Mobile Computing Devices in the Perioperative Environment: A Survey Exploring Uses and Experiences Among Certified Registered Nurse Anesthetists

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The use of mobile computing devices (MCDs) such as smartphones, tablet computers, and laptops among Certified Registered Nurse Anesthetists (CRNAs) in the clinical area may provide benefits as well as pose risks. Limited research is available on the use of MCDs in the practice of nurse anesthesia. The purpose of this study was to answer the following questions: (1) What are the clinical and nonclinical uses of mobile computing devices among Michigan CRNAs? and (2) What are the experiences of Michigan CRNAs with regard to the impact of using these devices on patient care? A descriptive survey design was used to answer the research questions.

Findings from the study reveal that CRNAs believe there are many important benefits as well as major risks associated with using MCDs while providing direct patient care. In addition, some respondents either personally experienced or witnessed incidents of distraction, performance declines, or serious anesthesia events as the result of MCD use during patient care. This study elucidates the need for the development and adoption of policies that promote safe, appropriate, patient-centered use of MCDs for the specialty of nurse anesthesia.

Keywords: *CRNA, distraction, informatics, mobile computing device, vigilance.*

Increasingly, contemporary clinical practice requires that patient care be data analytics driven and that information be instantly available. This trend, coupled with the growing availability of powerful and highly portable mobile computing devices (MCDs) such as smartphones and tablet computers, has placed new demands on those working in complex environments such as the operating room. The need to communicate and the ability to multitask are not new to anesthesia providers. What has changed is the increasing pressure to interact with these devices.

The American Association of Nurse Anesthetists (AANA) *Standards for Nurse Anesthesia Practice* clearly state that continuous clinical observation and vigilance are the basis of safe anesthesia care.[1] *Vigilance* can be defined as "a state of readiness to detect and respond to certain specified small changes occurring at random intervals in the environment."[2(p549)] As technology advances, Certified Registered Nurse Anesthetists (CRNAs) are challenged to maximize the beneficial use of MCDs while remaining vigilant and maintaining continuous clinical observation.

Mobile devices and health-related applications (apps) offer many benefits to healthcare providers, trainees, and patients. According to industry estimates, there are currently 325,000 available healthcare apps, and 50% of the more than 3.4 billion smartphone and tablet users are projected to have downloaded mobile health apps by this year.[3] A survey of training programs by the Accreditation Council for Graduate Medical Education showed that more than 85% of trainees used smartphones, and more than 50% of trainees reported daily use of mobile apps.[4] Numerous studies have demonstrated that MCDs are currently used by healthcare professionals for medical consultation, documentation, education, and their applications such as calculators, logbooks, and algorithms are used for patient management.[5-7]

While beneficial in many ways, the use of MCDs is increasingly being recognized as having the potential to negatively affect patient care if practitioners become distracted by these devices during care.[8-10] The Emergency Care Research Institute, a nonprofit healthcare research organization, annually publishes the top 10 technology hazards.[11] For 2013, caregiver distraction as a result of smartphone or other MCD use came in at No. 9.[11] In a study examining usage patterns, 19% of residents and 12% of attending physicians reported that smartphones had distracted them during inpatient rounds, causing them to miss important clinical information.[12] In another study, the use of a cell phone to send text messages during the performance of cardiopulmonary bypass (CPB) was reported by 49.2% of perfusionists.[13] Of these respondents, 3% acknowledged visiting local networking

Characteristic	No. (%)
Gender	
Female	173 (67)
Male	85 (33)
Age, y, mean ± SD (range)	47 ± 10.7 (27-69)
Years in practice, mean ± SD (range)	15 ± 10.4 (1-45)
Education level	
Diploma	4 (1.6)
Bachelor's	21 (8.1)
Master's	218 (84.5)
Doctorate	14 (5.4)
Missing	1 (0.4)
Employment status	
Not working	2 (0.8)
Part time	31 (12.0)
Full time	224 (86.8)
Missing	1 (0.4)
Primary position	
Practice	234 (90.7)
Education	8 (3.1)
Management	13 (5.0)
Other	2 (0.8)
Missing	1 (0.4)
Practice setting	
Hospital	230 (89.0)
Ambulatory center	20 (7.8)
Office	3 (1.2)
Other	4 (1.6)

Table 1. Demographic Characteristics of the Sample (N = 258)

sites during this time, and most (77.7%) agreed that cell phone use during CPB introduced potentially serious risks to the patient.[13]

Researchers have examined distractions and interruptions caused by the use of MCDs and other technologies in anesthesia. Pape and Dingman[14] reported that CRNAs experience an average of 68 interruptions per hour, with phone calls identified as a source of distraction and noise. This finding is particularly concerning because this study focused on the induction phase of anesthesia, a time requiring intense focus on the patient. In a covert observational study of CRNAs and anesthesiology residents to determine the frequency with which these individuals engaged in activities unrelated to direct patient care, the researchers found that personal Internet use was the most common distraction.[15]

Available research is mixed regarding the impact of MCDs on performance in the clinical setting. In a study examining the relationship between information and communication technology use and nursing performance, the researchers found a significant negative correlation between the number of emails sent by cell phone and performance ($r = -0.10$, $P < .05$; $r = -0.21$, $P < .01$).[16] In another study, researchers monitored 1,061 anesthetics performed by 171 providers to determine if the amount of time using a computer for nonpatient care–related activities correlated with performance declines as evidenced by patient hemodynamic variability and hemodynamic aberrancies. The researchers found that anesthesia providers spent sizable portions of case time performing nonrecord-keeping computer activities. This use, however, was not independently associated with greater hemodynamic variability or aberrancies in patients during maintenance of general anesthesia.[17]

Given the paucity of data available in the anesthesia literature regarding the impact of technology use on performance, research from the transportation industry is enlightening. Studies have shown that using personal communication devices while driving has resulted in slower reaction times to brake lights and stop signs.[18] Studies have also shown that peripheral vision, and thus the visual field, is reduced when subjects respond to questions on a cell phone.[19]

In the practice of nurse anesthesia, clinical vigilance is essential to patient safety and good outcomes. Although there are studies examining the benefits and risks associated with MCD use in clinical practice, no studies, to our knowledge, have been specific to the specialty of

Clinical information sought	Total No. (%) of comments[a]
Drug information	231 (23.1)
Diagnostic/laboratory	89 (8.9)
Physiology/pathophysiology	172 (17.2)
Anesthetic management	122 (12.2)
Anesthetic procedure	65 (6.5)
Surgical procedure	117 (11.7)
Patient outcomes	26 (2.6)
Evidence-based practice guidelines	78 (7.8)
Literature search	88 (8.8)
Not applicable	9 (0.9)
Other	
Coexisting diseases	2 (0.2)
Formulas	1 (0.1)
Medical dictionary	1 (0.1)
Continuing education	1 (0.1)

Table 2. Summary of Open-Ended Responses: Types of Clinical Information Sought Using a Mobile Computing Device
[a]Percentages do not total to 100 because participants could provide more than 1 response. Total comments provided numbered 1,002.

nurse anesthesia. The specific research questions for the current study on CRNAs in the state of Michigan were:

1. What are the clinical and nonclinical uses of mobile computing devices in the CRNA community?

2. What are the experiences of CRNAs in regard to the impact of using these devices on patient care?

Methods
A nonprobability convenience sample of CRNA members of the Michigan Association of Nurse Anesthetists (MANA) was asked to complete an electronic survey. Questionnaire recipients were CRNAs who were members of MANA in active practice in the state of Michigan with email addresses on file in the MANA database. The study was approved by the institutional review board from the local university and was distributed by MANA. Potential participants (N = 2,163) were recruited via an email invitation generated through SurveyMonkey. Data were collected over a 3-week period. The invitation stated that a completed and returned survey would serve as implied consent. Participants were offered the opportunity to withdraw from the study at any point while taking the survey.

• *Survey Description.* The 33-question survey used in this study was divided into 4 sections: demographics, mobile computing device general usage, mobile computing device use during direct patient care (DPC), and opinions on mobile computing device use. Questions relating to MCD general usage were taken, with permission, from the social media usage survey created by Piscotty et al.[20] The remainder of the questions were developed by the researchers. Two doctorally prepared nurse scientists with expertise in survey methods and the use of mobile technology and healthcare informatics were consulted to establish the content validity of the survey items. The survey was then pilot tested with 6

CRNAs before distribution.

The following definitions were included in the survey:

• *Mobile computing devices (MCD)* include any device that is both portable and capable of collecting, storing, transmitting, or processing electronic data or images. Examples include but are not limited to smartphone, iPad (Apple), iPod (Apple), tablet computer, personal digital assistant (PDA), netbook, notebook, and laptop.

• *Distraction* is defined as something that attracts the CRNA's attention away from the task at hand and disrupts the thought processes.

• *Performance* is defined as the extent to which the actions of a CRNA conform to practice guidelines, medical review criteria, or standards of quality.

• *Data Analysis.* Data were cleaned and then analyzed using IBM SPSS Statistics for Windows (Version 21.0, IBM Corp). The main purpose of the study was descriptive in nature; therefore, descriptive statistics were used to examine frequencies and percentages.
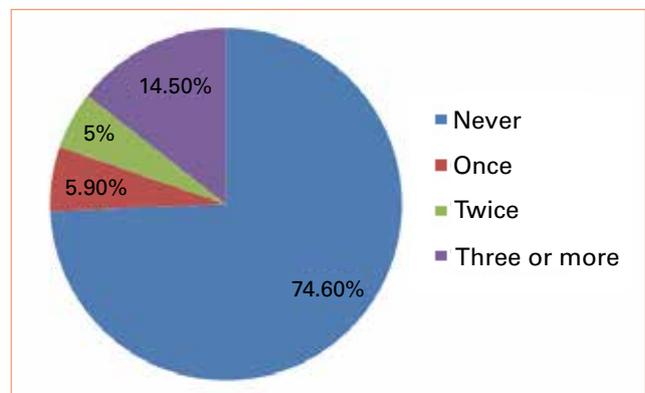
Results
• *Respondents.* Of the 2,163 potential participants, 271 opened the survey and 264 met the inclusion criteria. Of the eligible surveys, 258 provided usable data and were included in the analysis, for an overall response rate of 12%. Table 1 presents demographic and background information about the participants.

• *General Ownership and Nonclinical Uses.* When asked to identify the types of MCDs owned, CRNAs reported possessing the following: smartphone (92.2%), iPad (65.9%), iPod (39.9%), tablet (10.5%), PDA (2.7%), and netbook (1.2%). Most (91%) reported owning more than 1 device, and only 1.2% (3/258) reported not owning any type of device. Most CRNAs (82%) reported being members of a social media site.
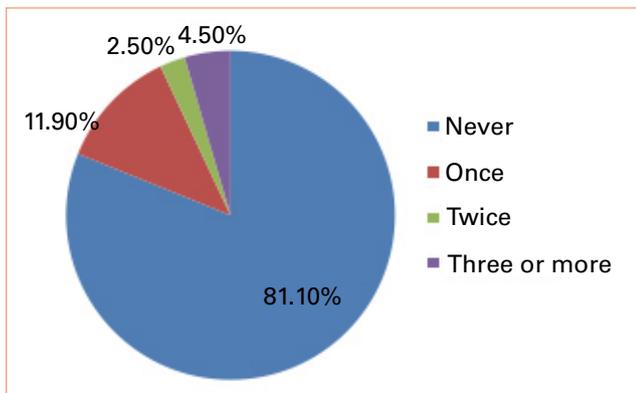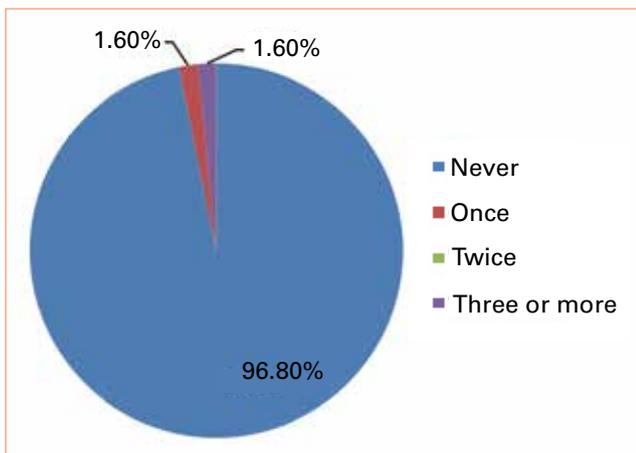
Figure 1. Percentage of Respondents Who Reported Becoming Distracted as a Result of Using Mobile Computing Devices During Direct Patient Care
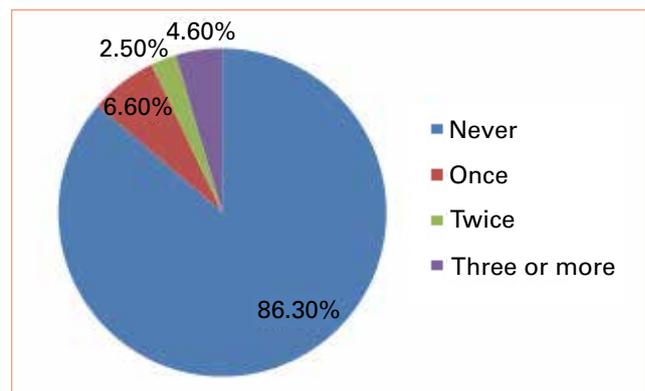

Figure 2. Percentage of Respondents Reporting They Were Aware of/Witnessed Another CRNA Becoming Distracted as a Result of MCD Use During Direct Patient Care
Abbreviations: CRNA, Certified Registered Nurse Anesthetist; MCD, mobile computing device.

Figure 3. Percentage of Respondents Who Reported That the Use of a MCD had a Negative Effect on Their Performance While Providing Direct Patient Care
Abbreviation: MCD, mobile computing device.

Figure 4. Percentage of Respondents Who Reported They Are Aware of an Instance When the Use of a MCD Negatively Affected the Performance of Another CRNA While Providing Direct Patient Care
Abbreviations: CRNA, Certified Registered Nurse Anesthetist; MCD, mobile computing device.

• *Use for Clinical Applications.* Nearly all respondents (95%) indicated that they had used an MCD to search for clinical information in the last 3 months. The mean number of searches reported for that period was 33.65 (SD ± 59.5). The types of clinical information sought by CRNAs are presented in Table 2. When asked if a policy governing the use of MCDs existed in the institution where they worked, fewer than half (47.2%) replied yes, 22.6% replied no, and 30.2% replied that they were not sure.

• *Use During Direct Patient Care.* Most respondents (85.3%) reported that they used MCDs during DPC; 93% reported witnessing another CRNA using a mobile device during DPC. The feature used most often, by self-report or observation of a colleague, was texting (63.2% self, 80.2% colleague) followed by Internet access/surfing (52.7% self, 72.5% colleague), checking/sending emails (50.8% self, 64% colleague), phone call (30.2% self, 54.3% colleague), and checking/posting to social media sites (8.5% self, 40.3% colleague).

When asked about MCDs as a source of distraction during DPC, 81.1% reported never having been distracted; 18.9% report being distracted 1 time or more (Figure 1). When asked the same question about a colleague, 25.4% reported witnessing another CRNA distracted by MCD use during DPC 1 time or more (Figure 2). Respondents were also asked if they believed that the use of an MCD had negatively impacted their performance while providing DPC or if they had ever witnessed this happening to another CRNA. The majority (96.8%) reported that they had never experienced a decline in performance attributable to using an MCD during DPC (Figure 3). However, 13.7% had witnessed another CRNA, on 1 or more occasions, experiencing performance declines during DPC because of MCD use (Figure 4).

Of the 258 who responded to the survey, 17 (6.6%) responded that they were aware of a near-miss or anesthesia accident attributable to the use of an MCD during

Description of near-miss/anesthesia accident
Positioning
• Returned from break to find relieving CRNA texting, patient repositioned into steep Trendelenburg, and SpO_2 levels trending significantly lower. Patient's ET tube migrated into the right main stem bronchus and was not recognized by CRNA who was texting.
• Discovered that patient's head was not secured after being placed in beach chair position … CRNA using mobile device when I entered room to give a break
Cardiac
• Using mobile device during laparoscopic insufflation … patient became asystolic
Drug error
• CRNA using phone and forgot to give heparin
• Hydromorphone administered via epidural instead of fentanyl
• Wrong drug administered
• Using mobile device in the heart room (not sure why) … did not hear call for protamine
Monitoring
• Using mobile device … did not notice sedated patient woke up until [he/she] moved and contaminated sterile field
• Texting and not paying attention to monitors resulted in poor outcomes greater than 3 times for providers that I know of
• BP very low and not noticed by CRNA using phone
• Ignoring patient vital signs
Respiratory event
• Patient aspiration
• Patient became apneic
• Respiratory arrest of patient under an anesthesia resident's care who was using [a smartphone]

Table 3. Summary of Qualitative Comments: Near-Miss/Accidents
Abbreviations: BP, blood pressure; CRNA, Certified Registered Nurse Anesthetist; ET, endotracheal.

Benefit	No. (%) of responses[a]
Clinical information	
Ability to access	144 (69.57)
Quick access	34 (16.43)
Easy access	6 (2.90)
Up to date	2 (0.97)
Real time	2 (0.97)
Searchable	3 (1.45)
Clinical communication	48 (23.19)

Table 4. Qualitative Responses: Benefits of Using a Mobile Computing Device During Direct Patient Care
[a]Percentages do not total to 100 because participants could provide more than 1 response. Total responses numbered 207.

DPC. Of those responding, 14 provided narratives describing the event, which were placed into categories as follows: positioning, 2; cardiac event, 1; drug error, 4; monitoring, 4; and respiratory event, 3 (Table 3).

• *Opinions on Mobile Computing Device Use and Safety.* Although most respondents (93%) replied "yes" when asked if they believed that for the specialty of nurse anesthesia, the use of an MCD during DPC had benefits, more than half (57%) also felt that such use posed potentially serious risks to the patient. When asked in an open-ended question to list the benefits of MCD use, 207 comments were provided. The most notable benefits identified were the ability to access clinical information and the ability to use MCDs for clinical communication (Table 4). In response to an open-ended question about risks, there were 129 comments with 3 major themes:

concerns about lapses in patient focus caused by distraction, the potential for poor patient outcomes, and appropriateness of use (Table 5). Regarding appropriateness of use, 24.8% of respondents (32/129) commented that MCD use was inappropriate for nonclinical applications or during critical or demanding times.

Discussion
There is a growing body of literature in nursing, medicine, and informatics detailing the success of mobile technology in clinical settings for communication, reference, research, patient engagement, and medical education.[3-7] Nevertheless, little is known about the impact of using MCDs in the context of patient care. To the best of our knowledge, this is one of the first studies to examine how CRNAs are using MCDs in practice and one of the

Risk	No. (%) of responses[a]
Patient focus	
Distraction	84 (65.12)
Inattention	19 (14.73)
Impaired monitoring	19 (14.73)
Decreased vigilance	16 (12.40)
Interruptions/disruptions	4 (3.10)
Patient outcome	
Poor outcome: near-miss, dangerous	11 (8.53)
Appropriateness of use	
Inappropriate to use for nonclinical applications or during critical/demanding times	32 (24.81)
Legal risk: discoverable, negligent	3 (2.33)
Image: unprofessional	3 (2.33)

Table 5. Qualitative Responses: Risks of Using a Mobile Computing Device During Direct Patient Care
[a]Percentages do not total 100 because participants could provide more than 1 response. Total responses numbered 129.

first to explore the experiences of CRNAs in terms of the impact on patient care.

Our data reveal that MCD use in the clinical area is prevalent among the sample of Michigan CRNAs surveyed. The number of responses to the open-ended question asking CRNAs to list the benefits of MCD use during DPC was nearly double the number of responses to the open-ended question about the risks of MCD use. Nearly all respondents reported using mobile devices for patient care–related uses such as searching for clinical information or communication. In order of preference, the preferred methods for communicating with an MCD were texting, sending or receiving emails, and making phone calls. Several CRNAs indicated in open-ended responses that they worked as independent practitioners and relied on MCDs to access information that would otherwise have not been available to them. Findings from numerous studies and a growing body of literature reveal that healthcare professionals perceive the ability to have access to clinical information and to communicate with other providers as some of the most important benefits of using MCDs and health information technology in practice.[3-7,21-27]

In terms of the impact on patient care, a small percentage of CRNAs reported that using an MCD during DPC caused them to become distracted or experience a decline in their performance. A slightly higher percentage of CRNAs reported witnessing incidents of distraction or performance declines in a fellow CRNA. Other studies also describe underestimation of self-reported distraction.[12,13] In a study examining smartphone use during inpatient attending rounds, physicians consistently reported observing others using these devices at higher rates than they reported for themselves.[12] In another study, perfusionists reported never being distracted by a cell phone during CPB; however, more than one-third (34.5%) had witnessed another perfusionist distracted by cell phone use during CPB.[13] A plausible explanation

for this tendency is reluctance to self-report becoming distracted if there is a belief, on some level, that using mobile devices during patient care is not an acceptable practice or may be viewed as substandard. Another possible explanation for the discrepancy in responses is that users of MCDs may not be aware of their own miscues or may not believe that they are distracted.

More concerning than the reports of distraction was the finding that some respondents had personally experienced or witnessed performance declines, near-misses, or serious anesthesia events as a result of using a mobile device during patient care. In 2015, the AANA Board of Directors updated their *Mobile Information Technology Position Statement*, stating that CRNAs have an "ethical responsibility to provide safe patient care by avoiding non-essential distractions."[28] The AANA supports the thoughtful integration of mobile information technology in a way that enhances patient care while minimizing interruptions and distractions.[28] Regardless of the intended use, the findings from this study and others have demonstrated that the use of MCDs can lead to distraction and impaired performance in the clinical area.[11-16] Table 6 provides recommended strategies for reducing MCD-associated risks and distractions in the clinical area.

This study has limitations. Convenience sampling was employed, and participants were recruited exclusively from the state of Michigan. In addition, the response rate was low (12%), which limits the generalizability of the results to the wider CRNA population. The low response rate may be evidence that there was some selection bias, which is possible in any survey that allows respondents to decide whether to participate. Another limitation, response bias, may explain the discrepancy in self-reported vs witnessed incidents of distraction and performance declines as the result of using an MCD during patient care. This may have been the result of the perceived sen-

Risk-reducing strategy
Patient privacy and confidentiality
• Recognize the paramount ethical and legal obligation to maintain patient privacy and confidentiality at all times.
• Do not share, post, or disseminate information, including images, about a patient with anyone unless there is a patient care–related need to disclose the information or other legal obligation to do so.
Guidelines and policies
• Review and comply with practice facilities' MCD guidelines and/or policies if they exist.
• Follow employer policies for taking photographs or video of patients for treatment or other legitimate purposes using employer-provided devices.
• Review current guidelines for handling MCDs developed by the AANA,[28] AORN,[29] and ASA.[30]
• Implement a "sterile cockpit" protocol during critical phases of procedures.
• Consider that bacteria present on MCDs can easily be transmitted to patients and healthcare workers.
Safe monitoring and vigilance
• Limit personal telephone calls and text messages to urgent or emergent situations.
• Forward cell phone calls and transmissions to voice mail.
• Silence ring tones and nonaudible alerts (ie, vibration).
• Limit Internet access in the OR to only patient-care related websites.
• Avoid discretionary Internet-based activities and browsing.

Table 6. Strategies for Reducing Risk Using Mobile Computing Devices (MCDs)
Abbreviations: AANA, American Association of Nurse Anesthetists; AORN, Association of periOperative Registered Nurses; ASA, American Society of Anesthesiologists; OR, operating room.

sitive nature of the subject, with respondents preferring not to admit that they had used an MCD during DPC. As a result, the findings may be an underestimation (or overestimation) of the true population parameter. Finally, this was a novel tool, and its reliability has not been established.

This study elucidates that, in the population surveyed, CRNAs highly value the ability of MCDs to assist in clinical decision making and communication essential to patient care. It also brings to light that MCD use during DPC may pose major threats to patient safety. Although no universally accepted standards exist governing MCD use in healthcare settings, professional organizations are increasingly aware that there is a need for guidelines. In addition to the position statement published by the AANA,[28] the Association of periOperative Registered Nurses updated their position statement on reducing noise in 2014 to include eliminating distractions and interruptions.[29] The American Society of Anesthesiologists (ASA) also published a *Statement on Distractions*, which was approved by the ASA House of Delegates in 2015.[30] These declarations all emphasize the importance of vigilance in ensuring attention to the patient and minimizing or eliminating distractions in the anesthesia care environment.

Finally, there is a need for further studies with more controls and a larger sample size to assess the impact of MCD use by CRNAs in the clinical setting. The results of further studies may provide guidance in the development of education and policies needed to address the use of MCDs in clinical settings in a manner that maximizes benefits while minimizing risks.

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