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29 **Quality Related Events Reported by Community Pharmacies in**
30 **Nova Scotia: A 7-year Descriptive Analysis**
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Abstract

Background: Quality-related events (QREs) are defined as any departure from the appropriate dispensing of a prescribed medication that is or is not corrected prior to the administration of the medication. Studies have examined reported QREs in hospital environments, but there has been limited research to quantitatively analyze these events in community pharmacies. The aim of this study is to characterize QREs reported by community pharmacies in a Canadian province.

Methods: A retrospective analysis was conducted on reported QREs from Nova Scotia community pharmacies occurring between October 1, 2010 and June 30, 2017. Descriptive analysis was performed on all QREs with respect to type of incident, discoverer, medication system stages, medications, and outcome.

Results: A total of 131,031 QREs were reported by 301 community pharmacies; 98,097 of which were medication-related. Overall, 82% of medication-related QREs did not reach the patient and 0.95% was associated with patient harm. Reports of incorrect dose/frequency, incorrect quantity, and incorrect drug were the most common types of QREs. The majority of medication-related QREs occurred at order entry, followed by preparation/dispensing and prescribing. Medications identified as conveying a potentially higher risk of harm include methadone, risperidone, and warfarin.

Interpretation: This is the first quantitative analysis of medication-related QREs reported by community pharmacies in Canada. We found that reported QREs from community pharmacies differ from institutional settings with respect to medications, outcomes, types, and stages of medication use. This analysis provides valuable information to guide quality improvement initiatives to strengthen medication safety in both community pharmacies and in primary care.

Introduction

Community pharmacies in Canada dispense over 600 million prescriptions each year; however, little is known about the quality-related events (QREs) associated with this process. [1] QREs are defined as any departure from the appropriate dispensing of a prescribed medication (e.g. incorrect drug, dose, and quantity) that is or is not corrected prior to the administration of the medication. [2] QREs occur when vulnerable medication-use systems and/or human factors affect prescribing, transcribing, dispensing, administration, and monitoring practices. [3] When a QRE reaches a patient and causes harm, it is defined as an adverse drug event (ADE). [4] It is estimated that ADEs are responsible for 12% emergency department visits and 24% of all adverse events (AEs) that occur in hospitals in Canada. [5, 6]

In an effort to address factors that lead to QREs, healthcare organizations and governments have developed and implemented reporting systems. Aside from providing data for large-scale aggregate analysis, reporting systems enable healthcare stakeholders to better understand the contributing factors that may have led to QREs, thereby aiding practitioners, pharmacies, and regulatory authorities in developing and sharing strategies to prevent recurrence. QRE reporting has also been associated with improvements in patient safety culture, and improved organizational learning. [7] Despite the potential benefits associated with QRE reporting, there has been limited implementation of these systems in community pharmacies in Canada. As of June 2017, the Nova Scotia College of Pharmacists (NSCP) is the only pharmacy regulatory authority in Canada that mandates QRE reporting. As part of the Standard of Practice (SOP) for Continuous Quality Assurance programs enacted in 2010, community pharmacies in Nova Scotia are required to anonymously report all QREs to a national incident data repository at the Institute for Safe Medication Practices Canada (ISMP Canada) through the Community Pharmacy Incident Reporting (CPhIR) system. [8] Although previous research in this area has focused largely on secondary and tertiary health care settings, analyses of reported QREs from community pharmacies in Denmark and the Netherlands revealed differences in type, stage of medication use, and outcome of reported QREs compared to institutional settings. [9, 10] To our knowledge, no studies have been conducted to quantitatively examine reported QREs from community pharmacies in North America. Therefore, the aim of this study is to characterize QREs reported to an independent third-party national medication safety organization by community pharmacies in a Canadian province over seven years.

Methods

QRE Reporting Form

The QRE reporting form was developed in collaboration with Nova Scotia and Ontario community pharmacy professionals; it consists of seven mandatory fields: (1) date incident occurred, (2) type of incident, (3) incident discovered by, (4) medication system stages involved, (5) medication(s), (6) patient outcome associated with the incident, and (7) a free-text incident description field (Figure 1). All members of the pharmacy team (e.g., owner, manager, pharmacist, technician, assistant) can report a QRE through the online CPhIR system. The reporter may only select one option from the “Type of Incident”, “Degree of Harm to Patient due

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3 to Incident”, and “Incident Discovered By” fields, but multiple options for “Medication System
4 Stages Involved in this Incident”. Reporters have the option to report an incident that is not
5 medication-related by unchecking the box titled “Is this medication related?”. For the purpose of
6 this study, we have included only those incidents that were reported as medication-related. The
7 medication field will auto-populate if a drug identification number (DIN) is entered. A DIN is an
8 8-digit unique identifier located on the label of prescription and over-the-counter drug products
9 that have been approved for sale in Canada. Reporters may also select the medication from a
10 drop-down menu when the user begins typing the medication name or they may choose to
11 manually enter a free-form medication name.
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14 *Data Extraction and Analysis*

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17 All reported medication-related QREs from Nova Scotia community pharmacies
18 occurring between October 1, 2010 and June 30, 2017 were extracted from the CPhIR system.
19 Single item and cross tabulation search statements were developed to further extract relevant
20 data for analysis. Descriptive analyses were performed on all medication-related QREs with
21 respect to patient outcome, medication system stages involved, type of QREs, and discoverer of
22 the QRE. Only QREs reported with a DIN, from which the Anatomical Therapeutic Chemical
23 (ATC) classification could be determined, were included in the analysis. For the purpose of this
24 quantitative analysis, we did not review the free-text narrative incident description of the QREs.
25 All analyses were performed using IBM SPSS version 24.
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| Date Incident Occurred REQUIRED | <div style="text-align: center;"> < August 2017 > </div> <table border="1" style="margin: 5px auto;"> <tr><td>30</td><td>31</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr> <tr><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr> <tr><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td></tr> <tr><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td></tr> <tr><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>1</td><td>2</td></tr> </table> | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 |
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| 27 | 28 | 29 | 30 | 31 | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Type of Incident REQUIRED | <ul style="list-style-type: none"> <input type="radio"/> Incorrect patient <input type="radio"/> Incorrect prescriber <input type="radio"/> Incorrect drug <input type="radio"/> Incorrect dose/frequency <input type="radio"/> Incorrect strength/concentration <input type="radio"/> Incorrect dosage form/formulation (include not splitting tablets as per patient's request) <input type="radio"/> Incorrect route of administration <input type="radio"/> Incorrect duration of treatment <input type="radio"/> Incorrect quantity <input type="radio"/> Incorrect storage <input type="radio"/> Omitted Medication/Dose <input type="radio"/> Expired medication <input type="radio"/> Drug Therapy Problem - Contraindication <input type="radio"/> Drug Therapy Problem - Adverse Drug Reaction <input type="radio"/> Drug Therapy Problem - Documented allergy <input type="radio"/> Drug Therapy Problem - Drug-drug/OTC/Natural Health Product interaction <input type="radio"/> Drug Therapy Problem - Drug-food interaction <input type="radio"/> Drug Therapy Problem - Drug-disease interaction <input type="radio"/> Incorrect third-party billing | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Incident Discovered By REQUIRED | <input type="text"/> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Medication System Stages Involved in this Incident REQUIRED | <ul style="list-style-type: none"> <input type="checkbox"/> Prescribing <input type="checkbox"/> Rx Order Entry <input type="checkbox"/> Prescription Preparation / Dispensing <input type="checkbox"/> Administration <input type="checkbox"/> Monitoring / Follow-up <input type="checkbox"/> Not Applicable (Unable to determine one or more of the above medication system phases) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Medications REQUIRED | <input checked="" type="checkbox"/> Is this incident medication-related? DIN: <input type="text"/> Medication: <input type="text"/> DIN: <input type="text"/> Medication: <input type="text"/> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Degree of Harm to Patient due to Incident REQUIRED | <ul style="list-style-type: none"> • NO ERROR <ul style="list-style-type: none"> <input type="radio"/> No Error (Medication Not Dispensed / Near Miss / Medication Discrepancy) - Circumstances or events that have the capacity to cause harm • NO HARM <ul style="list-style-type: none"> <input type="radio"/> No Harm (Medication Dispensed) - No symptoms detected; no treatment required • HARM <ul style="list-style-type: none"> <input type="radio"/> Mild Harm - Symptoms were mild, temporary and short term; no treatment or minor treatment was required <input type="radio"/> 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 <input type="radio"/> Severe Harm - Symptoms required major treatment to save the patient's life; the incident shortened life expectancy; or caused major permanent or long term harm • DEATH <ul style="list-style-type: none"> <input type="radio"/> Death - There is reason to believe that the incident caused the patient's death or hastened the patient's death | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Incident Description / How the Incident was Discovered REQUIRED | <div style="border: 1px solid gray; padding: 5px;"> <p>Example: Patient dropped off a prescription for Bisoprolol 5mg (Directions: 1 tablet once daily x 30 days). Prescription was entered as Apo-Bisacodyl 5mg (Directions: 1 tablet once daily x 30 days). It was then filled with Apo-Bisacodyl 5mg x 30 tablets. Pharmacist caught the error when checking the prescription.</p> </div> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 1. Mandatory fields of the Community Pharmacy Incident Reporting (CPhIR) system

Results

A total of 301 community pharmacies in Nova Scotia reported 131,031 QREs to the CPhIR system between October 1, 2010 and June 30, 2017. An average of 19,412 QREs were reported annually. Of all QREs, 98,097 were reported as being medication-related and were included in the analysis. The mean number of reported medication-related QREs for each pharmacy during the study period was 326 (SD = 439). There was a large variability between pharmacies with a range of 1 to 2806 QREs reported per pharmacy over the study period. In addition, it was found that 10% (30) of the pharmacies accounted for 42.7% (41,926) of all reported medication-related QREs.

Analysis of outcomes revealed that 82.1% (80,488) of reported medication-related QREs did not reach the patient (i.e. near misses) and only 0.95% (928) was associated with patient harm or death (Table 1).

Of all analyzed medication-related QREs, 17.5% (17,135) were reported as occurring in multiple medication system stages. The medication system stage most frequently associated with QREs was prescription order entry, followed by prescription preparation/dispensing and prescribing (Table 2). Among QREs associated with harm, there was a more even distribution across the medication system stages, with prescription preparation/dispensing accounting for the largest proportion of harm reports, followed by order entry and administration. Administration and monitoring/follow-up were found to have the highest proportion of QREs with harm at 10.5% and 12.8%, respectively.

The most frequently reported types of QRE were incorrect dose/frequency, followed by incorrect quantity and incorrect drug (Table 3). For QREs associated with harm, the highest number of QREs was associated with incorrect dose/frequency, followed by incorrect strength/concentration and incorrect drug. It was found that 29.8% of reported adverse drug reactions resulted in patient harm, the highest proportion of reported QREs associated with harm.

Overall, pharmacists, pharmacy technicians/assistants, and patients discovered the majority of QREs (Table 4). Pharmacists contributed the largest portion (75.2%; 73,739) followed by pharmacy technicians/assistants and patients at 10.3% (10,094) and 9.9% (9,728) of QREs, respectively. There were differences in who discovered the QREs with respect to the type of QREs and in what medication system stage the QREs were involved. Compared to pharmacists and pharmacy technician/assistants, patients discovered a greater proportion of QREs in the administration and monitoring/follow-up stage (Supplemental 1) and a greater proportion of expired medication and adverse drug reactions (Supplemental 2).

Analysis based on the ATC classification was performed on 89.6% (87,859) of QREs that were reported with a DIN, representing 851 unique medications or chemical substances. The medications most often involved in QREs were levothyroxine sodium, amoxicillin, and rosuvastatin (Table 5). The medications with the highest number of QREs associated with harm were levothyroxine sodium, citalopram, and hydromorphone (Table 6). Assessment of the proportion of QREs associated with harm for each medication found that methadone (10.3%), risperidone (3.5%), and warfarin (3.0%) had the highest proportion of QREs associated with

harm (Table 7). Analysis of the relationship between medications and type of QRE or medication system stages identified medications that were associated with QREs in specific stage or type of QRE (Supplemental 3, 4). For example, 41.8% of QREs involving moxifloxacin occurred in the prescribing stage, 94.4% of QREs involving clozapine occurred in the prescription processing/dispensing stage, and 16.9% of QREs involving tetracycline were associated with incorrect duration of treatment.

Interpretation

Since 2010, there has been a rapid uptake of QRE reporting with the introduction of a new SOP for Continuous Quality Assurance programs in Nova Scotia. Despite variability in reporting between pharmacies, 100% of community pharmacies in Nova Scotia (n = 301) reported at least one QRE during the study period, indicating universal compliance with the SOP.

Pharmacists discovered the majority of QREs, supporting their role in identifying and preventing QREs from reaching the patient. An analysis of outcomes revealed that most of the reported medication-related QREs (82.1%) did not reach the patient. This finding is in contrast to analysis of reported QREs from community pharmacies in the Netherlands where 54.7% of QREs did not reach the patient. [9] In addition, results from the National Reporting and Learning System (NRLS) in the UK, which collects reports largely from secondary and tertiary care settings, found that 83.5% of QREs did not reach the patient. [11] These differences in reported patient outcomes may be the result of a number of factors. First, anonymous QRE reporting is just one component of the SOP for Continuous Quality Assurance programs in Nova Scotia community pharmacies, which also includes an annual medication safety self-assessment, and quarterly staff meetings to implement and monitor ongoing QI initiatives at the pharmacy. [8] These additional QI components contribute to a culture of safety and help facilitate QRE reporting by addressing several common barriers to incident reporting, including lack of feedback on action taken as a result of reporting, insufficient justification for reporting a “near miss”, and the belief that reporting is unlikely to lead to system changes. [12, 13] Second, pharmacy compliance with all required components of the SOP are regularly audited by the NSCP. As a result, our data collection and analysis may provide a more representative view of QREs and associated outcomes that occur in community pharmacies.

The most common medication system stages involved in the reported medication-related QREs were prescription order entry and prescription preparation/dispensing. This finding aligns with studies conducted in community pharmacies [9,10], but not in hospitals, where the most common stage involved was prescribing. [11, 14-16] We found that QREs that occurred during administration or monitoring/follow-up have a higher likelihood of resulting in patient harm. This supports Reason’s “Swiss Cheese” model of accident causation, whereby QREs can be prevented from causing patient harm through the presence of latent and active barriers. [17] Each barrier has unintended weaknesses, or holes, that when aligned, enables the QRE to reach the patient and potentially cause harm. QREs that occur in earlier stages of the medication-use process, such as, prescribing or order entry, have more opportunities to be discovered and intercepted by subsequent barriers in medication system stages like prescription preparation/dispensing. QREs in later stages, such as administration, have fewer barriers and opportunities for interception, and are more likely to reach the patient. [17]

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4 The most frequent types of reported QREs (e.g. incorrect dose/frequency, incorrect
5 quantity, and incorrect drug) were generally in agreement with previous studies in community
6 pharmacies. [10, 18] Hospital and mixed reporting studies often have a higher proportion of
7 reports related to incorrect frequency. [11, 14] By calculating the proportion of QREs associated
8 with harm for each type of QRE, we identified that adverse drug reactions may result in a higher
9 potential of harm to patients. Our findings align with previous research that identified adverse
10 drug reactions as the most common cause for drug-related emergency department visits. [5]
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14 As expected, the most frequently reported medications were among the top dispensed
15 medications in Canada. [1] The top medications associated with harmful QREs include high-alert
16 medications identified by previous studies and by ISMP. [19, 20] In fact, 35% of the top 20
17 medications associated with harm in this study are listed as high-alert medications in
18 community/ambulatory healthcare by ISMP. [20] We also calculated the proportion of QREs that
19 resulted in harm for each medication and identified a number of medications not frequently
20 associated with a high-alert nature in the literature (e.g. risperidone and citalopram). [19] Further
21 analysis will be required to identify factors that increase the risks associated with these
22 medications.
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26 There are a number of limitations to be considered in this study. First, we found
27 significant variability in the reporting rates among community pharmacies. This is in line with
28 previous research and may imply under-reporting of QREs to some extent. [21] Second, 10% of
29 reported medication-related QREs were excluded from our analysis due to the use of free-form
30 medication name in QRE reporting. Since we were unable to quantify the medications or ATC
31 codes associated with the use of free-form entry, we could not determine if this represents any
32 biases in our analysis. Finally, our findings represent QREs reported from one reporting system
33 in one province in Canada. Since community pharmacies are largely governed by provincial
34 pharmacy regulatory authorities, our results may not be generalizable to the rest of Canada.
35 Nonetheless, our findings provide a foundation in characterizing QREs in Canadian community
36 pharmacies and will provide important comparative data for other provincial pharmacy
37 regulatory authorities in Canada who are mandating QRE reporting in the coming years. [22, 23]
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41 While the findings of this research provide an important first step in describing
42 community pharmacy QREs, it is unable to provide insight into the various factors that may
43 contribute to QREs in community pharmacies. As a result, future research should focus on
44 qualitative analysis of the free-text narrative incident description to better understand the
45 potential contributing factors associated with QREs in community pharmacy practice. Combined
46 with quantitative analysis, this will provide a comprehensive view of key safety risks and trends,
47 allowing for the development of recommendations to improve medication safety.
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51 Overall, this study aimed to characterize the reported QREs from community pharmacies
52 in Nova Scotia, Canada. Our results suggest that reported QREs from community pharmacies
53 differ from institutional settings with respect to medications, outcomes, type, and stage of
54 medication use. Currently, QRE reporting in community pharmacies is still in its infancy in
55 Canada. As provincial regulators move towards requiring QRE reporting in community
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3 pharmacy, ensuring a standardized, national QRE reporting system will strengthen the integrity
4 of data and analysis, thereby facilitating shared learning and improving medication safety.
5

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Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

Tables

| QREs Reached Patient | Outcome | Number of QREs (%) |
|-----------------------------|----------------|---------------------------|
| No | No Error | 80,488 (82.05%) |
| Yes | No Harm | 16,681 (17.00%) |
| | Mild Harm | 839 (0.86%) |
| | Moderate Harm | 80 (0.08%) |
| | Severe Harm | 7 (0.01%) |
| | Death | 2 (0.00%) |
| | Total | 98,097 (100%) |

Table 1. QREs reported by outcome.

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Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Stage | Number of QREs | Number of QREs with Harm | Proportion of QREs with Harm |
|---------------------------------------|------------------------|--------------------------|------------------------------|
| Prescribing | 110,658 (8.65%) | 159 (10.61%) | 1.49% |
| Rx Order Entry | 69,856 (58.71%) | 411 (27.44%) | 0.59% |
| Prescription Preparation / Dispensing | 34,859 (29.30%) | 571 (38.12%) | 1.64% |
| Administration | 2,167 (1.82%) | 228 (15.22%) | 10.52% |
| Monitoring / Follow-up | 704 (0.59%) | 90 (6.01%) | 12.78% |
| Not Applicable | 743 (0.62%) | 39 (2.60%) | 5.25% |
| Total | 118987 * (100%) | 1498 * (100%) | - |

Table 2. Total number of QREs, number of QREs associated with harm, and proportion of QREs with harm for each medication system stage.

* The reporter can select multiple options for “Medication System Stages Involved in this Incident” field; hence the total number of QREs and the number of QREs with harm are greater than those shown in Table 1.

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Type | Number of QREs | Number of QREs with Harm | Proportion of QREs with Harm |
|--|----------------------|--------------------------|------------------------------|
| Incorrect dose/frequency | 25,089 (25.58%) | 254 (27.37 %) | 1.01% |
| Incorrect quantity | 19,619 (20.00%) | 19 (2.05 %) | 0.10% |
| Incorrect drug | 13,951 (14.22%) | 185 (19.94 %) | 1.33% |
| Incorrect strength/concentration | 10,508 (10.71%) | 187 (20.15 %) | 1.78% |
| Incorrect prescriber | 8,454 (8.62%) | 0 (0%) | 0.00% |
| Incorrect patient | 5,685 (5.80%) | 32 (3.45 %) | 0.56% |
| Incorrect duration of treatment | 5,048 (5.15%) | 18 (1.94 %) | 0.36% |
| Incorrect dosage form/formulation (include not splitting tablets as per patient's request) | 3,281 (3.34%) | 32 (3.45 %) | 0.98% |
| Omitted medication/dose | 1,919 (1.96%) | 58 (6.25 %) | 3.02% |
| Incorrect route of administration | 1,121 (1.14%) | 7 (0.75 %) | 0.62% |
| Incorrect storage | 857 (0.87%) | 3 (0.32 %) | 0.35% |
| Incorrect third-party billing | 803 (0.82%) | 1 (0.11 %) | 0.12% |
| Drug Therapy Problem - Drug-drug/OTC/Natural Health Product interaction | 506 (0.52%) | 19 (2.05 %) | 3.75% |
| Drug Therapy Problem - Documented allergy | 447 (0.46%) | 31 (3.34 %) | 6.94% |
| Drug Therapy Problem - Contraindication | 356 (0.36%) | 12 (1.29 %) | 3.37% |
| Expired medication | 191 (0.19%) | 9 (0.97 %) | 4.71% |
| Drug Therapy Problem - Adverse Drug Reaction | 188 (0.19%) | 56 (6.03 %) | 29.79% |
| Drug Therapy Problem - Drug-disease interaction | 63 (0.06%) | 3 (0.32 %) | 4.76% |
| Drug Therapy Problem - Drug-food interaction | 11 (0.01%) | 2 (0.22 %) | 18.18% |
| Total | 98,097 (100%) | 928 (100%) | - |

Table 3. Total number of QREs, number of QREs with harm, and proportion of QREs with harm with respect to type of QRE.

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Discovered By | Number of QREs | Proportion of QREs |
|--|-----------------------|---------------------------|
| Pharmacist | 73,739 | 75.17% |
| Pharmacy Technician/Assistant | 10,094 | 10.29% |
| Pharmacy Student | 730 | 0.74% |
| Patient | 9,728 | 9.92% |
| Physician | 502 | 0.51% |
| Nurse | 1,432 | 1.46% |
| Patient's Family Member/Relative | 1,283 | 1.31% |
| Paramedic | 2 | 0.00% |
| Dentist | 6 | 0.01% |
| CCAC Home Care Coordinator | 24 | 0.02% |
| Other | 182 | 0.19% |
| Social Worker | 2 | 0.00% |
| Patient's Friend/Visitor | 28 | 0.03% |
| Patient's Caregiver/Home Aid/Assistant | 327 | 0.33% |
| Veterinarian | 11 | 0.01% |
| Respiratory Therapist | 1 | 0.00% |
| Medical Student | 4 | 0.00% |
| Nursing Student | 1 | 0.00% |
| Occupational Therapist | 1 | 0.00% |
| Total | 98,097 | 100.00% |

Table 4. Number of QREs by discoverer.

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| Medication | ATC Classification | Number of QREs |
|--|--------------------|-----------------|
| Levothyroxine sodium | H03AA01 | 2,433 (2.34%) |
| Amoxicillin | J01CA04 | 2,361 (2.27%) |
| Rosuvastatin | C10AA07 | 1,905 (1.84%) |
| Lorazepam | N05BA06 | 1,840 (1.77%) |
| Hydromorphone | N02AA03 | 1,826 (1.76%) |
| Metoprolol | C07AB02 | 1,786 (1.72%) |
| Salbutamol | R03AC02 | 1,745 (1.68%) |
| Metformin | A10BA02 | 1,568 (1.51%) |
| Rabeprazole | A02BC04 | 1,459 (1.41%) |
| Zopiclone | N05CF01 | 1,374 (1.32%) |
| Atorvastatin | C10AA05 | 1,290 (1.24%) |
| Citalopram | N06AB04 | 1,261 (1.21%) |
| Prednisone | H02AB07 | 1,254 (1.21%) |
| Naproxen | M01AE02 | 1,236 (1.19%) |
| Clonazepam | N03AE01 | 1,175 (1.13%) |
| Codeine, combinations excl. Psycholeptics | N02AA59 | 1,163 (1.12%) |
| Hydrochlorothiazide | C03AA03 | 1,158 (1.12%) |
| Venlafaxine | N06AX16 | 1,143 (1.10%) |
| Cefalexin | J01DB01 | 1,127 (1.09%) |
| Pantoprazole | A02BC02 | 1,044 (1.01%) |
| Total | - | 103,812* |

*Total of all reported medications in QREs (excluding free-form entry of medication name)

Table 5. Top 20 medications with respect to the number of reported QREs.

* The reporter can input more than one medication per QRE; hence the total number of QREs in this table is greater than that shown in Table 1.

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Medication | ATC Classification | Number of Harm QREs |
|-----------------------------------|---------------------------|----------------------------|
| Levothyroxine sodium | H03AA01 | 46 (4.32%) |
| Citalopram | N06AB04 | 27 (2.54%) |
| Hydromorphone | N02AA03 | 25 (2.35%) |
| Warfarin | B01AA03 | 22 (2.07%) |
| Methadone | N07BC02 | 19 (1.79%) |
| Rosuvastatin | C10AA07 | 18 (1.69%) |
| Morphine | N02AA01 | 16 (1.50%) |
| Furosemide | C03CA01 | 15 (1.41%) |
| Atenolol | C07AB03 | 14 (1.32%) |
| Ramipril | C09AA05 | 14 (1.32%) |
| Venlafaxine | N06AX16 | 14 (1.32%) |
| Amoxicillin | J01CA04 | 14 (1.32%) |
| Gliclazide | A10BB09 | 13 (1.22%) |
| Sulfamethoxazole and trimethoprim | J01EE01 | 13 (1.22%) |
| Naproxen | M01AE02 | 13 (1.22%) |
| Prednisone | H02AB07 | 13 (1.22%) |
| Metoprolol | C07AB02 | 13 (1.22%) |
| Amlodipine | C08CA01 | 12 (1.13%) |
| Metformin | A10BA02 | 12 (1.13%) |
| Total | - | 1,064* |

Table 6. Top 20 medications by number of QREs with harm.

* Total of all reported medications in QREs with harm (excluding free-form entry of medication name)

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Medication | ATC Classification | Number of QREs with Harm | Number of QREs | Proportion of QREs with Harm |
|-----------------------------------|--------------------|--------------------------|------------------|------------------------------|
| Methadone | N07BC02 | 19 (1.79%) | 184 (0.18%) | 10.33% |
| Risperidone | N05AX08 | 11 (1.03%) | 313 (0.30%) | 3.51% |
| Warfarin | B01AA03 | 22 (2.07%) | 746 (0.72%) | 2.95% |
| Morphine | N02AA01 | 16 (1.50%) | 568 (0.55%) | 2.82% |
| Atenolol | C07AB03 | 14 (1.32%) | 544 (0.52%) | 2.57% |
| Citalopram | N06AB04 | 27 (2.54%) | 1,261 (1.21%) | 2.14% |
| Norgestimate and estrogen | G03AB11 | 10 (0.94%) | 528 (0.51%) | 1.89% |
| Levothyroxine sodium | H03AA01 | 46 (4.32%) | 2,433 (2.34%) | 1.89% |
| Gliclazide | A10BB09 | 13 (1.22%) | 694 (0.67%) | 1.87% |
| Ramipril | C09AA05 | 14 (1.32%) | 778 (0.75%) | 1.80% |
| Sulfamethoxazole and trimethoprim | J01EE01 | 13 (1.22%) | 808 (0.78%) | 1.61% |
| Furosemide | C03CA01 | 15 (1.41%) | 1,024 (0.99%) | 1.46% |
| Hydromorphone | N02AA03 | 25 (2.35%) | 1,826 (1.76%) | 1.37% |
| Venlafaxine | N06AX16 | 14 (1.32%) | 1,143 (1.10%) | 1.22% |
| Amlodipine | C08CA01 | 12 (1.13%) | 988 (0.95%) | 1.21% |
| Sertraline | N06AB06 | 10 (0.94%) | 845 (0.81%) | 1.18% |
| Naproxen | M01AE02 | 13 (1.22%) | 1,236 (1.19%) | 1.05% |
| Prednisone | H02AB07 | 13 (1.22%) | 1,254 (1.21%) | 1.04% |
| Pantoprazole | A02BC02 | 10 (0.94%) | 1,044 (1.01%) | 0.96% |
| Rosuvastatin | C10AA07 | 18 (1.69%) | 1,905 (1.84%) | 0.94% |
| Total | - | 1,064* | 103,812** | - |

Table 7. Top 20 medications by proportion of QREs with harm (minimum of 10 QREs reported with harm).

*Total of all reported medications in QREs with harm (excluding free-form entry of medication name)

**Total of all reported medications in QREs (excluding free-form entry of medication name)

** The reporter can input more than one medication per QRE; hence the total number of QREs in this table is greater than that shown in Table 1.

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Supplementary File

| Pharmacists | | |
|---------------------------------------|-----------------------|---|
| Stage | Number of QREs | Proportion of QREs Discovered by Pharmacists |
| Prescribing | 7,975 (9.04%) | 74.83 |
| Rx Order Entry | 56,049 (63.54%) | 80.24 |
| Prescription Preparation / Dispensing | 22,630 (25.66%) | 64.92 |
| Administration | 868 (0.98%) | 40.06 |
| Monitoring / Follow-up | 354 (0.40%) | 50.28 |
| Not Applicable | 330 (0.37%) | 44.41 |
| Total | 88,206 (100%) | - |

| Pharmacy Technicians/Assistants | | |
|--|-----------------------|---|
| Stage | Number of QREs | Proportion of QREs Discovered by Pharmacy Technicians/Assistants |
| Prescribing | 1,263 (10.81%) | 11.85 |
| Rx Order Entry | 7,264 (62.19%) | 10.40 |
| Prescription Preparation / Dispensing | 2,818 (24.12%) | 8.08 |
| Administration | 183 (1.57%) | 8.44 |
| Monitoring / Follow-up | 56 (0.48%) | 7.95 |
| Not Applicable | 97 (0.83%) | 13.06 |
| Total | 11,681 (100%) | - |

| Patients | | |
|---------------------------------------|---------------------------|--|
| Stage | Number of QREs (%) | Proportion of QREs Discovered by Patients |
| Prescribing | 946 (7.31%) | 8.88 |
| Rx Order Entry | 4,098 (31.66%) | 5.87 |
| Prescription Preparation / Dispensing | 6,722 (51.94%) | 19.28 |
| Administration | 754 (5.83%) | 34.79 |
| Monitoring / Follow-up | 201 (1.55%) | 28.55 |
| Not Applicable | 221 (1.71%) | 29.74 |
| Total | 12942 (100%) | 10.88 |

Supplemental 1. Number of QREs and proportion of QREs discovered by patients, pharmacy technicians/assistants, and pharmacists with respect to medication system stages.

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Pharmacists | | |
|---|-----------------------|---|
| Type | Number of QREs | Proportion of QREs Discovered by Pharmacists |
| Incorrect dose/frequency | 20,268 (27.49%) | 80.78% |
| Incorrect quantity | 14,407 (19.54%) | 73.43% |
| Incorrect drug | 10,117 (13.72%) | 72.52% |
| Incorrect strength/concentration | 7,824 (10.61%) | 74.46% |
| Incorrect prescriber | 6,990 (9.48%) | 82.68% |
| Incorrect duration of treatment | 4,066 (5.51%) | 80.55% |
| Incorrect patient | 3,178 (4.31%) | 55.90% |
| Incorrect dosage form/formulation (include not splitting tablets as per patient's request) | 2,397 (3.25%) | 73.06% |
| Omitted medication/D=dose | 1,159 (1.57%) | 60.40% |
| Incorrect route of administration | 881 (1.19%) | 78.59% |
| Incorrect third-party billing | 566 (0.77%) | 70.49% |
| Incorrect storage | 537 (0.73%) | 62.66% |
| Drug Therapy Problem - Drug-drug/OTC/Natural Health Product interaction | 456 (0.62%) | 90.12% |
| Drug Therapy Problem - Contraindication | 313 (0.42%) | 87.92% |
| Drug Therapy Problem - Documented allergy | 305 (0.41%) | 68.23% |
| Drug Therapy Problem - Adverse Drug Reaction | 117 (0.16%) | 62.23% |
| Expired medication | 97 (0.13%) | 50.79% |
| Drug Therapy Problem - Drug-disease interaction | 55 (0.07%) | 87.30% |
| Drug Therapy Problem - Drug-food interaction | 6 (0.01%) | 54.55% |
| Total | 73,739 (100%) | - |

| Pharmacy Technicians/Assistants | | |
|--|-----------------------|---|
| Type | Number of QREs | Proportion of QREs Discovered by Pharmacy Technicians/Assistants |
| Incorrect dose/frequency | 2,472 (24.49%) | 9.85% |
| Incorrect quantity | 1,903 (18.85%) | 9.70% |
| Incorrect drug | 1,181 (11.70%) | 8.47% |
| Incorrect prescriber | 1,107 (10.97%) | 13.09% |
| Incorrect strength/concentration | 982 (9.73%) | 9.35% |

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
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| | | |
|--|----------------------|--------|
| Incorrect patient | 974 (9.65%) | 17.13% |
| Incorrect duration of treatment | 520 (5.15%) | 10.30% |
| Incorrect dosage form/formulation (include not splitting tablets as per patient's request) | 264 (2.62%) | 8.05% |
| Incorrect storage | 164 (1.62%) | 19.14% |
| Incorrect route of administration | 155 (1.54%) | 13.83% |
| Omitted medication/dose | 127 (1.26%) | 6.62% |
| Incorrect third-party billing | 117 (1.16%) | 14.57% |
| Drug Therapy Problem - Documented allergy | 70 (0.69%) | 15.66% |
| Expired medication | 25 (0.25%) | 13.09% |
| Drug Therapy Problem - Contraindication | 15 (0.15%) | 4.21% |
| Drug Therapy Problem - Drug- drug/OTC/Natural Health Product interaction | 12 (0.12%) | 2.37% |
| Drug Therapy Problem - Adverse Drug Reaction | 5 (0.05%) | 2.66% |
| Drug Therapy Problem - Drug- disease interaction | 1 (0.05%) | 1.59% |
| Total | 10,094 (100%) | - |

| Patients | | |
|--|-----------------------|--|
| Type | Number of QREs | Proportion of QREs Discovered by Patients |
| Incorrect quantity | 2,621 (26.94%) | 13.36% |
| Incorrect drug | 1,950 (20.05%) | 13.98% |
| Incorrect dose/frequency | 1,214 (12.48%) | 4.84% |
| Incorrect strength/concentration | 1,185 (12.18%) | 11.28% |
| Incorrect patient | 1,118 (11.49%) | 19.67% |
| Incorrect dosage form/formulation (include not splitting tablets as per patient's request) | 444 (4.56%) | 13.53% |
| Omitted medication/dose | 295 (3.03%) | 15.37% |
| Incorrect duration of treatment | 247 (2.54%) | 4.89% |
| Incorrect prescriber | 245 (2.52%) | 2.90% |
| Incorrect storage | 98 (1.01%) | 11.44% |
| Incorrect third-party billing | 91 (0.94%) | 11.33% |
| Incorrect route of administration | 46 (0.47%) | 4.10% |
| Drug Therapy Problem - Documented allergy | 46 (0.47%) | 10.29% |
| Expired medication | 46 (0.47%) | 24.08% |

Quality Related Events Reported by Community Pharmacies in Nova Scotia:
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| | | |
|---|---------------------|--------|
| Drug Therapy Problem - Adverse Drug Reaction | 43 (0.44%) | 22.87% |
| Drug Therapy Problem - Drug-drug/OTC/Natural Health Product interaction | 21 (0.22%) | 4.15% |
| Drug Therapy Problem - Contraindication | 14 (0.14%) | 3.93% |
| Drug Therapy Problem - Drug-disease interaction | 2 (0.02%) | 3.17% |
| Drug Therapy Problem - Drug-food interaction | 2 (0.02%) | 18.18% |
| Total | 9,728 (100%) | - |

Supplemental 2. Number of QREs and proportion of QREs discovered by patients, pharmacy technicians/assistants, and pharmacists with respect to the type of QRE.

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Quality Related Events Reported by Community Pharmacies in Nova Scotia:
A 7-year Descriptive Analysis

| Medication Use Stage | Medication | ATC Classification | Number of QREs | Proportion of QREs |
|------------------------------------|----------------------------------|--------------------|----------------|--------------------|
| Prescribing | Moxifloxacin | J01MA14 | 41 | 41.84% |
| | Amiodarone | C01BD01 | 15 | 31.25% |
| | Cilazapril | C09AA08 | 10 | 31.25% |
| | Atenolol and other diuretics | C07CB03 | 11 | 30.56% |
| | Quinapril | C09AA06 | 14 | 29.17% |
| Rx Order Entry | Dexamethasone and antiinfectives | S03CA01 | 19 | 100.00% |
| | Glucagon | H04AA01 | 12 | 100.00% |
| | Adapalene | D10AD03 | 24 | 96.00% |
| | Prazosin | C02CA01 | 22 | 95.65% |
| | Loteprednol | S01BA14 | 42 | 95.45% |
| Prescription Processing/Dispensing | Clozapine | N05AH02 | 17 | 94.44% |
| | Chlorpromazine | N05AA01 | 11 | 78.57% |
| | Flupentixol | N05AF01 | 16 | 72.73% |
| | Botulinum toxin | M03AX01 | 25 | 65.79% |
| | Haloperidol | N05AD01 | 45 | 65.22% |
| Administration | Methadone | N07BC02 | 17 | 9.24% |
| | Combinations | J07BC20 | 18 | 8.49% |
| | Digoxin | C01AA05 | 10 | 8.33% |
| | Lisinopril | C09AA03 | 11 | 6.01% |
| | Clopidogrel | B01AC04 | 12 | 5.04% |
| Monitoring/Follow-up | Warfarin | B01AA03 | 18 | 2.41% |
| | Paroxetine | N06AB05 | 11 | 2.01% |
| | Methylphenidate | N06BA04 | 12 | 1.82% |
| | Gliclazide | A10BB09 | 10 | 1.44% |
| | Levothyroxine sodium | H03AA01 | 32 | 1.32% |
| Not Applicable | Latanoprost | S01EE01 | 12 | 5.15% |
| | Acetylsalicylic acid | B01AC06 | 10 | 3.45% |
| | Insulin (human) | A10AC01 | 10 | 2.29% |
| | Atenolol | C07AB03 | 10 | 1.84% |
| | Methylphenidate | N06BA04 | 12 | 1.82% |

Supplemental 3. Top 5 medications with highest proportion of QREs reported in each medication system stage.

*Minimum of 10 reported QRE in a stage for each medication.

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| Type of QRE | Medication | ATC Classification | Number of QREs | Proportion of QREs |
|---|-----------------------------------|--------------------|----------------|--------------------|
| Incorrect drug | Amiloride | C03DB01 | 24 | 72.73% |
| | Enalapril and diuretics | C09BA02 | 10 | 71.43% |
| | Gentamicin | S02AA14 | 14 | 70.00% |
| Incorrect dose/frequency | Itraconazole | J02AC02 | 16 | 61.54% |
| | Diphenoxylate | A07DA01 | 16 | 55.17% |
| | Fluorouracil | L01BC02 | 12 | 54.55% |
| Incorrect strength/concentration | Homatropine | S01FA05 | 11 | 39.29% |
| | Tretinoin | D10AD01 | 44 | 36.97% |
| | Botulinum toxin | M03AX01 | 14 | 36.84% |
| Incorrect dosage form/formulation | Etanercept | L04AB01 | 22 | 37.29% |
| | Nystatin, combinations | G01AA51 | 10 | 31.25% |
| | Adalimumab | L04AB04 | 37 | 28.91% |
| Incorrect durations of treatment | Tetracycline | J01AA07 | 14 | 16.87% |
| | Medroxyprogesterone | G03AC06 | 16 | 16.00% |
| | Chlorhexidine | A01AB03 | 16 | 14.16% |
| Incorrect route of administration | Flumetasone and antiinfectives | S02CA02 | 12 | 20.34% |
| | Dexamethasone and antiinfectives | S02CA06 | 61 | 17.38% |
| | Misoprostol | A02BB01 | 10 | 16.67% |
| Incorrect patient | Combinations | D01AC20 | 24 | 18.46% |
| | Epinephrine | C01CA24 | 25 | 14.79% |
| | Mupirocin | D06AX09 | 14 | 13.86% |
| Incorrect storage | Fludrocortisone | H02AA02 | 16 | 37.21% |
| | Latanoprost | S01EE01 | 33 | 14.16% |
| | Combinations | J07BC20 | 14 | 6.60% |
| Drug Therapy Problem - Contraindication | Clarithromycin | J01FA09 | 41 | 4.15% |
| | Ciprofloxacin | J01MA02 | 12 | 1.44% |
| | Citalopram | N06AB04 | 15 | 1.19% |
| Drug Therapy Problem - Documented allergy | Sulfamethoxazole and trimethoprim | J01EE01 | 52 | 6.44% |
| | Amoxicillin and enzyme inhibitor | J01CR02 | 29 | 5.14% |

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| | | | | |
|---|--|---------|-----|--------|
| | Nitrofurantoin | J01XE01 | 22 | 4.84% |
| Drug Therapy Problem - Drug-drug/OTC/Natural Health Product interaction | Clarithromycin | J01FA09 | 119 | 12.03% |
| | Sulfamethoxazole and trimethoprim | J01EE01 | 31 | 3.84% |
| | Azithromycin | J01FA10 | 27 | 3.78% |
| Incorrect quantity | Liraglutide | A10BX07 | 59 | 49.17% |
| | Phenobarbital | N03AA02 | 14 | 43.75% |
| | Buprenorphine, combinations | N07BC51 | 19 | 43.18% |
| Omitted medication/dose | Acetylsalicylic acid | B01AC06 | 57 | 19.66% |
| | Acetaminophen (paracetamol) | N02BE01 | 28 | 12.28% |
| | Clopidogrel | B01AC04 | 20 | 8.40% |
| Drug Therapy Problem - Adverse Drug Reaction | Clarithromycin | J01FA09 | 24 | 2.43% |
| | Quetiapine | N05AH04 | 12 | 1.69% |
| Incorrect third-party billing | Celecoxib | M01AH01 | 10 | 2.89% |
| | Esomeprazole | A02BC05 | 15 | 2.68% |
| | Omeprazole | A02BC01 | 19 | 2.49% |
| Incorrect prescriber | Finasteride | G04CB01 | 17 | 17.71% |
| | Vaginal ring with progestogen and estrogen | G02BB01 | 15 | 16.85% |
| | Ezetimibe | C10AX09 | 11 | 16.42% |

Supplemental 4. Top 3 medications with highest proportion of QREs reported for each type of QRE. Expired medication, Drug Therapy Problem - Drug-food interaction, and Drug Therapy Problem - Drug-disease interaction were not included due to insufficient QREs.

*Minimum of 10 reported QREs in a type for each medication.

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