial survey of the KP Side Effect Monitor*




*Invites will be sent out to each channel according to the following criteria: i) Secure message invite: Participants who have registered online with kp.org; ii) Text invite: Participants for whom e-mail contact information is not available, and a mobile number is available; iii) E-mail invite: Participants for whom mobile contact information is not available, and a valid e-mail address is available; iv) 50:50 split for e-mail or text: Participants who have **both** e-mail and mobile contact information available. A random 50% of these individuals will receive a text message and 50% will receive an e-mail invitation; v) Reminder invites: After 24 hours, if members have not responded, a reminder message will be sent through an alternative invitation channel.

**Participants are asked survey question 4 if they answer "Yes" to either question 2 or question 3. Otherwise, they are taken directly to the final thank you page.

**Table 1.** Overview of survey administration.

| Timeline | Contact method | Participant population | Question / Page 1 | Question / Page 2 | Question / Page 3 | Question / Page 4 | Question / Page 5 |
|---|---|---|---|---|---|---|---|
| Day of vaccination (Day 0) | QR code sign up in-clinic | For participants who use a smartphone to sign up at the clinic. The information on flyers and posters will include a QR code that will contain a link to a secure sign on page. After this, participants will be sent to the information page. | Sign-on to KP.org | Information page | Consent page | Contact preferences page | Participants brought directly to the 1st survey |
| Approximately Day 1 following vaccination | Initial invitation via secure link sign up | For those not recruited at the clinic, invitations will be sent according to contact details on file: secure message through kp.org, text message or e-mail. | Invite message | Information page | Consent page | Contact preferences page | Participants brought directly to the 1st survey |
| Approximately Day 1 following vaccination | Initial invitation via text message | For those not recruited at the clinic, invitations will be sent via text message according to contact details on file. Participants may choose to consent directly via text, for continued text message surveys. | Invite text | Consent text | Day 1 text survey starts | | |
| Approximately Day 2 following vaccination | Second invitation to non-responders | Reminder invitation sent after 24 hours if no response to initial invite. Channel used will be the alternative channel used for the initial invitation. | Second invite message | Information page | Consent page | Contact preferences page | Day 1 survey starts |
| First ever Online survey | Survey #1, Online one-time survey (on day of consent) | Participants will complete this initial survey online if they consent via webpage sign up. After consenting, they will be taken straight to question 1. | Survey Q1: Prior COVID-19 status | Survey Q2: Local reactions | Survey Q3: Systemic reactions | Survey Q4: Medical care (if yes to Q2 or Q3) | End of survey: Thank you for participating |
| First ever Text survey* | Survey #1, Text message one-time survey (on day of consent) | For participants who consented directly via text message, participants will complete the survey by replying directly to the survey questions with text message replies. | Survey Q1: Prior COVID-19 status | Survey Q2: Local reactions | Survey Q3: Systemic reactions | Survey Q4: Medical care (if yes to Q2 or Q3) | End of survey: Thank you for participating |
| Approximately 2 – 7 days following vaccination: Online and text survey* | Survey #2 Daily survey | For those who opted to take survey online, an individualized hyperlink will be sent to take online via preferred contact method (text, online KP portal or e-mail). For those who opted to | Survey reminder message | Survey Q1: Local reactions | Survey Q2: Systemic reactions | Survey Q3: Medical care (if yes to Q1 or Q2) | End of survey: Thank you for participating |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | respond via direct text message, a survey will be texted directly. | | | | | |
| Approximately days 8 – 14 following vaccination: Online and text* survey | Survey #3 Every other day | For those who opted to take survey online, an individualized hyperlink will be sent for convenience to take online via contact channel of preference (text, online KP portal or e-mail). For those who opted to take survey via direct text message, a survey will be texted directly. | Survey reminder message | Survey Q1: Local reactions | Survey Q2: Systemic reactions | Survey Q3: Medical care (if yes to Q2 or Q3) | End of survey: Thank you for participating |
| Approximately 3 & 4 weeks following vaccination: Online and text* survey | Survey #4 Weekly | For those who opted to take the survey online, an individualized hyperlink will be sent for convenience to take online via contact channel of preference (text, online KP portal or e-mail). For those who opted to take survey via direct text message, a survey will be texted directly. | Survey reminder message | Survey Q1: New or worsening symptoms | Survey Q2: Medical care (if yes to Q1) | End of survey: Thank you for participating | |
| Approximately 5 weeks following vaccination: Online and text* survey | Survey #5 final survey | For those who opted to take survey online, an individualized hyperlink will be sent for convenience to take online via contact channel of preference (text, online KP portal or e-mail). For those who opted to take survey via direct text message, a survey will be texted directly. | Survey reminder message | Survey Q1: New or worsening symptoms | Survey Q2: Medical care (if yes to Q1) | End of program: Final thank you message | |

*If participants decide to submit responses to the survey via text message, they will be reminded that text messages are potentially accessible by a third party. The consent page will outline the options to submit responses securely online.

## Alternative text message survey options (A/B tests)

For participants who opt to respond directly via text message, two alternative types of surveys will be deployed in parallel as A/B tests. As outlined in **Table 2,** versions A and B will ask similar questions, however one survey will ask participants to respond with a simple "YES" or "NO" reply (version A), whereas the other survey will ask participants to reply with numbers corresponding to the specific symptoms they may be experiencing (version B). Response rates will be compared between the populations that receive each version of the survey to assess the impact of the altered wording/reporting style on participation and data quality. The system will capture all answers to the survey, allowing us to assess the participants data entry errors. If participants fail to follow instructions for version B and instead write out text responses using words similar to the options for version B, we will categorize them as experiencing this symptom. For example, if the type "Pain" rather than "1" in their text response to question 2, the pain outcome will be recorded. However, if they respond with words that do not match the response options provided, they will be sent an error message and will be asked to submit their response again. Similarly, if participants do not include a comma (",") between numbers in their text responses, we will record the answers as normal, regardless of spaces or other characters between numbers. However, if they provide a number which is not one of the options provided, they will be sent an error message and will be asked to retry. We will aim to test the two different approaches on populations with similar distributions of key demographics.

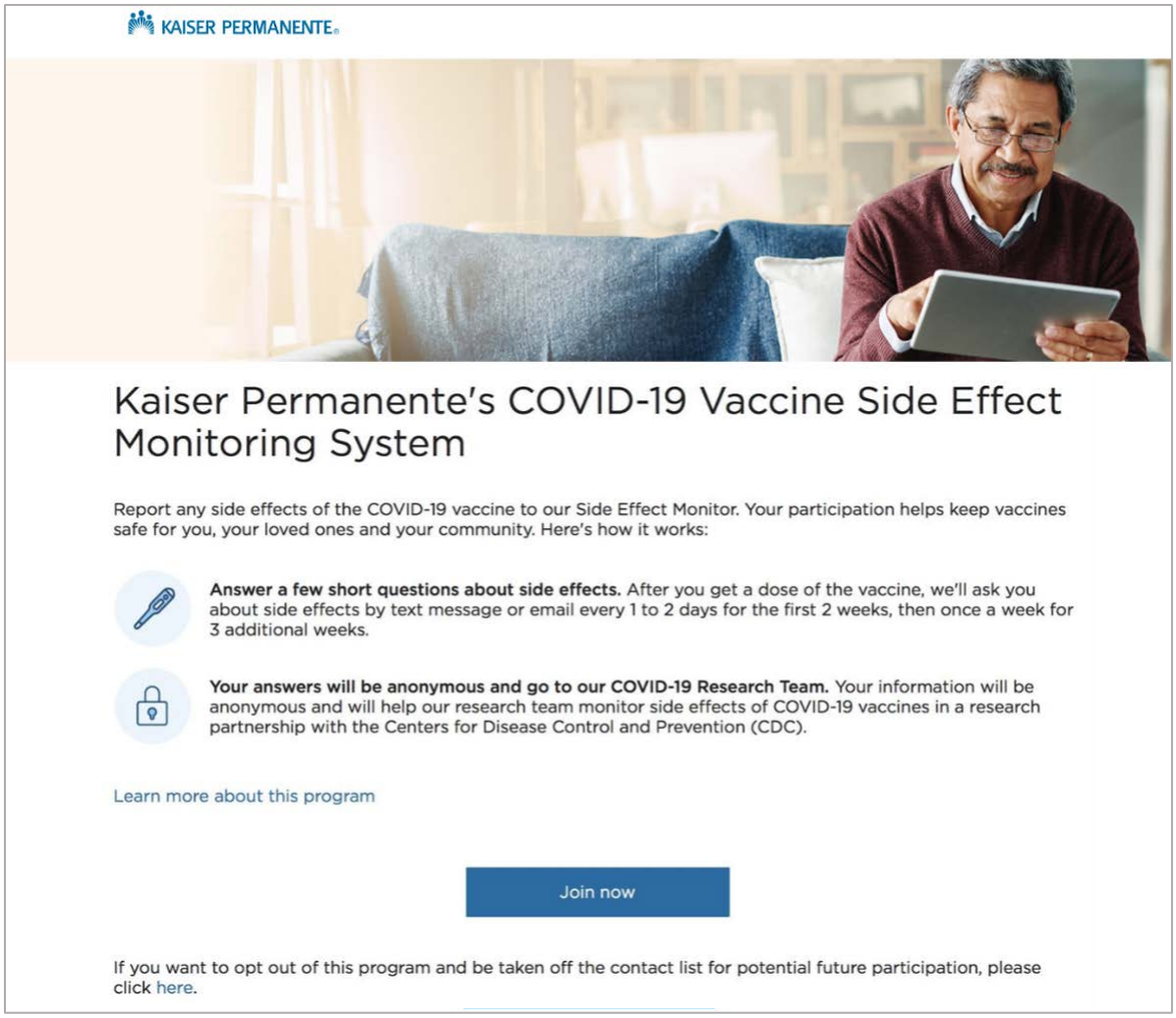
**Table 2.** Differences between numbered and aggregate versions of the A/B test among participants opting in to respond via text message.

| Question | Version A | Version B |
|---|---|---|
| **Example question 2 of first survey via text** | Since getting your COVID-19 vaccine, have you experienced any pain, redness, swelling, or itching at or near the injection site? Reply YES or NO.<br>Reply END to opt out, or HELP for help. | Since getting your COVID-19 vaccine, have you experienced any of the following side effects at or near where you got the shot?<br>1. Pain<br>2. Redness<br>3. Swelling<br>4. Itching<br>5. None of the above<br>Reply with the numbers corresponding to the side effects you've experienced. For example: 1, 3.<br>Reply END to opt out, or HELP for help. |
| **Example question 3 of first survey via text** | Since getting your COVID-19 vaccine, have you experienced any of the following side effects?<br>- Fever<br>- Chills<br>- Fatigue or tiredness<br>- Joint pain or body or muscle aches<br>- Headache<br>- Nausea or vomiting<br>- Rash, not including the injection site<br>Reply YES or NO.<br>Reply END to opt out, or HELP for help. | Since getting your COVID-19 vaccine, have you experienced any of the following side effects?<br>1. Fever<br>2. Chills<br>3. Fatigue or tiredness<br>4. Joint pain or body or muscle aches<br>5. Headache<br>6. Nausea or vomiting<br>7. Rash, not including the injection site<br>8. None of the above<br>Reply with the numbers corresponding to the side effects you've experienced. For example: 1, 3.<br>Reply END to opt out, or HELP for help." |

## Legal, Marketing, Branding and ADA Compliance review

All participant-facing language will be reviewed for HIPAA/privacy, Telephone Consumer Protection Act (TCPA), and legal issues. Marketing and branding teams will ensure the language is consistent with the Kaiser Permanente brand and business strategy. Furthermore, the survey design will undergo additional review to ensure compliance with the Americans with Disabilities Act (ADA). **Figure 2** shows a draft information page with approved legal, branding and marketing features.

**Figure 2.** Draft information page for KP Side Effect Monitor



## Developing the underlying data structure

Once participants have been determined eligible, key variables (**Appendix B**) required to run the KP Side Effect Monitor will be identified for each individual and uploaded to a secure file location using secure file transfer protocols. This step will be automated, and the data will be uploaded daily. Data will be stored in this location for 7 days and will be date-stamped.

Using this data, initial survey invitations will be sent to study participants according to the contact information provided. Participant responses from the KP Side Effect Monitor will be updated in real-time on KPIT servers. They will also be automatically uploaded onto a secure file location daily for KPSC research staff to access. KPSC research staff will integrate these data with clinical and demographic datasets.

## Developing scalable and real-time data visualizations

The data will be provided on interactive dashboards which will summarize daily participation rates and other user interactions of interest. This summary-level data will be provided in Tableau, a software with a user-friendly interface. Key stakeholders will have access to this summary level data, including KPSC and KPIT study personnel, KP Leadership, clinical operations teams, CDC and VSD partners. An example of the dashboards created for the previous VSR tool is provided in **Appendix C**. This interface will be updated daily, rapidly pulling user interaction data from the KPIT server and displaying participant characteristics and interactions as consumable visualizations, where the data are available. The dashboards will be developed to allow users to stratify the KP Side Effect Monitor responses by important variables of interest such as date of vaccination, date of symptom reporting, and vaccine dose number. When displaying aggregate data, IRB mandated procedures for the protection of confidentiality of subject data will be carefully followed. For example, we will not allow aggregate data to be grouped by categories containing very few individuals, to protect those individuals from being identified. The Tableau dashboards will be designed by KPIT teams, but with the aim to share learnings and underlying code with KPSC programming teams and other regions at the expansion phase.

Continued improvements to these dashboards will be made throughout the pilot study in response to evolving requests from key stakeholders. This will help the dashboards meet the needs of public health surveillance partners and clinical teams when using data collected by the KP Side Effect Monitor to drive public health action.

# Aim 2: Piloting the KP Side Effect Monitor in KPSC

## Identifying eligible participants

Participants will be deemed eligible to receive an invitation to take part in the KP Side Effect Monitor based on the following criteria:

- Aged ≥18 years.
- Have received a COVID-19 vaccination through Kaiser Permanente, either by receiving the vaccine at a KPSC facility, or receiving the vaccine at a non-KP facility, but as KPSC members this data is provided in health records up to seven days following date of vaccination (outlined below). We aim to start the pilot among participants receiving the vaccination at the KP Baldwin Park and LAMC sites, after which we aim to expand quickly to other KPSC sites.
    - *Administrative delay:* We will allow a maximum administrative delay in receiving data of 7 days from receipt of vaccination. For example, if a participant received their vaccine on March 7$^{th}$, but the data was not received in the system until March 15$^{th}$, they would not be invited. However, if we receive their data on any day up until March 14$^{th}$, they will receive an invitation to take part in the program.
- Have digital contact information on file.
- Have not opted out of digital health communications.
- This population will include both members and non-members, as well as any individuals covered by Medi-Cal and Medicare insurance policies.

Individuals will be invited according to the contact details available on-file, as described previously.

## Data Collection of KP Side Effect Monitor Responses

The KP Side Effect Monitor responses will be collected from study participants up to a total of 5 weeks per dose. These responses will be automatically uploaded onto KPIT servers, where the response data will be cleaned and stored as time-stamped variables such as those outlined in **Appendix D** per participant. Most variables will be updated in real-time and displayed in aggregate on Tableau Dashboards, as described above. Information displayed on these dashboards will be discussed by the working groups. By the end of the pilot phase, the goal for the KP Side Effect Monitor is to operate automatically by collecting, analyzing, and displaying aggregate user responses continuously in real-time.

## Communication plan

Although recruitment will be handled remotely, the option for participants to sign up for the KP Side Effect Monitor using in-house flyers and posters will allow an opportunity for staff to engage with patients about the monitoring system.

Therefore, staff awareness will likely enhance participation. To aid staff awareness, clinical teams will receive a ‘Frequently Asked Questions’ (FAQ) document about the system in routine internal communication, and informational flyers and posters about the KP Side Effect Monitor will be available in the clinic. Staff at the initial pilot center(s) will also be provided with a virtual demonstration of KP Side Effect Monitor. During this session, they will have the opportunity to ask questions and make suggestions on the design.

## Aim 3: Assessing participation and other system attributes

### Summary

Study Design: Descriptive study.

Study Purpose: To assess participation in Kaiser Permanente's COVID-19 Vaccine Side Effect Monitoring System.

Study Setting: KPSC

Study Period: We will include KP Side Effect Monitor responses, demographic, utilization, comorbidity, clinical, laboratory and other data on KPSC members and non-members who have received COVID-19 vaccinations over a two-week period in mid-March. Data collection will continue for five weeks following participants' consent to take part in the KP Side Effect Monitor.

Index date: The index date will be defined as the date of receiving the COVID-19 vaccination.

Study Cohort: The cohort will include vaccinated individuals aged ≥18 years who have contact details on file and have not opted out of KP digital communications and have received a dose of the COVID-19 vaccination in KPSC during the 14-day pre-specified recruitment period starting with 1-2 medical centers. From there, we plan to rapidly expand to the other KPSC medical centers. We plan to allow for a maximum administrative data delay of 7 days to be invited from receipt of vaccination. For example, if a participant received their vaccine on March 7$^{th}$, but the data was not received on the system until March 15$^{th}$, they would not be invited. However, if we receive their data on any day up until March 14$^{th}$, they will receive an invitation to take part in the program.

Covariate Data: Where data are available, we will use a combination of demographic data, laboratory data, membership data, and disease coding across all care settings and across relevant specialties to describe the characteristics of the population who choose to participate in this active Side Effect Monitoring System. At a minimum, we plan to collect demographic and comorbidity data including BMI, demographic characteristics (age, sex, race/ethnicity, Kaiser enrollment status, MediCal status and Medicare status), prior healthcare utilization (prior influenza vaccination records, prior SARS-CoV-2 test), clinical characteristics (prior COVID-19 infection, diabetes, cardiovascular disease, chronic kidney disease, congestive heart failure, chronic obstructive pulmonary disease, stroke and HIV), and other potential covariates of interest for stratified subgroup analyses. The full list of covariates are outlined in **Tables 4 & 5**. A full list of corresponding ICD codes is provided in **Appendix E**. We are aware that these data may be incomplete for non-members

and KPSC members with <12 months prior membership. Ancillary files may be created.

## Data Analysis

### Participation assessment

We will describe the overall proportion of participants by their interactions with the KP Side Effect Monitor using a flow diagram, outlining the proportion of initial invitees who viewed the information page, consented to take part, actively opted out, actively reported and dropped out at each stage (**Figure 3**). We will describe the proportion of participants at each category of interaction separately by invitation and reminder channels used to communicate with them, paying particular attention to opt-in rates (**Figure 4**).

We plan to assess participation by notification channel, paying particular attention to opt-in rates, reporting consistency and drop-out rates over 5 weeks of follow-up (**Table 3**). Additionally, we will analyze the demographics of the population by categories of interaction (**Table 4**). Similarly, we can analyze the same categories by clinical characteristics (**Table 5**). This analysis will be repeated for each channel of participation (e.g. text, e-mail, or secure message participation). Where possible, summaries of these analyses will be presented using interactive Tableau dashboards.

As mentioned, for those participants who opted to respond to surveys directly with text messages, two survey designs will be deployed in parallel which will be randomly assigned to participants. Participation and population characteristics will be compared between the two versions of the survey to assess the impact of altered reporting style on participation. We will also assess the effect of other differences in the system attributes on overall participation, such as the time of day participants received invites and survey reminders.

### Data quality assessment

Using the data collected by the KP Side Effect Monitor during the pilot study, we will complete a full assessment of data quality. This will include the following analyses:

i) We will assess the opportunity for error in reporting when participants alternate between reporting outcomes (i.e. switch back and forth between survey pages) within the same session. This limitation has been noted elsewhere, however the consensus is unclear whether the first or last reported outcome is the most accurate. We will monitor how often this reporting error occurs and describe the population characteristics of

participants who change their responses within the same session. If the data allows, we will validate whether participants sought medical care (as self-reported using KP Side Effect Monitor) using clinical records among KPSC members to assess whether the first or last response should be used in this situation.

ii) We will validate the self-reported COVID-19 status as reported via the KP Side Effect Monitor using COVID-19 diagnosis or positive COVID-19 test results (including antibody tests, rapid antigen tests, and PCR tests) from KPSC members clinical records. We will use a similar approach to assess the sensitivity of the system in detecting whether participants sought medical care from a healthcare provider due to their symptoms. To do this, we will assess the sensitivity, specificity, and predictive value positive (PVP) of the system in identifying prior COVID-19 status and medically attended adverse events according to the following calculation, as outlined in **Table 6**:

Predictive value positive = A / (A+B)
Sensitivity = A / (A+C)
Specificity = D / (B+D)

iii) We plan to assess the potential for duplication errors in the data, by identifying participants who were recruited more than once through multiple invite channels, or participants who were recruited without meeting the inclusion criteria.

## Assessing the interoperability of the system by linking KP Side Effect Monitor responses with VSD study files.

Individual-level data obtained by the KP Side Effect Monitor will be linked to VSD files by VSD study ID using unique patient medical record numbers (MRNs). After this, KPSC research staff will be able to produce summary-level aggregate data in regular reports and share with the CDC. Variables of interest can be accessed through VSD study files, including detailed vaccine information such as vaccination date, dose number, vaccine type and vaccination history, demographic characteristics, insurance enrollment status and length, COVID-19 test results, COVID-19 infection diagnosis, risk factors, pregnancy status, comorbidity and medical history. Any programming code produced for this purpose will be clearly annotated and retained for future use.

## Assessing other system attributes

We will assess other attributes of the system in accordance with standard approaches to evaluating surveillance systems and digital health tools developed by CDC and WHO, [21, 22] The following attributes will be assessed from the CDC's updated guidelines for evaluating a surveillance system: usefulness, simplicity, flexibility, data quality, acceptability, sensitivity, representativeness, timeliness, stability, informatics system quality, informatics user experience/service quality, and informatics interoperability. For each system attribute, we will gather credible evidence to summarize the performance of the system. Where possible, we will aim to include objective measures in our assessment of each attribute.

**Figure 3.** Study population flow chart for inclusion in data analysis

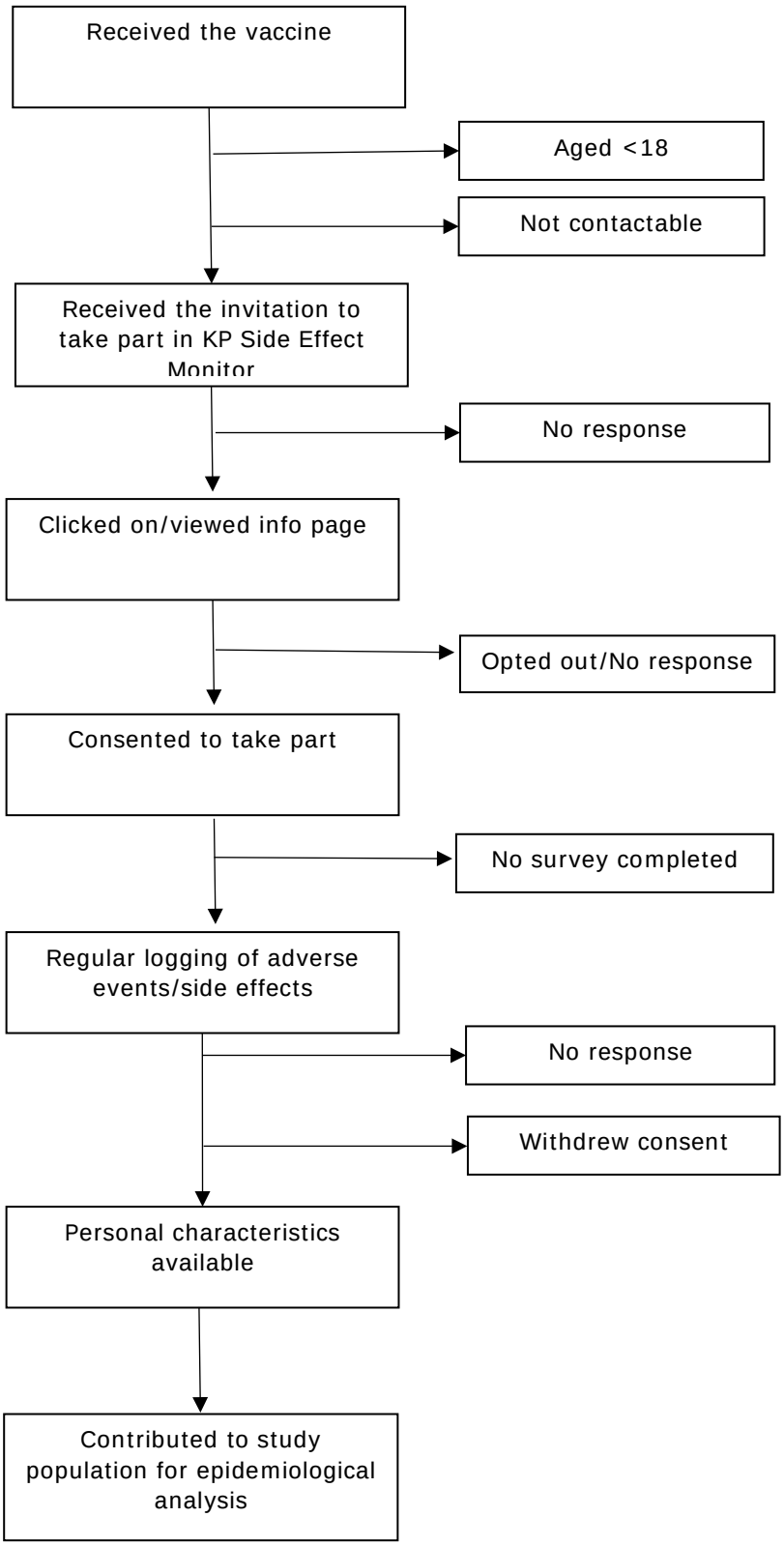


**Figure 4.** Example Sankey diagram showing channels used for recruitment and opt-in rates for each

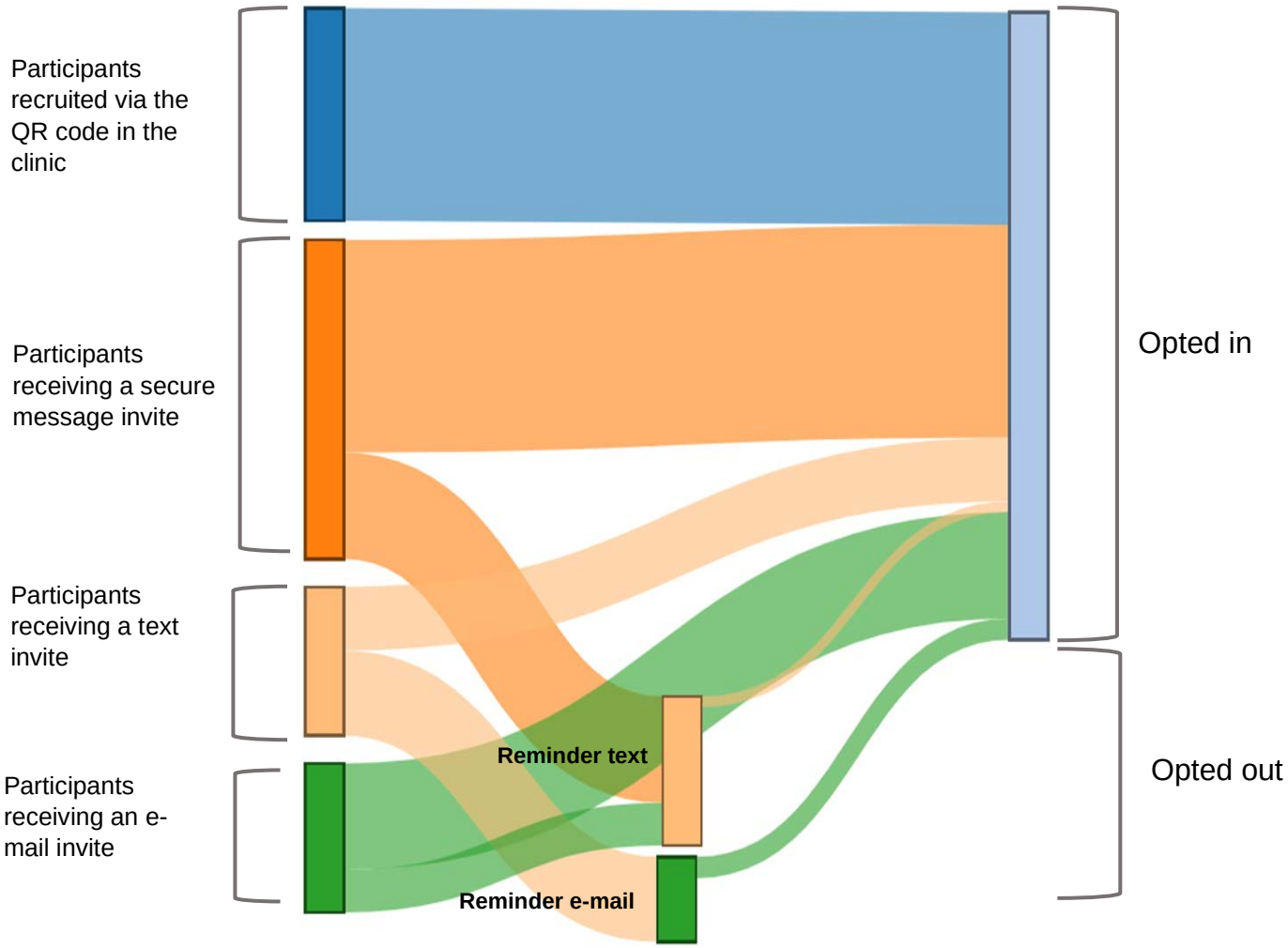


**Table 3.** Participation in KP Side Effect Monitor by reminder notification preference category

| | Contact preferences | | | |
|---|---|---|---|---|
| | **Text survey** | **Text reminders** | **E-mail reminders** | **Secure message reminder** |
| **Total** | | | | |
| **Recruitment method** | | | | |
| Secure portal invitation | | | | |
| E-mail invitation | | | | |
| Text invitation | | | | |
| **Received reminder invitation** | | | | |
| No | | | | |
| Yes | | | | |
| **Participation** | | | | |
| No response | | | | |
| Completed 1st survey (~Day 1) | | | | |
| Completed 2nd survey (~Day 2) | | | | |
| Completed 3rd survey (~Day 3) | | | | |
| Completed 4th survey (~Day 4) | | | | |
| Completed 5th survey (~Day 5) | | | | |
| Completed 6th Survey (~Day 6) | | | | |
| Completed 7th survey (~Day 7) | | | | |
| Completed 8th survey (~Day 8) | | | | |
| Completed 9th survey (~Day 10) | | | | |
| Completed 10th survey (~Day 12) | | | | |
| Completed 11th survey (~Day 14) | | | | |
| Completed 12th survey (~Day 21) | | | | |
| Completed 13th survey (~Day 28) | | | | |
| Completed 14th survey (~Day 35) | | | | |
| Completed at least 1 survey | | | | |
| Completed at least 4 surveys | | | | |
| Completed at least 10 surveys | | | | |
| Completed all surveys | | | | |
| Withdrew consent during week 1 | | | | |
| Withdrew consent during week 2 | | | | |
| Withdrew consent during week 3 | | | | |
| Withdrew consent during week 4 | | | | |
| **Self-reported outcomes during follow-up** | | | | |
| Prior COVID-19 infection | | | | |
| Local symptoms | | | | |
| Systemic symptoms | | | | |
| New or worsening health problems | | | | |
| Sought medical care | | | | |

**Table 4.** Characteristics at index date, by KP Side Effect Monitor participation category

| Characteristics, N (%) | Members | | | | | |
|---|---|---|---|---|---|---|
| | Invited | Consented | Responded at least once | Submitted all surveys | No response | Withdrew |
| **Total, (row %)** | | | | | | |
| **KPSC membership** | | | | | | |
| Enrolled ≥1 year | | | | | | |
| Enrolled <1 year | | | | | | |
| Non-members | | | | | | |
| **Sex** | | | | | | |
| Male | | | | | | |
| Female | | | | | | |
| **Age, years** | | | | | | |
| 18-25 | | | | | | |
| 26-40 | | | | | | |
| 41-60 | | | | | | |
| >60 | | | | | | |
| **Mean (SD)** | | | | | | |
| **NDI, Quintiles** | | | | | | |
| Q1 | | | | | | |
| Q2 | | | | | | |
| Q3 | | | | | | |
| Q4 | | | | | | |
| Q5 | | | | | | |
| **Race/Ethnicity** | | | | | | |
| Hispanic | | | | | | |
| Asian | | | | | | |
| Black | | | | | | |
| White | | | | | | |
| Other | | | | | | |
| **Insurance** | | | | | | |
| Medi-Cal | | | | | | |
| Medicare | | | | | | |

NDI: Neighborhood Deprivation Index

**Table 5.** Characteristics at index date, by KP Side Effect Monitor participation category

| Characteristics | Invited | Consented | Responded at least once | Responded to all surveys | No response | Opted out |
|---|---|---|---|---|---|---|
| **Total, N (row %)** | | | | | | |
| **COVID-19** | | | | | | |
| Vaccine – 1st dose | | | | | | |
| Vaccine – 2nd dose | | | | | | |
| Prior COVID-19 infection | | | | | | |
| **Health-seeking behavior** | | | | | | |
| Proportion with at least one prior SARS-CoV-2 test | | | | | | |
| Proportion receiving annual influenza vaccination over 3 years | | | | | | |
| **BMI category, N (%)** | | | | | | |
| 18-25 | | | | | | |
| 26-30 | | | | | | |
| 31-40 | | | | | | |
| >40 | | | | | | |
| **Mean (SD)** | | | | | | |
| **Comorbidity, N (%)** | | | | | | |
| Type II Diabetes | | | | | | |
| CHF | | | | | | |
| CVD | | | | | | |
| Stroke | | | | | | |
| CKD | | | | | | |
| COPD | | | | | | |
| HIV | | | | | | |

**Table 6. Calculation of Predictive Value Positive, Sensitivity, and Specificity of KP Side Effect Monitor**

| | | Medical record of prior COVID-19 infection | | |
|---|---|---|---|---|
| | | **Yes** | **No** | **Total** |
| **Self-reported prior COVID-19 infection** | **Yes** | True positive (A) | False positive (B) | Total detected by KP Side Effect Monitor (A + B) |
| | **No** | False negative (C) | True negative (D) | Total missed by KP Side Effect Monitor (C + D) |
| | **Total** | Total true COVID-19 prior infections (A + C) | Total (B + D) | Total (A + B + C + D) |

| | | True medically attended event | | |
|---|---|---|---|---|
| | | **Yes** | **No** | **Total** |
| **Self-reported medically attended event** | **Yes** | True positive (A) | False positive (B) | Total detected by KP Side Effect Monitor (A + B) |
| | **No** | False negative (C) | True negative (D) | Total missed by KP Side Effect Monitor (C + D) |
| | **Total** | Total medically attended events (A + C) | Total non-medically attended events (B + D) | Total (A + B + C + D) |

## Disseminating findings

We plan to combine the main findings of the pilot study evaluation as a collaborative manuscript. For this, we will report on the findings according to the WHO guidelines on evaluating digital health interventions to ensure that the findings are comparable with future evaluations of similar digital tools.[22] The report will clearly identify the challenges encountered, and lessons learned throughout the pilot study.

## Plan for rapid expansion & Project timeline

We hope to optimize the KP Side Effect Monitor in accordance with the findings related to system attributes and lessons learned throughout the pilot study. Following system optimization, we hope to expand rapidly to other sites within KPSC and then other KP regions. The full proposed timeline is outlined below:

| | |
|---|---|
| February 2021 | Prepare underlying data systems and IT environment; Finalize analysis plan; Plan pilot phase; Decide on survey questions; Develop KP Side Effect Monitor tool; Submit IRB for pilot study |
| March – April 2021 | Provide final protocol of pilot study to CDC; Conduct pilot study in KPSC at select medical centers; Prepare for rapid expansion to all KPSC sites |
| April - May 2021 | Data cleaning & Analysis; Draft report for CDC and VSD review; Expand to other KPSC sites; Continue data collection at initial pilot sites |
| June 2021 | Submit manuscript for publication; Prepare for expansion phase to additional KP VSD regions |
| July 2021 | Provide CDC with a report of findings from the pilot study |

## Human Subjects Protection

Privacy and confidentiality will be strictly protected according to VSD and KPSC standard procedures. There will be minimal risks to patient privacy and confidentiality. All information will be stored on secure KPSC computers and at participating sites. IRB approval will be obtained for this study and will include a waiver for the requirement to obtain HIPAA authorizations.

## Data Security

This study will be conducted at the Kaiser Permanente Department of Research & Evaluation Southern California (KPSC). KPSC has procedures in place to maximally protect the security of all data used for the purposes of this study. KPSC employees are required, as a condition of their employment, to complete training in HIPAA and IRB requirements. All research conducted in the KPSC region complies with federal regulations regarding the privacy and confidentiality of study participants and their protected health information as specified in the Common Rule and the HIPAA Privacy Rule. KPSC and KPIT have robust procedures to protect the security of the computing environment. All data used for this study will be kept on password-protected servers.

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# Appendix A. Literature search results

| Country & year | Vaccine | N | Intervention | Brief description | Follow-up | Outcome | % Enrollment | % symptoms | Challenges/Strengths identified |
|---|---|---|---|---|---|---|---|---|---|
| Australia, 2014[16, 17] | Trivalent Influenza Vaccine (TIV) | 688 | Text and telephone (Non-response sent reminder text) | 344 randomly selected women received a telephone call 7 days following TIV about AEFI. 344 age matched women received a text message instead. | Single communication 7 days post vaccination. | AEFI | Response rate was higher for text compared to telephone interview (90.1% vs. 63.9%). | Telephone: 30%, via text: 12%. Of those reporting AEFI via text, almost 40% were unreachable. | Data collection by text results in significantly improved response rates and timeliness of vaccine safety data. However, loss to follow-up occurred more frequently in text group. |
| USA, 2014[19] | Influenza vaccine | 605 | Interactive voice response system. Non-response followed up with computer-assisted telephone interviewing. | Convenience sampling of adults receiving vaccines. Registered and consented in the clinic. | Daily for 14 days post-vaccination | AEFI | 90% (N=545) of study population reported, and 49% (N=299) reported for full 14-day period. | 62% reported one or more AEFI, for a total of 594 AEFIs reported. 85% of AEFIs were mild. | Convenience sampling meant the sample was not geographically diverse or representative. Participants could report multiple times per day. Older participants and those with higher education were more willing to provide daily reports. |
| Australia, 2007-2013[11] | All vaccines | 5295 | Regional passive surveillance | A review of adverse event reports received in Victoria since surveillance commencement (6 years). | Passive, 6 years | AEFI | Passive<br><br>**Findings:** Although online reporting increased to 32% of all reports, 85% of consumers continued to report by phone. | 5295 over 6 years | Consumer reporting reached 21% in 2013. Consumer reports were 5% more likely to describe serious AEFI than HCP. Changes are required to AEFI reporting systems to implement efficient consumer AEFI reporting. |
| Scotland, 2009 - 2010[14] | H1N1 influenza A vaccination | 4028 | Text and e-mail (feasibility study) | Contacted via preferred method of contact (e-mail or text). Reminder messages sent to no responders. | Monthly survey for 7 months post-vaccination | AEFI | Convenience recruitment<br><br>81% of those who consented had at least one interaction. | Total events: 827 | Difficulties contacting patients where contact details had been incorrectly completed at registration. Not able to identify vaccine type. Workload concerns prohibited recruitment via some general practices. Did not report on local effects or mild systemic effects. |
| France, 2010[10] | H1N1 influenza A vaccination | 5.7M doses of vaccine | National passive surveillance | A National analysis of surveillance data for AEs in France summarizing surveillance data from 5.7 M doses of vaccine. For the first time, patient reporting was formally introduced in France, reaching 21.2% of the collected reports. | At least 8 months | AEFI | Among all reports, 3,740 (78.8%) were from health practitioners and 1,006 (21.2%) were from patients. | 4,180 AEs for Pandemrix®, (reporting rate 102/100,000 doses)<br>334 “medically serious” and 193 “serious” | Data was not linked to patient records. Could analyze by vaccine type. Spontaneous notifications suffer from underreporting, the magnitude of which varies between 82% and 98%. |

AEFI: Adverse event following immunization; NA: Missing information; HCP: Healthcare Providers

# Appendix A Continued

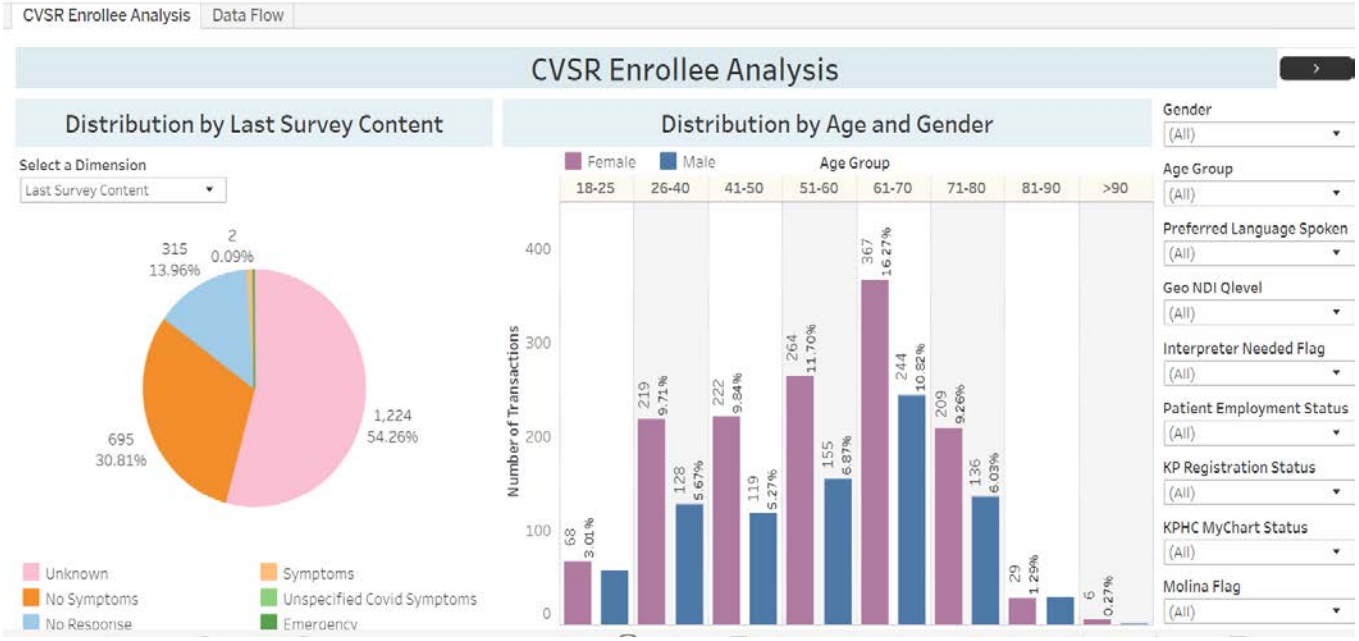
| Country & year | Vaccine | N | Intervention | Brief description | Follow-up | Outcome | % Enrollment | % symptoms | Challenges/strengths identified |
|---|---|---|---|---|---|---|---|---|---|
| Scotland, 2009-2010[20] | Influenza A (H1N1p) or seasonal influenza vaccine | 1103 | Web-based system supplemented by telephone reporting (for individuals with no access to internet) | This evaluation was designed to collect data from people who had received an influenza vaccination during the 2009-2010 season using a web-based data collection tool supplemented by telephone reporting (PROBE). Recruited through media advertising and awareness campaigns in public places and work. | Data collection on day of immunization, after 3 days, 8 days, 6 weeks, 12 weeks and 26 weeks. Survey<5 minutes. | AEFI. Time off work. | Not actively invited.<br><br>Preferences: 63% web-based and 37% telephone | 57% reported pain, 42% other side effects. Female sex and H1N1p vaccination associated higher risk of local reaction, 70+ age group associated with lower risk. | Could distinguish between type of vaccine. Used absenteeism as additional question for AE severity in a sub-study. Sample likely not representative as relied on marketing tools. |
| Netherlands, 2010[12] | influenza A (H1N1) vaccine | 3569 adults aged ≥60 years | E-mail questionnaire | Administrator handed over an information flyer of the web-based monitoring program. Received a questionnaire via e-mail within a week after registration. The second questionnaire was sent three weeks later and the third questionnaire three months after the first questionnaire. | 3 Surveys: Within one week of vaccination, again at 3 weeks, again at 3 months. | AEFI | Not directly invited- relied on flyers being distributed. | 1311 (36.7%) patients reported an AEFI.<br><br>Median latency: 1 day. Median duration: 2 days for the first immunization and 3 days for the second. | Relied on recruitment via flyers at GP offices, and therefore sample not likely representative. |
| Canada, 2009[13] | Seasonal Influenza vaccine and Pandemic Influenza vaccine | 270 HCPs | Web-based form.<br><br>No response triggered e-mail reminder after 7 days. | Recruited at vaccine visit, during 15-minute anaphylaxis observation period. Automated e-mail with a link to the survey was sent 72hrs after vaccine receipt. Secure login created. | Single communication | AEFI. Time off work. | Total e-mail response rate was 90%, 169 (62%) responded after first e-mail and 73 (27%) responded after 2nd reminder e-mail. Close to 75% completed the survey within 5 minutes of the e-mail receipt. | Up to 90% reported local reactions.<br><br>Systemic ranged from 15-60% reporting rate.<br><br>29% reported that AEFIs interfered with daily activities. | Study highlighted the importance of sending a reminder e-mail. No info on gender was collected. |
| Canada, 2009[18] | H1N1 vaccine | 4850 households. one member as proxy/ informant. | Active telephone survey | Random digit dialing used to administer a telephone survey across the British Colombia region. | Single communication | “Any side effect”, and severity of side effect. | NA | 39.0% (N=894) 'any side effect' of which 68.0%, 28.5%, and 3.4% reported as mild, moderate or severe, respectively. | |
| USA, 2004[15] | Smallpox vaccine | NA | Telephone/ Internet-based monitoring system | Novel telephone system used to monitor vaccinated individuals during the U.S. Army's smallpox vaccination campaign. | NA | AEFI | NA | User reported on average 6.8 (SD 6.2) times. The sensitivity and positive predictive value of self-reported reports were high, 98.8% and 99.6%, respectively. | The tracking system provided an early warning system for adverse events |

AEFI: Adverse event following immunization; NA: Missing information; HCP: Healthcare Providers

# Appendix B. Variable requirements to run KP Side Effect Monitor

| | Variable Name |
|---|---|
| Epic patient ID | pat_id |
| Patient Medical Record Number (MRN) | pat_mrn_id |
| Flag for inclusion in recruitment cohort | Pilot_cohort |
| Type of vaccine received | Vaccine_type |
| Missing age variable | Missing_age |
| Missing contact information | Missing_contact_info |
| COVID-19 vaccination sequence (dose) | DOSE_NUM |
| Date Received COVID-19 vaccination | IMMUNE_DT |
| Site of vaccination (medical center) | Vaccination_site |
| Administrative delay in receiving record (Y/N) | Admin_delay |
| Patient online details -misc | PAT_ACCESS_CODE_TM |
| Patient online details – active status | PAT_ACCESS_STAT_C |
| Patient online details – mychart status | MYCHART_STATUS_C |
| Patient online details – active via email | RECV_EMAIL_YN |
| Deactivated account | DEACT_ACCT_YN |
| Proxy patient | CODE_FOR_PROXY_YN |
| Patient online details -misc | PAT_ACCESS_CODE |
| Email address | email_address |
| Home number | home_phone |
| Work Number | work_phone |
| Mobile number | is_phone_remndr_yn |
| KP Employer ID | employer_id |
| Employment status | empy_status_c |
| Epic patient ID available (Y/N) | epiccare_pat_yn |
| Medical number | Medicaid_num |
| Medicare number | Medicare_num |
| Enrolled in Medicaid (or medi-Cal, CA) | HAS_MEDICAID |
| Enrolled in Medicare | HAS_MEDICARE |
| KP member | KP_MEM_ELIGIBILITY_YN |
| Test patient | is_test_pat_yn |
| Notification preference | NOTIF_PAT_EMAIL_YN |
| Notification preference | NOTIF_PAT_SCHED_YN |
| Notification preference | NOTIF_PAT_CANC_YN |
| Notification preference | NOTIF_PAT_MISSED_YN |
| First language | language_c |
| Preferred language for care | lang_care_c |
| Written language | lang_writ_c |
| Requires an interpreter | intrptr_needed_yn |
| Last name | pat_last_name |
| First name | pat_first_name |
| Middle name | pat_middle_name |
| Patient status for comms | pat_status_c |
| Notification flag is patient comms change | NOTIF_PAT_CHNG_YN |
| Patient digital notification preferences | HOW_NOTIF_PAT_C |
| Patients preferred name on file | PREFERRED_NAME |
| Fluency in English language | ENGLISH_FLUENCY_C |
| Contact priority | CONTACT_PRIORITY |
| Contact notes Misc. | CONTACT_NOTES |
| Able to write questionnaire back to health records | cur_pcp_prov_id |
| KP Patient is a proxy subject | proxy_pat_yn |
| KP Patient proxy name | proxy_name |
| KP Patient proxy phone number | proxy_phone |
| KP Patient proxy contact pref | proxy_pack_yn |
| Online services registration date | reg_date |
| Online services registration status | reg_status_c |
| Patient contact is restricted | restricted_yn |
| Contact preferences | preferences_id |
| Able to send text messages about care | send_sms_yn |
| Blind | BLIND_YN |
| Deaf | DEAF_YN |
| No communication preferences | PAT_NO_COMM_PREF_C |
| Date of mychart expiry | MYCHART_EXP_DATE |
| MyChart ID | MYPT_ID |
| MyChart Type | MYC_PAT_TYPE_C |
| Number of failed attempts to contact | FAILED_ATTEMPTS |
| Time zone | NOTIF_TM_ZNE_C |
| Communication line | LINE |
| Other type of communication | OTHER_COMMUNIC_C |
| Other number on file | OTHER_COMMUNIC_NUM |
| Communication start date | START_DAY_C |
| Communication end date | END_DAY_C |
| Communication start time | START_TIME |
| Communication end time | END_TIME |

## Appendix C. Example Tableau dashboard developed for the previous VSR tool



## Appendix D. Variables produced by KP Side Effect Monitor (Draft)

| | Variable Name |
|---|---|
| **IDENTIFIERS:** | |
| Test user flag | vsm_tst_usr_flag |
| MRN | mrn |
| EPIC patient ID | pat_id |
| Unique user ID for VSM tool | vsm_uuid |
| Digital session ID | vsm_session_id |
| **INVITE AND CONSENT PROCESS:** | |
| Recruited via QR code flag | vsm_qr_recruitment |
| Date and time of initial invite to VSM | vsm_invite_dt_tm (time-stamp) |
| Channel used to recruit | vsm_invite_channel |
| Date sent second dose survey | Vsm_survey_restart_2nd_round |
| Channel used for reminder invitation | vsm_invite_reminder_channel |
| Consent status | vsm_cnsnt_sts |
| Date of consent | vsm_cnsnt_dt_tm |
| Channel used to consent | vsm_cnsnt_channel |
| Opted out of consent | vsm_opt_out |
| Date of opt out | vsm_opt_out_dt_tm |
| Included in pilot study | vsm_pilot_study |
| **INITIAL SURVEY:** | |
| Date and time of survey notification | vsm_svy_dt_tm |
| Channel used to receive survey | vsm_svy_ntfcnt_channel |
| Version of text survey received (Version 1: Aggregated; version 2: numbered) | vsm_SMS_srvy_version |
| FIRST EVER text response to COVID QUESTION - option 1 | vsm_first_text_response_COVID_opt1 |
| FIRST EVER text response to LOCAL SYMPTOMS QUESTION - option 1 | vsm_first_text_response_local_opt1 |
| FIRST EVER text response to SYSTEMIC SYMPTOMS QUESTION - option 1 | vsm_first_text_response_systemic_opt1 |
| FIRST EVER text response to CARE QUESTION - option 1 | vsm_first_text_response_care_opt1 |
| FIRST EVER text response to COVID QUESTION - option 2 | vsm_first_text_response_COVID_opt2 |
| FIRST EVER text response to LOCAL SYMPTOM QUESTION - option 2 | vsm_first_text_response_local_opt2 |
| FIRST EVER text response to SYSTEMIC SYMPTOM QUESTION - option 2 | vsm_first_text_response_systemic_opt2 |
| FIRST EVER text response to CARE QUESTION - option 2 | vsm_first_text_response_care_opt2 |
| FIRST EVER Webpage response to COVID QUESTION | vsm_first_Web_response_COVID |
| FIRST EVER Webpage response to LOCAL SYMPTOM QUESTION | vsm_first_Web_response_local |
| FIRST EVER Webpage response to SYSTEMIC SYMPTOM QUESTION | vsm_first_Web_response_systemic |
| FIRST EVER Webpage response to CARE QUESTION | vsm_first_Web_response_care |
| Left survey at question 1 | vsm_left_q1 |
| Left survey at question 2 | vsm_left_q2 |
| Left survey at question 3 | vsm_left_q3 |
| Left survey at question 4 | vsm_left_q4 |
| No response/Abandoned | vsm_no_response |
| **REGULAR SURVEY (2ND DAY – 14TH DAY POST-VACCINATION)** | |
| text Survey response to Local symptoms question - option 1 | vsm_text_response_local_opt1 |
| text Survey response to systemic symptoms question - option 1 | vsm_text_response_systemic_opt1 |
| text Survey response to care question - option 1 | vsm_text_response_care_opt1 |
| text Survey response to local symptoms question - option 2 | vsm_ text_response_local_opt2 |
| text Survey response to systemic symptoms question - option 2 | vsm_text_response_systemic_opt2 |
| text Survey response to care question - option 2 | vsm_ text _response_care_opt2 |
| Web response to local symptoms question | vsm_Web_response_local |
| Web response to systemic symptoms question | vsm_Web_response_systemic |
| Web response to care question | vsm_Web_response_care |
| Date and time of survey start | vsm_survey_response_start_dt_tm |
| Date and time of survey completion | vsm_survey_response_completion_dt_tm |
| Channel used to fill out survey | vsm_survey_channel |
| Channel used to receive reminder message | Vsm_survey_reminder_channel |
| Left the online survey without answering | vsm_left_survey_ web |
| **WEEKLY SURVEY (WEEKS 3-5 POST-VACCINATION)** | |
| text Survey response to new symptoms question | Vsm_text_wkly_response_newsymptoms |
| Web portal response to new symptoms question | Vsm_web_wkly_response_newsymptoms |
| text Survey response to care question | Vsm_text_wkly_response_care |
| Web portal response to care question | Vsm_web_wkly_response_care |
| Multiple outcomes per session | vsm_no_outcomes_per_session |
| Persistent flag variable (when appending new data) | vsm_persistent_flag |

# Appendix E. Variables required for data abstraction

| Category / Variable | Classification / Description | Diagnosis | ICD-9 | ICD-10 | CPT |
|---|---|---|---|---|---|
| MRN | Medical Record Number | - | - | - | - |
| DOB | Date of Birth | - | - | - | - |
| Sex | Sex | - | - | - | - |
| Ethnic_gp | Race/Ethnicity | - | - | - | - |
| Insurance | Insurance type or lack of insurance | - | - | - | - |
| Death data | All-cause death | - | - | - | - |
| Membership data | All membership data | - | - | - | - |
| Vaccination date | All VSD vaccination data | - | - | - | - |
| Height | Height on medical record | - | - | - | - |
| Weight | Weight on medical record | - | - | - | - |
| EDU_LT_HS | % adult pop with less than high school. | - | - | - | - |
| UNEMPLOYMENT | Proportion of civilian noninstitutionalized population between 18 and 64 who are unemployed. | - | - | - | - |
| PCT_CROWDING | % crowded housing: Proportion of households with >= 1 person per room. | - | - | - | - |
| FEMALE_HEAD_OF_HH | Proportion of households headed by females (no male present), with dependent children. | - | - | - | - |
| HINC_LT_30K | % households earning less than $30,000 per year. | - | - | - | - |
| HOUSPOVERTY | %Households with below-poverty level income. | - | - | - | - |
| HH_PUBLIC_ASSISTANCE | Proportion of households on public assistance. | - | - | - | - |
| MGR_MALE | % males in management or professional occupations. | - | - | - | - |
| Medically attended events | Visit to or from medical personnel for any reason. | - | - | - | - |
| NDI | Neighborhood Deprivation Index | - | - | - | - |
| CVD | Acute myocardial infarction | Transmural-Anterior wall | 410.0;410.1 | I21.0 | - |
| CVD | Acute myocardial infarction | Transmural-Inferior wall | 410.2 | I21.1 | - |
| CVD | Acute myocardial infarction | Transmural- Other sites | 410.3;410.4;410.5;410.6;410.8 | I21.2 | - |
| CVD | Acute myocardial infarction | Transmural-Unspecified site | 410.9 | I21.3 | - |
| CVD | Acute myocardial infarction | Subendocardial infarction | 410.7 | I21.4 | - |
| CVD | Acute myocardial infarction | Myocardial infarction, Unspecified | 411 | I21.9 | - |
| CVD | Subsequent myocardial infarction | Anterior wall | - | I22.0 | - |
| CVD | Subsequent myocardial infarction | Inferior wall | - | I22.1 | - |
| CVD | Subsequent myocardial infarction | Other sites | - | I22.8 | - |
| CVD | Subsequent myocardial infarction | Unspecified site | 410.92; 410.x0 | I22.9 | - |
| CVD | Certain complications following MI | Haemopericardium | 423.0, 860.2 | I23.0 | - |
| CVD | Certain complications following MI | Atrial septal defect | - | I23.1 | - |
| CVD | Certain complications following MI | Ventricular septal defect | - | I23.2 | - |

| | | | | | |
|---|---|---|---|---|---|
| CVD | Certain complications following MI | Rupture of cardiac wall | - | I23.3 | - |
| CVD | Certain complications following MI | Rupture of chordae tendinae | - | I23.4 | - |
| CVD | Certain complications following MI | Rupture of papillary muscle | - | I23.5 | - |
| CVD | Certain complications following MI | Thrombosis of atrium | - | I23.6 | - |
| CVD | Certain complications following MI | Other | - | I23.8 | - |
| CVD | Other acute ischemic heart disease | Acute, unspecified | - | I24.9 | - |
| CVD | Other acute ischemic heart disease | Silent myocardial ischemia | - | I25.6 | - |
| CVD | Other acute ischemic heart disease | Other | - | I25.8 | - |
| CVD | Other acute ischemic heart disease | Chronic, unspecified | 412; 414 | I25.9 | - |
| CVD | Cardiac complications, non-arrhythmia | Cardiomyopathy | 427.5 | I42.9 | - |
| Stroke | Stroke (TIA) (other codes) | Other cerebrovascular diseases | | I67 | - |
| Stroke | Stroke (TIA) (other codes) | Other | | G45.8 | - |
| Stroke | Stroke (TIA) (other codes) | Sequelae of cerebrovascular disease | | I69 | - |
| Stroke | Stroke (TIA) (other codes) | Stroke, unspecified | | I64 | - |
| Stroke | Stroke (TIA) (other codes) | TIA | | G45 | - |
| Stroke | Stroke (TIA) (other codes) | TIA, unspecified | | G45.9 | - |
| Stroke | Stroke (TIA) | Stroke, all codes | | I63 | - |
| Stroke | History of stroke | Prior history of stroke | | Z86.73 | - |
| CHF | Congestive heart failure | Congestive heart failure – All codes | | I50 | - |
| CHF | Congestive heart failure | complicating abortion or ectopic or molar pregnancy | | O00.X; O07; O08.8 | - |
| CHF | Congestive heart failure | due to hypertension | | I11.0 | - |
| CHF | Congestive heart failure | due to hypertension with chronic kidney disease | | I13.X | - |
| CHF | Congestive heart failure | following surgery | | I97.13 | - |
| CHF | Congestive heart failure | obstetric surgery and procedures | | O75.4 | - |
| CHF | Congestive heart failure | cardiac arrest | | I46.X | - |
| COPD | Chronic Obstructive Pulmonary Disease | All | 491.22; 496 | J44.9 | - |
| CKD | Chronic kidney disease | stage 1. | 585.1 | N18.1 | - |
| CKD | Chronic kidney disease | stage 2 (mild) | 585.2 | N18.2 | - |
| CKD | Chronic kidney disease | stage 3 (moderate) | 585.3 | N18.3 | - |
| CKD | Chronic kidney disease | stage 4 (severe) | 585.4 | N18.4 | - |
| CKD | Chronic kidney disease | stage 5 | 585.5 | N18.5 | - |
| CKD | Chronic kidney disease | End stage renal disease. | 565.1 | N18.6 | - |
| CKD | Chronic kidney disease | unspecified. | 585.9 | N18.9 | - |
| T2DM | Type II Diabetes | T2DM – Incl. other & unspecified | 250.X | E11.X; E13.X | - |
| T2DM | Type II Diabetes–complications | Polyneuropathy | 357.2 | | - |

| | | | | | |
|---|---|---|---|---|---|
| T2DM | Type II Diabetes–complications | Diabetic cataract | 366.41 | | - |
| T2DM | Type II Diabetes–complications | Disease of the retina | 362.01-362.07 | | - |
| T2DM | Type II Diabetes–complications | Disease of the retina | 362.0 | | - |
| HIV | Human Immunodeficiency Virus | All | Registry | Registry | - |
| COVID-19 | COVID-19 Diagnosis | All | - | VSD-defined codes | - |
| COVID-19 test | PCR test | - | - | - | VSD-defined codes |
| COVID-19 test | Antigen test | - | - | - | VSD-defined codes |
| COVID-19 test | Serology IgG IgM immunoassays | - | - | - | VSD-defined codes |
| Influenza Vaccination | All | - | - | - | VSD-defined CVX codes |