Exploratory Research in Clinical and Social Pharmacy 12 (2023) 100379

Contents lists available at ScienceDirect

Exploratory Research in Clinical and Social Pharmacy

journal homepage: www.elsevier.com/locate/rcsop

# Investigating the impact of the COVID-19 pandemic on the occurrence of medication incidents in Canadian community pharmacies

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ARTICLE INFO

*Keywords:*
Community pharmacies
Medication incidents
Pandemic
Risk factors
COVID-19

ABSTRACT

As the COVID-19 pandemic unfolded, community pharmacies adapted rapidly to broaden and adjust the services they were providing to patients, while coping with severe pressure on supply chains and constrained social interactions. This study investigates whether these events had an impact on the medication incidents reported by pharmacists. Results indicate that Canadian pharmacies were able to sustain such stress while maintaining comparable safety levels. At the same time, it appears that some risk factors that were either ignored or not meaningful in the past started to be reported, suggesting that community pharmacists are now aware of a larger set of contributing factors that can lead to medication incidents, notably for medication incidents that can lead to harm.

## 1. Introduction

The COVID-19 pandemic had a significant impact on almost every aspect of the health care sector. The pandemic's effects were particularly felt in community pharmacies as they faced a myriad of new demands, such as incorporating staff and patient virus protection, vaccine administration, and staff shortages, all of which built on the already increasing work demands on pharmacists. The unrelenting pandemic pressures posed serious new safety risks to community pharmacy practice. What were the safety consequences? And how should the understanding of these consequences affect future pharmacy practice? The present paper investigates how the COVID-19 pandemic impacted safety in Canadian community pharmacies. The present research parallels similar efforts in other health disciplines like mental health[30] or early childhood vaccination[35]. During the COVID-19 pandemic, community pharmacies became one of the few open and accessible sites where patients could receive accurate health advice, which increased pharmacists value as perceived by the public, the government and other health professionals.[18] The pharmacists' role as information providers expanded significantly, educating the public on appropriate infection control measures and evidence-based treatment options.[22] In addition, community pharmacists played a key role in the mass vaccination effort.

The pandemic introduced environmental disruptions that occurred in community pharmacies worldwide, forcing pharmacists to build on their existing roles and adapt quickly to offer more advanced services (as regulations allowed).[25] For example, in Canada, in addition to vaccine administration, some jurisdictions allowed regulatory exemptions for pharmacists to provide essential access to controlled medications[10] or increased electronic prescribing and home delivery.[17] Others allowed an increased reliance on telephone/electronic pharmacy communications to facilitate patient access.[23] Social distancing guidelines and mask usage made communication between pharmacists and patients more challenging.[3] Pharmacies had to overcome medication shortages and mitigate supply issues.[31] Researchers suggest that the pandemic could bring a paradigm shift, in which the pharmacy moves from a dispensing focus to a more direct clinical and patient centered focus.[26] In that role the community pharmacy can be redefined as a provider of health outcomes, not simply as a place where medications are dispensed.[29] All these pandemic-driven changes impact safe pharmacy operations, and recent research indicates that these changes also affected patient safety.[20]

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https://doi.org/10.1016/j.rcsop.2023.100379
Received 15 September 2023; Received in revised form 4 November 2023; Accepted 22 November 2023
Available online 27 November 2023

The present study assesses whether these new demands and work pressures on pharmacists had an impact on the safety of their work, more specifically on the Medication Incidents (MIs) made during the dispensing process.

MIs can be defined as "Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer." (NCCMERP website[1]) "Medication incidents may be related to professional practice, drug products, procedures, and systems, and include prescribing, order communication, product labeling/ packaging/ nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use." (NCCMERP website). MIs in community pharmacies have been studied for decades.[34] The research clearly indicates that avoiding medication incidents and mitigating their consequences are key challenges in assuring patient safety[36].

Significant effort has been made to assess and understand the rate and impact of MIs[5,9,14,15] and the determinants and importance of reporting those incidents.[7] Subsequent research identified the reasons behind those MIs.[4] These included communication factors, number of steps, pharmacy layout,[33] similarities in drug names or appearance (including similar packaging),[5] poor handwriting,[1] heavy workload and staffing issues,[1,5] as well as low compliance with standard processes.[19] These findings led to a variety of solutions to lower the odds of such MIs occurring like automated dispensing system,[33] bar coding of medicines[5] or authentication at the point of dispensing.[15]

### 1.1. Canadian context

Medication incident reporting requirements for community pharmacies across Canada is determined by each provincial regulatory body.[8,24] Reporting requirements vary with several provinces in Canada that have implemented, or are in the process of implementing, mandatory, anonymous, deidentified error reporting to an independent third party which is meant to promote just culture.[12] Punitive damages are rarely awarded in cases that do not involve malicious intent in Canada. Despite efforts to make incident reporting mandatory, under-reporting remains a concern.[6] Currently work is being done to promote just culture, however fear of reporting still exists[37].

Despite these limitations, medication incident reporting is a useful indicator of community pharmacy safety and pharmacy practice. The present research draws on the analysis of Canadian community pharmacy MI reports to investigate and assess the effects of the pandemic on safe pharmacy practice.

Given that the record of MIs does provide an indicator of community pharmacy safety and pharmacy practice, the present research draws on the analysis of Canadian community pharmacy MI reports to investigate and assess the effects of the pandemic on safe pharmacy practice.

## 2. Method

The research team partnered with Pharmapod, a Think Research company, to analyze data on medication incidents reported in Canada. Pharmapod develops and supports one of the largest global digital medication incident reporting platforms. In Canada, 65% of the community pharmacies from different provinces use this system to manage their medication incident reports. Pharmacists, registered technicians, assistants, and students in each community pharmacy entered data related to medication errors and near-miss events. To encourage user engagement, platform features include date pickers, drop-down menus, skip logic and radio buttons. The data from each case was standardized in that it forced the reporter to identify "what" happened - the incident type (e.g., incorrect drug, dose, patient, or quantity), "when" it happened – the process stage or step (e.g., prescribing, dispensing, delivery), "why" it happened - contributing factors (i.e., potential variables that were present in the moment of the incident and might have caused the incident e.g., interruptions, distractions) and the level of patient harm (i.e., this data indicates whether the incident reached the patient and the level of harm done). MIs that did not reach the patient are classified as near-misses and are also reported and analyzed. Through the research partnership, Pharmapod provided aggregate anonymized deidentified data from community pharmacies across Canada using their platform.

This study focused on the analysis of contributing factors associated with patient harm before and after the pandemic. Reporting of factors for cases before and after the pandemic were compared. For each one, the relative prevalence is reported in Table 3, along with a *T*-Test assessing if the observed difference between pre and post-COVID scores is significant. Association between factors was assessed by computing phi coefficients (Pearson's equivalent for two categorical variables).[13,32] These are reported in Appendix 1.

If the prevalence of different factors changed from one period to another, it means that one could predict the period to which a case belongs by looking at its factors. Logistic regression was performed to assess if it is the case. All factors were first assessed using a univariate logistic regression to assess potential predictors. Eight factors (out of 12) met the recommended criteria ($p < 0.1$) and were entered into the multivariable model. This procedure followed guidelines by Ranganathan et al..[28] The quality of the model fit was assessed using the chi-square and the Hosmer-Lemeshow tests, and the predictive ability of the model was evaluated using Nagelkerke's R2 coefficient.[11] Odds-ratio were computed as exp.(β) where β are the parameters estimated by the logistic regression.[27] Analysis was performed using IBM SPSS version 28.0.1.1.

Ethics approval was granted for the extraction of data and secondary use of anonymous information in aggregate form that did not contain identifiable information. Confidentiality agreements are signed in the partnership.

## 3. Results

A total of 56,422 incidents were extracted from the company data repository from January 2019 to January 2022 to study both sides of the WHO declaration of the pandemic in March 2020. Among the initial dataset, 56 cases were excluded from the analysis because of incomplete information. March 13th, 2020 was chosen as a cut-off date to categorize the data analysis between pre-COVID and post-COVID. Of these incidents, 21,030 were categorized as pre-COVID and 35,336 incidents were identified as post-COVID. On average there were 48 incidents per day declared pre-COVID and 51.2 incidents per day declared post-COVID. Minimal information was collected about patients; only date of birth and gender. Medical condition was not reported by the pharmacist. Table 1 shows the patient descriptive data available.

As shown in Table 2, out of the 56,366 incidents, 37,420 (66.5%)

**Table 1**
Patients.

| Age group (DoB provided for 54,684 patients | Percentage of sample | Gender (provided for 55,939 patients) | Percentage of sample |
|---|---|---|---|
| Under 5-year-old | 1.3% | | |
| 5-year-old ≤ X < 18-year-old | 4.1% | Female | 57.3% |
| 18-year-old ≤ X < 40-year-old | 16.2% | Male | 41.7% |
| 40-year-old ≤ X < 65-year-old | 34.4% | Other (or prefer not to disclose) | 1.0% |
| 65-year-old ≤ X < 80-year-old | 26.6% | | |
| 80-year-old and over | 17.5% | | |

[1] National Coordinating Council for Medication Error Reporting and Prevention, https://www.nccmerp.org/

incidents reached the patient. In those cases, the associated level of harm reported is defined as: no harm (no symptoms detected; no treatment required); mild harm (symptoms were mild; temporary and short term; no treatment or minor treatment was required); moderate harm (symptoms required additional treatment or an operation; the incident kept the patient in hospital longer than expected; or caused permanent harm or loss of function); severe harm (symptoms required major treatment to save the patient's life; the incident shortened life expectancy; or cause major permanent or long term harm); and death (there is a reason to believe that the incident caused the patient's death or hastened the patient's death). An analysis of patient outcomes showed that approximately 14.5% of reported incidents pre-COVID (1486) and post-COVID (2413) were reported as harm incidents. This percentage is not dissimilar to previous studies (for example[4]).

### 3.1. Contributing factors

From the MIs that reached the patient, the most frequently reported (top four) factors leading to these incidents were staff distribution (35%), followed by lack of control or independent checks (23%), lack of staff education (16.3%) and prescription miscommunication issues (13.4%). These factors were reported at relatively constant levels before and after COVID as well as whether the medication incident caused harm or caused no harm to patients (Table 3).

When focusing on the factors occurring post-COVID, we observed that the next five categories (shaded in Table 3) were reported with more frequency and with greater magnitude than the ones reported pre-COVID; especially for medication incidents that resulted in harm to the patient. These factors were drug related issues (8.6% harmless incident; 15.9% harm incident), critical patient information that was missing or incorrect (2.9% harmless incident; 5.6% harm incident), patient/ caregiver education issues (3% harmless incident; 9% harm incident), environmental distractions (11.4% harmless incident; 18.8% harm incident), operational process issue (6.2% harmless incident; 10.1% harm incident). As the prior descriptive stats indicated, the presence of these factors increased massively after COVID. For example, environmental distraction is ten times more frequently observed after COVID than it was before COVID when MIs are reported.

If there is a difference of occurrence patterns for factors before and after COVID, we should be able to predict if a case happened before or after the start of the pandemic by looking at the factors observed. As mentioned in the methodology section, logistic regression was used to that avail. When the whole dataset was used, no satisfactory results could be obtained. The logistic regression model could not classify cases into pre/post-COVID categories (it simply lumped all case predictions into the largest post-COVID category), and the Hosmer-Lemeshow test was below acceptable levels ($p < 0.05$).

The model estimated shows satisfactory fit results (as shown by chi-square and Hosmer-Lemeshow tests) but only explains a moderate portion of the variance as shown by the classification results (60.9%) and the Nagelkerk $R^2$ score. Examination of results in Table 4 indicates that two factors show a strong odds-ratio: environmental distractions and operational process issues have odds-ratio (column exp.(β)) of 14.889 and 5.076 respectively. This means that, when patients experienced harm, cases showing environmental distractions have almost 15 times more chances of being post-COVID than pre-COVID cases. Similarly, cases showing operational process issues have five times more chances to be post-COVID ones.

We also looked at the associations between factors, identifying factors that were likely to appear together in a MI (association matrices are provided in Appendix 1). When analyzing these associations, we observed that the contributing factors observed before COVID had fewer linkages with other factors than what was observed after COVID. We can also note that MIs where harm was experienced by patients show more associated factors than MIs where no harm was experienced by patients.

Figure 1 illustrates some of the key associations between factors leading to harm. For instance, if we consider the left side of Fig. 1, we note that pre-COVID MIs creating harm were reporting the following associated factors: the presence of environmental distractions, operational process issues, technology /equipment issues, and look alike/ sound alike issues. In post-COVID MIs, environmental distractions and operational process issues are the factors that are most often associated with other factors (details provided in Appendix 1). This suggests that, for MIs causing harm to the patient, there could be configurations of factors that together create a more severe incident. MIs do not appear to be always caused by one single trigger.

## 4. Discussion

This analysis identified two notable changes in reporting between the pre-COVID and post-COVID periods. The first was an upsurge in the reported level of occurrence of five specific contributing factors in the post-COVID period, which were particularly pronounced in incidents involving patient harm. The second change was the large odds-ratios observed for environmental distractions and operational process issues (see Table 4). These two factors were much more likely to be associated with post-COVID events. Several potential explanations may account for these observations.

Before discussing these, we first consider what remained constant throughout the two observation periods. The top four contributing factors remained unchanged, even after considering differences in the length of time between the two periods and differences in sample selection. This finding suggests that the dominant activities in the pharmacy contributing to most reported medication incidents remained constant. As pharmacy medication incidents are self-reported, it is important to note that access, ease of access and ease of use to the reporting platform were not significantly different between periods. Furthermore, reporting requirements as imposed by each provincial professional governing body were only changed in one province, Manitoba, during the evaluation period.

**Table 2**
Distribution of incidents.

| | | Unknown or not reported | None | Mild | Moderate | Severe | Death | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Number of cases* | | | | | | | % |
| Event year | 2019 | 6679 | 9282 | 1023 | 172 | 21 | 12 | 17,189 | 30.5% |
| | 2020 | 6934 | 11,113 | 1005 | 156 | 31 | 13 | 19,252 | 34.2% |
| | 2021 | 7079 | 10,752 | 1183 | 197 | 20 | 11 | 19,242 | 34.1% |
| | 2022 | 251 | 389 | 37 | 3 | 3 | 0 | 683 | 1.2% |
| COVID period | Before | 8035 | 11,518 | 1223 | 208 | 30 | 16 | 21,030 | 37.3% |
| | After | 12,908 | 20,018 | 2025 | 320 | 45 | 20 | 35,336 | 62.7% |
| Sum | | **20,943** | **31,536** | **3248** | **528** | **75** | **36** | **56,366** | |
| % | | 37.2% | 55.9% | 5.8% | 0.9% | 0.1% | 0.1% | 100.0% | |

**Table 3**
Contributing factors leading to medication incidents.

| | All cases | | | | Cases with harm[a] | | | |
|---|---|---|---|---|---|---|---|---|
| Cases indicating contributing factors: | No. of cases before COVID | No. of cases after COVID | *Z*-Value | p bi-lateral | No. of cases before COVID | No. of cases after COVID | Z-Value | p bi-lateral |
| Staff distribution | 6403 (30.4%) | 11,045 (31.3%) | −2.01 | <0.05 | 477 (32.3%) | 697 (28.9%) | 2.21 | <0.05 |
| Lack of quality control /independent checks | 4406 (21%) | 6928 (19.6%) | 3.82 | <0.001 | 385 (26.1%) | 542 (22.5%) | 2.51 | <0.05 |
| Lack of staff education | 2722 (12.9%) | 5418 (15.3%) | −7.94 | <0.001 | 188 (12.7%) | 349 (14.5%) | −1.56 | |
| Prescription mis-communication. Issues | 2551 (12.1%) | 3928 (11.1%) | 3.60 | <0.001 | 233 (15.8%) | 409 (17.0%) | −0.98 | |
| Drug related issues | 978 (4.7%) | 3044 (8.6%) | −19.02 | <0.001 | 103 (7.0%) | 384 (15.9%) | −8.98 | <0.001 |
| Critical Patient info missing/ incorrect | 364 (1.7%) | 1012 (2.9%) | −8.97 | <0.001 | 40 (2.7%) | 134 (5.6%) | −4.53 | <0.001 |
| Patient/Caregiver education issue | 341 (1.6%) | 1061 (3.0%) | −10.98 | <0.001 | 77 (5.2%) | 216 (9.0%) | −4.57 | <0.001 |
| Environmental/ Distractions | 221 (1.1%) | 4012 (11.4%) | −56.34 | <0.001 | 15 (1.0%) | 454 (18.8%) | −21.26 | <0.001 |
| Technology / Equipment issue | 85 (0.4%) | 266 (0.8%) | −5.49 | <0.001 | 2 (0.1%) | 7 (0.3%) | −1.07 | |
| Operational Process issue | 75 (0.4%) | 2189 (6.2%) | −43.35 | <0.001 | 13 (0.9%) | 243 (10.1%) | −13.95 | <0.001 |
| Look alike sound alike issues | 39 (0.2%) | 86 (0.2%) | −1.46 | | 3 (0.2%) | 10 (0.4%) | −1.21 | |
| Use of an external agency | 3 (0.0%) | 13 (0.0%) | −1.71 | | | | | |
| Other factor category | 7857 (37.4%) | 10,240 (29.0%) | 20.36 | <0.001 | 537 (36.4%) | 569 (23.6%) | 8.38 | |
| **Total number of cases** | **21,030** | **35,336** | | | **1477** | **2410** | | |

When only cases where patients experienced harm were considered, the results were significant, as shown in Table 4:
[a] Harm medication incidents refer to incidents that lead to a mild, moderate, severe harm or death to a patient.

**Table 4**
Multivariate Logistic Regression Results – Predicting period (Post COVID = 1) using factors observed.

| | β | S.E. | Wald | df | Sig. | Exp(β) | 95% confidence interval for Exp(β) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Critical Patient information missing/incorrect | 0.401 | 0.197 | 4.150 | 1 | 0.042 | 1.493 | 1.015 | 2.195 |
| Drug related issues | 0.461 | 0.128 | 12.940 | 1 | 0.000 | 1.585 | 1.233 | 2.038 |
| Environmental/ Distractions | 2.701 | 0.269 | 100.894 | 1 | 0.000 | 14.889 | 8.791 | 25.219 |
| Lack of quality control or independent checks | −0.092 | 0.084 | 1.183 | 1 | 0.277 | 0.912 | 0.773 | 1.076 |
| Operational Process issue | 1.625 | 0.298 | 29.796 | 1 | 0.000 | 5.076 | 2.833 | 9.096 |
| Other factor category | −0.316 | 0.082 | 14.820 | 1 | 0.000 | 0.729 | 0.621 | 0.856 |
| Patient/Caregiver education issue | 0.295 | 0.147 | 4.014 | 1 | 0.045 | 1.343 | 1.006 | 1.793 |
| Staff distribution | −0.292 | 0.080 | 13.266 | 1 | 0.000 | 0.746 | 0.638 | 0.874 |
| Constant | 0.390 | 0.068 | 32.704 | 1 | 0.000 | 1.477 | | |

| | | Predicted | | % Correct | Chi-square test "*p*-value" | Hosmer-Lemeshow test "*p* value" | Nagelkerk $R^2$ |
|---|---|---|---|---|---|---|---|
| | | Pre COVID | Post COVID | | | | |
| Observed | Pre COVID | 858 | 619 | 58.1 | | | |
| | Post COVID | 899 | 1511 | 62.7 | < 0.001 | 0.467 | 0.160 |
| Percentage | | | | 60.9 | | | |

This would suggest that while changes were happening at the onset of the pandemic, like increased information role,[18] advanced services,[25] access measures,[23] drug shortages and supply issues,[31] and the adoption of social distancing measures,[3] community pharmacies were able to maintain the overall quality of service. This is illustrated by the rate of errors causing harm that has not increased after the onset of the pandemic.

Supply shortages were managed by reducing quantities per purchase,[31] which in turn increased the number of transactions as patients had to renew their prescriptions more often. This increased the workload. Tensions emerged between competing demands: rules had to be implemented to deal with masks and distancing, while pharmacies were putting in place a massive vaccinating program.[3,31] Such tensions could well explain the rise in operational process issues. Likewise, restrictions in travel and face to face communication resulting from the pandemic (e.g., isolation requirements, masks, remote work) could also have threatened smooth process execution.

A heightened sense of awareness when dealing with more complex scenarios may have contributed to the upsurge in reporting environmental distractions during this period of increased pressure in the pharmacy. Juggling the management of more frequent prescription renewals, emergency supplies, substitutions due to drug supply shortages, administering vaccines, creating new appointment-based services as well as new delivery was challenging.[31] At the same time, plexiglass shields had to be installed, markers on the floor were drawn, and new sets of rules were being adopted. The first period of the pandemic was

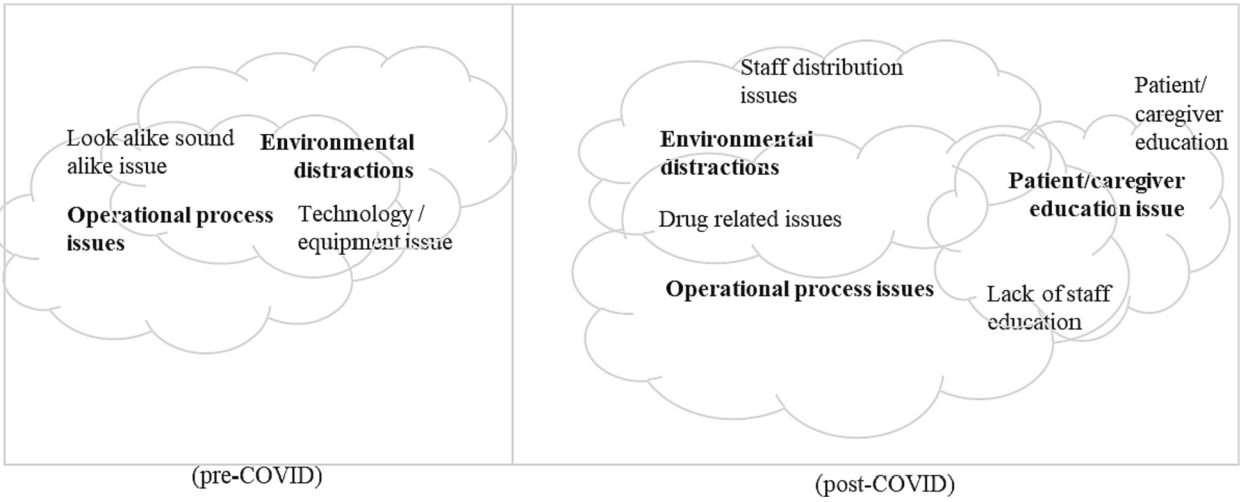


**Fig. 1.** Co-occurrence of Factors when Patients Experience Harm.

characterized by fear experienced by many patients,[16] who had to be reassured that it was still safe to access health services. All this created a very different work environment. This may have indeed been a distracting environment.

The strong observed odds-ratios of environmental distractions and operational process issues in post-COVID cases involving harm to the patient (see Table 4) as well as the post-COVID upsurge of five factors (shaded in Table 3) suggest that the pharmacies were under greater stress than before the pandemic and perhaps the increased pressure made pharmacy staff more acutely mindful of events unfolding, which could lead to a more accurate and detailed reporting patterns in the future.

More regulators are requiring mandatory reporting for MIs while maintaining self-reporting to encourage a safe space to report. It appears the rate of reporting from a pharmacy is not based on region but on the degree of the culture. The perceived lack of 'just culture' has historically been offered as an explanation for under-reporting. The number of pharmacies compared to the number of incidents reported suggests that not all errors and near-miss events were reported from every pharmacy. Further work needs to be done to convince pharmacists, technicians, and staff to report not only errors that reached the patient but also "good catches" because trending all this information will lead to system improvements. For example, if we wish to stop the rate of drug shortages, we need aggregate data showing that the contributing factor of drug shortages is a problem leading to medication incidents.

Some limitations of the study should be taken into consideration when interpreting the results. The research relies solely on quantitative and self-reported data of MIs. Qualitative data, such as interviews, surveys, or text data, could provide additional context and insights into the factors influencing medication incidents. The mechanisms linking factors and consequences still need to be investigated. MIs are self-reported, which may introduce bias as not all incidents are reported, and reporting may be influenced by the pharmacy's culture and willingness to report. Also, because the study focused on Canadian community pharmacies, the generalizability of the findings is limited.

## 5. Conclusion

The COVID-19 pandemic put great stress on the health care systems in Canada and globally. Community pharmacies adapted rapidly to broaden and adjust the services they were providing to patients, while coping with severe pressure on supply chains and constrained social interactions. The research study conducted a thorough analysis of a large dataset of medication incidents reported over a three-year period, making it a comprehensive study. One of its strengths relies on the data available. Reporting systems were in place before the pandemic, and continued after the pandemic, which provided a solid basis for comparison. The research also highlighted the specific characteristics of cases in which patients experienced harm, which are the first cases we want to eliminate through better knowledge and risk management practices.

The results highlight what really changed from the onset of the pandemic. Results of the present study indicated that Canadian pharmacies were able to sustain such stress while maintaining comparable safety levels. At the same time, the challenges showed that some risk factors that were either ignored or not meaningful in the past started to be reported. Challenges introduced by the required changes linked with the pandemic seemed to have put pressure on process execution, leading to additional process issues, and created a more distracting environment for pharmacists.

This suggests that community pharmacists are now aware of a larger set of contributing factors that can lead to medication incidents, notably for medication incidents that can lead to harm. Future work should seek to identify specific configurations of contributing factors that are specifically problematic for pharmacy staff to recognize them and to take appropriate measures to prevent such incidents. Additional qualitative data analysis could also provide insights into the factors influencing the incidents to identify examples or concrete situations that are prone to different MIs and levels of harm. The results of the study also identified changes in reporting patterns across pharmacies which calls for a more in-depth exploration on how and why these reporting requirements vary and their potential influence on these patterns.

In summary, this research article provides valuable insights into the impact of the COVID-19 pandemic on MIs in Canadian community pharmacies. While it has notable strengths, including its comprehensive data analysis and relevance, it also has limitations, such as the lack of qualitative data explaining the role and the complexity of contributing factors. The research findings can be beneficial for healthcare professionals, policymakers, and researchers working to improve medication safety in community pharmacy practice.

## Funding

MITACS IT24471 Identifying Data Analytics Capabilities.

## Declaration of Competing Interest

None to disclose.

## Appendix A. Association between factors

Association between factors (pre-COVID).

| | Critical Patient information missing/ incorrect | Drug related issues | Environ-mental/ Distractions | Lack of quality control or independent checks | Lack of staff education | Look alike sound alike issues | Operational Process issue | Patient/ Caregiver education issue | Prescription miscom-munication / issues | Staff distribu-tion | Technology / Equipment issue | Use of an external agency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Patient information missing/incorrect | 1 | | | | | | | | | | | |
| Drug related issues | −0.007 | 1 | | | | | | | | | | |
| Environmental/ Distractions | 0.011 | 0.013 | 1 | | | | | | | | | |
| Lack of quality control or independent checks | −0.028** | −0.058** | −0.038** | 1 | | | | | | | | |
| Lack of staff education | −0.006 | −0.028** | 0.019** | −0.039** | 1 | | | | | | | |
| Look alike sound alike issues | −0.006 | 0.032** | 0.104** | −0.017* | −0.003 | 1 | | | | | | |
| Operational Process issue | 0.017* | 0.006 | 0.064** | −0.013 | −0.004 | 0.072** | 1 | | | | | |
| Patient/Caregiver education issue | 0.058** | 0.009 | 0.005 | −0.003 | 0.025** | −0.006 | 0.018* | 1 | | | | |
| Prescription miscommunication / issues | −0.002 | −0.032** | −0.027** | −0.104** | −0.073** | −0.013 | 0.002 | 0.041** | 1 | | | |
| Staff distribution | −0.051** | −0.094** | −0.042** | −0.053** | −0.101** | −0.026** | −0.029** | −0.015* | −0.139** | 1 | | |
| Technology / Equipment issue | 0.015* | −0.003 | 0.038** | −0.027** | 0.000 | −0.003 | 0.009 | −0.002 | −0.021** | −0.041** | 1 | |
| Use of an external agency | −0.002 | 0.016* | 0.038** | −0.006 | −0.005 | −0.001 | −0.001 | −0.002 | −0.004 | −0.008 | 0.062** | 1 |
| Other factor category | −0.066** | −0.120** | −0.069** | −0.287** | −0.230** | −0.029** | −0.036** | −0.047** | −0.193** | −0.332** | −0.046** | −0.009 |

* $p < 0.05$, ** $p < 0.01$.

Association between factors (post-COVID).

| | Critical Patient information missing/ incorrect | Drug related issues | Environ-mental/ Distractions | Lack of quality control or independent checks | Lack of staff education | Look alike sound alike issues | Operational Process issue | Patient/ Caregiver education issue | Prescription miscom-munication / issues | Staff distribu-tion | Technology / Equipment issue | Use of an external agency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Patient information missing/incorrect | 1 | | | | | | | | | | | |
| Drug related issues | 0.077** | 1 | | | | | | | | | | |
| Environmental/ Distractions | 0.097** | 0.220** | 1 | | | | | | | | | |
| Lack of quality control or independent checks | −0.007 | −0.046** | −0.096** | 1 | | | | | | | | |
| Lack of staff education | 0.030** | 0.010 | 0.034** | 0.006 | 1 | | | | | | | |
| Look alike sound alike issues | −0.002 | −0.005 | 0.008 | −0.023** | −0.008 | 1 | | | | | | |
| Operational Process issue | 0.099** | 0.156** | 0.316** | −0.026** | 0.074** | −0.008 | 1 | | | | | |
| Patient/Caregiver education issue | 0.130** | 0.096** | 0.112** | 0.019** | 0.060** | −0.009 | 0.130** | 1 | | | | |
| Prescription miscommunication / issues | 0.072** | 0.060** | 0.036** | −0.054** | −0.029** | −0.014** | 0.039** | 0.113** | 1 | | | |
| Staff distribution | −0.010 | −0.050** | 0.021** | −0.051** | −0.083** | −0.025** | −0.021** | 0.009 | −0.092** | 1 | | |
| Technology / Equipment issue | −0.015** | −0.024** | −0.012* | −0.039** | −0.023** | 0.002 | −0.020** | −0.015** | −0.027** | −0.054** | 1 | |
| Use of an external agency | −0.003 | −0.006 | −0.007 | −0.009 | −0.008 | −0.001 | −0.005 | −0.003 | −0.007 | −0.013* | −0.002 | 1 |
| Other factor category | −0.084** | −0.161** | −0.228** | −0.212** | −0.210** | −0.028** | −0.163** | −0.075** | −0.163** | −0.285** | −0.050** | −0.009 |

* $p < 0.05$, ** $p < 0.01$.

Association between factors when patients experienced harm (pre-COVID).

| | Critical Patient information missing/ incorrect | Drug related issues | Environ-mental/ Distractions | Lack of quality control or independent checks | Lack of staff education | Look alike sound alike issues | Operational Process issue | Patient/ Caregiver education issue | Prescription miscom-munication / issues | Staff distribu-tion | Technology / Equipment issue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Patient information missing/incorrect | 1 | | | | | | | | | | |
| Drug related issues | 0.036 | 1 | | | | | | | | | |
| Environmental/ Distractions | 0.025 | 0.025 | 1 | | | | | | | | |
| Lack of quality control or independent checks | −0.042 | −0.072** | 0.001 | 1 | | | | | | | |
| Lack of staff education | −0.014 | −0.057* | 0.022 | −0.032 | 1 | | | | | | |
| Look alike sound alike issues | −0.008 | 0.047 | 0.145** | −0.027 | −0.017 | 1 | | | | | |
| Operational Process issue | 0.074** | 0.031 | 0.135** | 0.043 | 0.008 | 0.157** | 1 | | | | |
| Patient/Caregiver education issue | 0.092** | −0.004 | 0.007 | 0.027 | 0.093** | −0.011 | 0.043 | 1 | | | |
| Prescription miscommunication / issues | −0.015 | −0.016 | −0.007 | −0.105** | 0.002 | −0.020 | 0.019 | 0.057* | 1 | | |
| Staff distribution | −0.044 | −0.098** | −0.027 | 0.029 | 0.010 | −0.031 | −0.003 | 0.033 | −0.108** | 1 | |
| Technology / Equipment issue | 0.107** | 0.062* | 0.180** | 0.020 | 0.096** | −0.002 | 0.194** | 0.074** | 0.035 | 0.014 | 1 |
| Use of an external agency | Calculation impossible – variable is a constant | | | | | | | | | | |
| Other factor category | −0.057* | −0.107** | −0.063* | −0.279** | −0.192** | −0.034 | −0.056* | −0.057* | −0.204** | −0.287** | −0.028 |

* $p < 0.05$, ** $p < 0.01$.

Association between factors when patients experienced harm (post-COVID).

| | Critical Patient information missing/ incorrect | Drug related issues | Environ-mental/ Distractions | Lack of quality control or independent checks | Lack of staff education | Look alike sound alike issues | Operational Process issue | Patient/ Caregiver education issue | Prescription miscom-munication / issues | Staff distribu-tion | Technology / Equipment issue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Patient information missing/incorrect | 1 | | | | | | | | | | |
| Drug related issues | 0.053** | 1 | | | | | | | | | |
| Environmental/ Distractions | 0.087** | 0.205** | 1 | | | | | | | | |
| Lack of quality control or independent checks | −0.022 | −0.091** | −0.120** | 1 | | | | | | | |
| Lack of staff education | 0.044* | 0.066** | 0.097** | 0.035 | 1 | | | | | | |
| Look alike sound alike issues | 0.013 | −0.028 | −0.015 | −0.019 | −0.008 | 1 | | | | | |
| Operational Process issue | 0.075** | 0.178** | 0.339** | −0.032 | 0.152** | −0.022 | 1 | | | | |
| Patient/Caregiver education issue | 0.101** | 0.054** | 0.101** | 0.005 | 0.110** | −0.020 | 0.151** | 1 | | | |
| Prescription miscommunication / issues | 0.069** | 0.036 | 0.034 | −0.024 | 0.031 | 0.005 | 0.073** | 0.179** | 1 | | |
| Staff distribution | 0.001 | −0.038 | 0.149** | −0.015 | 0.055** | −0.041* | 0.023 | 0.002 | −0.062** | 1 | |
| Technology / Equipment issue | −0.013 | −0.023 | −0.026 | −0.011 | −0.022 | −0.003 | 0.008 | −0.017 | −0.024 | −0.034 | 1 |
| Use of an external agency | Calculation impossible – one of the variables is a constant | | | | | | | | | | |
| Other factor category | −0.109** | −0.189** | −0.268** | −0.152** | −0.168** | −0.036 | −0.186** | −0.082** | −0.173** | −0.180** | −0.030 |

* $p < 0.05$, ** $p < 0.01$.

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