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Opioid losses in terms of dosage and cost: a retrospective analysis of Health Canada data

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Abstract

Background: Despite increasing opioid-related mortality, there has been no analysis of opioids lost from healthcare facilities (i.e., community pharmacies, companies, and hospitals). We analyzed opioid losses reported to Health Canada (HC) to identify the amount missing, the distribution of losses between types of facilities, and the direct costs of the lost opioids. Additionally, we compared losses as measured in milligrams, 'dosage units', or 'incidents', to identify how they may lead to different trends and interpretations.

Methods: We calculated milligrams of drug lost from 5.75 years of HC data, restricting our analysis to codeine, fentanyl, hydromorphone, morphine and oxycodone. We converted the lost milligrams into oral morphine equivalents, daily defined doses, approximate wholesale value, and approximate street value.

Results: Over 112 kilograms of opioids were lost, an estimated \$8.7 million in wholesale cost or \$136 million in street value. Unexplained losses were common, but each facility type had other dominant loss categories: armed robberies and break and enter (community pharmacies), losses in transit (companies), and pilferage (hospitals). Loss trends over 5.75 years varied by reporting unit and facility type: community pharmacy losses increased (dosage units, incidents) or remained stable (milligrams); hospital losses increased (milligrams) or showed no

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3 clear trend (dosage units, incidents); companies showed no clear loss trend from
4
5 any reporting metric.
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8 **Interpretation:** Large quantities of opioids are going missing and cost healthcare
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10 facilities millions of dollars. Controlled drug losses should be reported in milligrams
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12 instead of 'dosage units' so that differences in drug strength are accounted for when
13
14 assessing trends.
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17 18 **Introduction**

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20 In recent years, there has been an increasing recognition of drug theft or loss
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22 from hospitals¹⁻⁵ and community pharmacies.^{6,7} Healthcare facilities bear the cost of
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24 medications diverted from their stock. For example, in 2018, hospitals were fined in
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26 excess of \$4 million to address inadequate safeguards.⁸ Drug thefts cost healthcare
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28 facilities in investigations, care for affected patients, and reputation-related
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30 damages.^{9,10} Furthermore, losses from healthcare facilities may have the potential to
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32 increase illegal supply of opioids via trafficking. While data from the US Drug
33
34 Enforcement Agency (DEA) has reported on opioid losses from healthcare
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36 institutions (e.g., community pharmacies, hospitals),^{11,12} we are unaware of any
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38 similar peer-reviewed or government-sponsored analyses based on Health Canada
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40 data.
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46 Health Canada (HC) maintains a database of lost opioids from Canadian
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48 facilities that are mandated to report opioid losses to HC within 10 days.¹³ Several
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50 news outlets have used HC data to report the losses as measured in 'dosage
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52 units'^{14,15} or as measured in 'incidents of loss',¹⁶ both of which have important
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54 limitations that may not be widely understood. Dosage units indiscriminately count
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3 tablets, vials, and packages as if the losses were equivalent. For example, a 'dosage
4 unit' could refer to the loss of 1 tablet or the loss of 1 bottle containing 500 tablets.
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8 'Incidents of loss' refers to the number of line items in the HC data and could be
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10 impacted based on reporting frequency. For example, hospital A may discover an
11
12 opioid that has been lost several times in the last 2 weeks and generate a single
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14 report, whereas hospital B might notice these losses regularly and report after each
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16 occurrence. As a result, hospital B would have more 'incidents of lost opioid' even
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18 though their total losses of the drug might be smaller. Therefore, losses as measured
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20 in 'dosage units' or 'incidents' do not support comparative analyses (e.g., differences
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22 year to year or between institutions).
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27 Reporting opioid losses in 'dosage units' is a phenomenon that extends
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29 beyond Canada. In the US, losses of opioids from healthcare facilities are captured in
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31 the DEA's Drug Theft and Loss database. A 2018 DEA report identifies 97.5 million
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33 dosage units of lost opioids between 2010 to 2017.¹² Given that both Canadian and
34
35 US reports of opioid losses are based on 'dosage units', policy makers have not yet
36
37 had reliable data to accurately assess or compare losses year to year, nor can they
38
39 accurately estimate costs of the lost drug based on dosage units alone.
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43 To rectify this situation, we analyzed HC data to 1) estimate actual milligram
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45 losses for five common opioids, and used this to estimate the approximate
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47 wholesale and street value of lost opioids in Canada, 2) compare losses, and reason
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49 for loss, by facility type, and 3) compare opioid loss trends as measured by
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51 milligrams, dosage units, and incidents of loss to determine whether they suggest
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3 different interpretations, and to select the metric that best represents quantity and
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5 cost of lost opioids.
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8 **Methods**

9 Data Source

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13 HC data on controlled drug losses is currently only accessible on request via
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15 Access to Information (ATI) legislation, a process which has been criticized for lack
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17 of timeliness.¹⁷ In June 2018, CBC News published HC data from an ATI request for
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19 all controlled drug losses between January 1, 2012 to September 30, 2017.^{18,19} This
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21 is the largest release we are aware of and is therefore valuable for assessing trends
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23 in Canadian healthcare sources. Pilot work by the authors suggests that HC data
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25 represents the best source of data on the incidence of Canadian drug losses (see
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27 Appendix).
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32 Inclusion Criteria and Constraints

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35 We limited our analysis to the most commonly dispensed opioids in Canada
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37 based on data from the Canadian Institutes of Health Information²⁰: codeine,
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39 fentanyl, hydromorphone, morphine, and oxycodone. Tramadol is among the 6 most
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41 dispensed opioids in Canada,²⁰ but is not yet classified as a controlled substance,²¹
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43 so no loss reports were captured for this drug.
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47 Data Analysis

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50 HC data states a numeric 'quantity' lost for each line item, but the 'unit code'
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52 (e.g., millilitres, tablets, patches) for each report varies. We used this information to
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54 manually calculate the milligrams lost for every reported drug loss. We then used
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3 the milligrams lost to calculate oral morphine equivalents (OMEQ) and daily defined
4 doses (DDD) (see Appendix for conversion factors).
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8 We deliberately used the lowest estimate of loss for ambiguous reports. For
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10 example, one report lists the loss of 728 ‘packages’ of Hydromorphone HP
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12 50mg/mL. From the dataset, it is unclear whether these containers were 1mL, 5mL,
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14 10mL, or 50 mL (each coming in boxes of various sizes). In this case, the smallest
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16 available package per the drug product monographs found on Health Canada’s Drug
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18 Product Database²² is a box of 10, 1mL vials.
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21 22 [Wholesale and Street Drug Costing](#)

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25 Approximate wholesale costs were calculated from the Ontario Drug Benefit
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27 (ODB) database for the entire dataset because Ontario lost the most OMEQs of all
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29 provinces. If the cost was not available from ODB, other provincial formularies were
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31 searched (see Supplemental file for wholesale pricing information). While street
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33 value fluctuates^{23,24} depending on cycles of supply and demand, geography, and
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35 drug strength, we used a single point-in-time street value based on information
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37 from the Ontario Provincial Police and literature (see Appendix).
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41 42 **Results**

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45 An analysis of all 64,964 loss reports determined that the cumulative loss of
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47 codeine, fentanyl, hydromorphone, morphine and oxycodone in the timeframe of
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49 January 2012 to September 2017 was over 112 kilograms (Table 1). This equates to
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51 approximately \$8.7 million in wholesale costs and \$136 million if all lost drugs were
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53 resold on the street.
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3 <Table 1>
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5 Community pharmacies, companies, and hospitals are responsible for nearly
6 all losses, comprising 76.8%, 17.1% and 6% of lost OMEQs, respectively (Table 2).
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8 As a result, we focused all subsequent analyses on these three facility types.
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12 <Table 2>
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14 The dominant reasons for loss (in milligrams) varies by facility type (Table
15 3). Community pharmacy losses are primarily from armed robberies (31.1%), break
16 and entry (28.1%), unexplained losses (17.6%), and pilferage (15.5%). Company
17 losses are primarily from unexplained losses (55.8%) and losses in transit (30.7%).
18
19 Hospitals are primarily affected by pilferage (57.4%) and unexplained losses
20 (33.4%). More detailed breakdowns of loss trends by province or territory for
21 community pharmacies and hospitals show that British Columbia (BC) has made
22 significant reductions in community pharmacy losses over time, whereas Ontario
23 hospitals report an increasing amount of pilferage losses in recent years (see
24 Appendix sections 5 and 6).
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40 Reporting milligrams of lost opioids shows different trends than when
41 reporting dosage units, or number of 'incidents of loss' (Table 4). Specifically, the
42 incidents of loss and dosage units lost from community pharmacies have steadily
43 increased since 2012, but milligram losses have not. Conversely, hospitals show
44 increased milligram losses in recent years, whereas line items and dosage units do
45 not show the same trend. There is no clear trend discernable from any of these
46 metrics for companies. See Appendix section 7 for a visual depiction of trends.
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6 Interpretation 7

8 We found Canadian facilities lost an annual average of 19.6 kilograms of five
9 common opioids; this equates to an annual value of approximately \$23.7 million in
10 street value. Community pharmacies were the largest contributor to the losses,
11 followed by companies and hospitals. Unexplained losses were a major category of
12 loss in all facility types, but each facility type was also particularly susceptible to
13 certain types of loss: community pharmacies were most susceptible to armed
14 robbery and break and enter, hospitals faced a high rate of pilferage, and companies
15 experienced a high proportion of drug losses in transit. Our analysis also showed
16 that community pharmacy losses remained stable over time as measured by dose
17 (i.e., milligrams), but loss rates appeared to be increasing when measured by dosage
18 units or incidents of loss. Opioid losses from hospitals are increasing when
19 measured in dose, but a clear trend is not visible when measured by dosage units or
20 incidents of loss. Based on this data, we suggest that losses as measured by dosage
21 units or incidents of loss can mischaracterize the severity of the opioid loss; a dose
22 based metric (e.g., milligrams, OMEQs) provides a more accurate means of assessing
23 loss trends over time within and between facility types or provinces.
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46 Our analysis suggests that differences in inspection practices across
47 community pharmacies and hospitals may have contributed to differences in how
48 opioid losses are reported. For example, Health Canada began a community
49 pharmacy inspection program (CPIP) in 2015.²⁵ Our analysis shows a clear upward
50 trend in the number of line items and dosage units of opioid lost after this program
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3 began, but there has been no substantial increase in milligrams lost. It appears the
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5 CPIP may have triggered a higher frequency of reporting from community
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7 pharmacies, but each report now describes smaller losses on average. In contrast,
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9 starting in 2016, Ontario hospitals reported a dramatic increase in milligrams lost to
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11 pilferage (Appendix section 6). One hypothesis is that this is the result of the Ontario
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13 College of Pharmacists' (OCP's) new mandate to inspect and accredit all hospital
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15 pharmacies for the first time, which began in 2016.²⁶ Perhaps OCP inspections led
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17 hospital pharmacies to enhance their record-keeping and subsequently led to a
18
19 greater detection of lost or stolen opioids. Although the reasons for this change are
20
21 unclear, we note that OCP inspects every hospital pharmacy, while CPIP only
22
23 conducts inspections on a random subset of community pharmacies. Perhaps if a
24
25 greater number of community pharmacies were inspected, there would be a
26
27 stronger regulatory pressure to ensure strong controlled drug management
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29 processes and by extension, community pharmacies would detect and report a
30
31 higher number of losses in response to the CPIP. Given the potential impact of
32
33 inspection programs on the detection and reporting of opioid losses, further
34
35 research is required to investigate whether expanded inspection programs for
36
37 community pharmacies, companies, and hospitals may be helpful in all Canadian
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39 provinces and territories.
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48 Fortunately, our analysis also suggests productive next steps for some areas.
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50 For example, British Columbia demonstrates a remarkable reduction in community
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52 pharmacy losses from armed robberies and break and enter incidents (see
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54 Appendix Table A7), possibly due to the implementation of time-delay safes.^{27,28}
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3 Sharing of best practices between provinces may therefore help reduce opioid
4 losses in the future. Similarly, if other provinces were to adopt a hospital
5 accreditation process like the OCP, it is possible that a similar increase in the
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Sharing of best practices between provinces may therefore help reduce opioid losses in the future. Similarly, if other provinces were to adopt a hospital accreditation process like the OCP, it is possible that a similar increase in the detection or reporting of opioid losses from other provinces' hospitals could occur.

Our data also suggests areas where more attention is needed. For example, community pharmacies, companies and hospitals all cite 'unexplained losses' as a major category of loss. Across these facility types, approximately 24.4 kilograms of opioids were lost without an explanation. Canadian facilities either lack sufficient guidance on how to track and account for controlled drugs, or are unable to implement known best practices; further work is urgently needed to amend this issue. While a recent scoping review outlines the literature on this topic for hospital settings,⁵ we are not aware of literature for community pharmacies or companies. Notably companies lost 17.1% of the OMEQs in our dataset, and 'losses in transit' are responsible for 30% of company losses. Further oversight of commercial entities may be an important priority for policy-makers and regulators moving forward.

We suspect that the true quantities of loss are even higher than what our analysis suggests. This is because previous literature highlights challenges with respect to detecting or reporting losses for both controlled and non-controlled drugs (e.g., propofol). For example, hospitals have previously been fined for insufficient record-keeping and failing to report drug losses.²⁹⁻³¹ One endoscopy clinic found over \$10,000 of propofol was unaccounted for in only a 4 week period.³² These examples suggest that poor traceability obscures detection and reporting of drug losses. In addition, there are other controlled substances that are

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3 reported to HC that we did not analyze, but may be prone to misuse and diversion
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5 (e.g., benzodiazepines). Inclusion of non-opioids in future studies would increase
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7 the total doses lost, and the subsequent costs of lost drug.
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10 Moving forward, we suggest that Health Canada (HC), like the DEA,¹² publish
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12 a freely accessible report describing controlled substance losses, preferably on an
13
14 annual basis. This report would facilitate a more accurate and regular assessment of
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16 controlled substance losses. However, we recommend the report describes dose
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18 (i.e., milligrams, OMEQs) losses by province and territory for use by policy makers
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20 and the public. As described previously, our findings show that milligram losses
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22 provide a more accurate representation of opioid loss trends than either dosage
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24 units or incidents of loss. Therefore, the HC loss and reporting form should capture
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26 the number of milligrams lost per drug, and the dosage format of the loss. The
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28 current HC form is ambiguous as the reported quantity could refer to the dosage
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30 form (e.g., patch, ampoule), or the unit (e.g., micrograms, millilitres). We believe
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32 such an annual report of dose losses will promote discussion and sharing of best
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34 practices, possibly accelerating uptake of safeguards across the country.
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41 Limitations

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44 Our analysis has several limitations. First, HC data may be subject to
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46 reporting bias. Jurisdictions with high reported losses may not be undergoing a
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48 higher true loss rate, but may only be more diligent at reporting the losses they do
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50 experience. Second, not all drugs reported lost are due to diversion, and diverted
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52 drugs may be used personally rather than resold on the street market. Our analysis
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54 is not intended to estimate actual revenue from street sales of lost drug, but to
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3 contextualize the potential losses and highlight the differences between wholesale
4 costs and street value. Third, our estimates of wholesale costs and street value are
5 simplified, as we applied single point-in-time estimates from select provincial
6 formularies or police services to the whole dataset.
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12 Conclusion

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16 The drug losses we have conservatively estimated are large and suggest the
17 need for further research given the other indirect costs of drug diversion. For
18 example, drugs diverted from the healthcare system can be resold, channelling
19 taxpayer dollars directly into the hands of drug traffickers, while increasing the
20 supply and harms of illicit opioids to surrounding communities and burdening
21 patients and prescribers who require opioids for legitimate medical use. Ensuring
22 that reports of controlled drug loss unambiguously capture the dose (e.g.,
23 milligrams) of the loss, as well as transparent and standardized methods of making
24 this data available, will further the understanding and causes of opioid losses from
25 Canadian facilities.
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47 to Tara Carman and CBC News for publishing the Health Canada dataset that was
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3 the basis for this article.
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Table 1

Analysis of opioid losses reported to Health Canada (Jan 2012 to Sept 2017)						
	Route	Milligrams lost (rounded)	Oral Morphine Milligram Equivalent (OMEQ)	Daily Defined Dose (DDD)	Estimated Wholesale Value	Estimated Street Value
Codeine	Oral	47,072,328	7,060,849	196,135	\$1,313,140	\$52,956,369
	Injectable	3,720	930	58	\$514	\$4,185
	Indeterminate	228,717	34,308	953	\$6,369	\$257,306
Fentanyl	Oral	66,828	8,687,588	111,379	\$3,212,163	\$26,731
	Injectable	10,642	1,064,527	66,513	\$302,036	\$4,257
	Patch	184,032	18,403,190	153,360	\$199,936	\$5,111,997
	Indeterminate	2,691	349,819	4,486	\$129,346	\$1,077
Hydro-morphone	Oral	12,157,649	60,788,244	607,882	\$1,446,912	\$18,236,474
	Injectable	544,387	9,526,775	136,097	\$199,890	\$816,581
	Rectal	468	2808	117	\$593	\$702
	Indeterminate	19,202	96,008	960	\$2,288	\$28,803
Morphine	Oral	15,154,599	15,154,599	151,546	\$353,846	\$12,578,317
	Injectable	325,571	976,713	10,852	\$205,417	\$270,224
	Rectal	73,045	87,654	2,435	\$11,318	\$60,627
	Indeterminate	134,692	134,692	1,347	\$3,151	\$111,794
Oxycodone	Oral	36,537,298	54,805,947	487,164	\$1,312,734	\$45,671,623
	Rectal	9,580	17,244	319	\$3,229	\$11,975
Total		112,525,448	177,191,636	1,931,603	\$8,702,882	\$136,149,042

Source: Authors' analysis of data for Jan. 2012 to Sept. 2017 from reports of controlled substances loss or theft to Health Canada as published by CBC News in June 2018.

Notes: Oral refers to tablets, capsules, sublingual and oral solutions (e.g., syrups). Injectable includes intravenous and subcutaneous formats. Fentanyl is typically dosed in micrograms, but for consistency with other drugs we report in milligrams. Indeterminate refers to line items in the dataset where the route or format of the drug was ambiguous. See Appendix for details on how OMEQ, DDD, wholesale and street value were calculated.

Table 2

Oral Morphine Equivalents (Milligrams) Lost by Facility Type (Jan 2012 to Sept 2017)						
	Codeine	Fentanyl	Hydromorphone	Morphine	Oxycodone	Total (% of column total)
Community Pharmacy	6,222,350	16,983,007	46,535,105	14,255,156	52,112,872	136,108,490 (76.8)
Companies	815,047	10,041,648	15,730,665	1,432,737	2,298,522	30,318,620 (17.1)
Hospital	42,530	1,468,245	8,143,350	647,885	395,222	10,697,232 (6.0)
Long term care facility	11,733	1,999	3,170	930	15,473	33,304 (0)
Nurse station*	3,653	2,000	420	8,580	578	15,230 (0)
Canadian Forces Base	774	7,250	1,100	1,200	525	10,849 (0)
Ambulatory Services%	-	1,975	25	7,170	-	9,170 (0)
Total	7096.1	28,506.1	70,413.8	16,353.7	54,823.2	177,192.9

Source: Authors' analysis of data for Jan. 2012 to Sept. 2017 from reports of controlled substances loss or theft to Health Canada as published by CBC News in June 2018.

* Nurse stations are found in small rural and isolated communities where access to health care is otherwise limited; they are staffed by registered nurses or nurse practitioners typically providing primary care, and have limited on-site availability of a physician partner.

% Ambulatory Services are typically clinics affiliated with an institution/hospital and provide procedures or services on an outpatient basis or are stand-alone clinics providing similar services.

Table 3**Milligrams Lost by Loss Description and Facility Type (Jan 2012 to Sept 2017)**

	Community Pharmacy	% of column total	Companies	% of column total	Hospitals	% of column total
Armed Robbery	30,935,204	31.1	10,948	0.1	16	0.0
Break and Entry	27,978,876	28.1	147,467	1.3	64,105	4.5
Breakage – In Transit	275,596	0.3	58,570	0.5	345	0.0
Breakage – On Site	5,898	0.0	-	0.0	595	0.0
Grab Theft	1,381,305	1.4	790,586	6.9	34,337	2.4
Impersonation	74,438	0.1	-	0.0	-	0.0
Loss in Transit	159,177	0.2	3,538,645	30.7	15,186	1.1
Loss Unexplained	17,481,035	17.6	6,429,180	55.8	475,411	33.4
Manufacturer's Defects (Ampoules)	20	0.0	100	0.0	15	0.0
Manufacturer's Shortage (Sealed Bottles)	28,642	0.0	34,543	0.3	1,066	0.1
Other	5,659,021	5.7	248,294	2.2	14,289	1.0
Over shipment (picking error)	433	0.0	2,800	0.0	-	0.0
Pilferage	15,459,032	15.5	260,175	2.3	817,574	57.4
Spillage	6,062	0.0	-	0.0	242	0.0
Under shipment	4,050	0.0	389	0.0	-	0.0

Source: Authors' analysis of data for Jan. 2012 to Sept. 2017 from reports of controlled substances loss or theft to Health Canada as published by CBC News in June 2018.

Table 4

Comparison of Incidents of Loss, Dosage Units Lost, and Milligrams Lost by Facility Type (Jan 2012 to Sept 2017)

	2012	2013	2014	2015	2016	2017 (up to Sept. only)	R ² Value
Community Pharmacies							
Incidents of Loss	4587	3948	5879	7768	13743	22517	0.809
Dosage units lost	736,886	596,185	947,010	978,053	1,152,808	1,425,626	0.870
Milligrams lost	17,090,993	10,904,398	16,870,555	18,286,108	17,425,604	18,871,131	0.308
Companies							
Incidents of Loss	338	412	524	568	407	252	0.034
Dosage units lost	90,562	136,032	173,273	111,022	53,296	24,053	0.399
Milligrams lost	1,355,671	1,974,753	2,144,427	1,585,595	3,680,476	780,775	0.008
Hospitals							
Incidents of Loss	650	673	649	625	707	576	0.124
Dosage units lost	29,692	17,820	47,679	18,379	45,929	16441	0.002
Milligrams lost	128,593	155,630	88,264	213,066	318,768	518,859	0.738

Source: Authors' analysis of data for Jan. 2012 to Sept. 2017 from reports of controlled substances loss or theft to Health Canada as published by CBC News in June 2018.

Appendix for “Opioid losses in terms of dosage and cost: a retrospective analysis of Health Canada data”
Authors: Fan, Tscheng, Hamilton, Trbovich

Appendix

The appendix is composed of eight sections.

1. **Database scan:** This section describes the methods and results of a pilot study the authors conducted to determine what databases containing controlled drug loss reports were available in Canada. Health Canada’s controlled drug loss database proved to have the largest volume of data for analysis.
2. **Milligram calculation procedure:** This section outlines the steps the authors undertook to extract the milligram losses from the Health Canada dataset, including assumptions we made for rows that were ambiguous in nature.
3. **Conversion factors:** This section outlines the conversion factors used to convert the milligrams lost into Oral Morphine Equivalents (OMEQs) and Daily Defined Doses (DDDs). It includes the references and reasoning we used to select the conversion factors. ****These conversion factors should not be used for clinical purposes****
4. **Street pricing estimates:** This section describes our strategy for estimating street pricing.
5. **Opioid milligram losses for community pharmacies:** This section provides an extended table showing the milligram losses for community pharmacies from each province and territory. The only loss types shown are armed robbery, break and entry, unexplained losses and pilferage, as these are the major categories of loss for pharmacies (see Table 3 in the main article).
6. **Opioid milligram losses for hospitals:** This section provides an extended table showing the milligram losses for hospitals from each province and territory. The only loss types shown are unexplained losses and pilferage, as these are the major categories of loss for hospitals (see Table 3 in the main article).
7. **Line graphs depicting loss trends for community pharmacies, companies, and hospitals:** Loss trends differ when measured in milligrams, dosage units, and incidents of loss (e.g., line items in Health Canada data).
8. **Reference list for Appendix**

Appendix for “Opioid losses in terms of dosage and cost: a retrospective analysis of Health Canada data”
Authors: Fan, Tscheng, Hamilton, Trbovich

1. Database Scan

Scope

As part of a pilot project to understand how hospitals were affected by diversion, data were requested from select national databases and from known Ontario databases. The detailed scan was undertaken in Ontario to assess the feasibility of a comprehensive review of all Canadian databases. Ontario is the most populous province in Canada, and its databases were deemed the most likely to return data if hospital diversion is a rarely reported phenomenon.

Database identification

The database scan was approved by the North York General Hospital Research Ethics Board (#17-0024). Members of the research team associated with the Institute for Safe Medication Practices Canada (ISMP Canada), through relationships with other health care data-holding organizations, identified a series of databases that might hold incident records or information related to diversion of controlled drugs. Clinical members of the research team identified regulatory college databases related to clinical practice in the various health disciplines expected to have contact with controlled drugs. During discussion with database custodians, researchers asked about any additional or alternative databases that might hold relevant data. For instance, one custodian of a regulatory database suggested review of an insurance database.

Database search methodology

Requests for data were made to organizations hosting potentially relevant diversion incidents between July 6, 2017, and November 2, 2017. Database requests were administered via 4 mechanisms (Table A1).

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Table A1

Mechanisms of database requests

Mechanism	Description
Freedom of information or access to information requests	Written requests for data held by provincial and federal public sector agencies (e.g., law enforcement agencies)
Direct queries	Searches performed by the research team, whereby XXX had direct interface with the database holdings
Manual review of public data	Individual manual review of publicly available disciplinary records (e.g., disciplinary reports from a regulatory body’s website) by members of the research team
Direct inquiries	Requests to database administrators for specific information from the databases of interest, whereby the research team did not have direct access to the databases

Source: Authors’ description of methodological approach to database scan.

These search strategies were individualized to reflect variations in data storage constraints, taxonomy and classification systems among the databases. In cases of direct inquiries, database custodians were given the theme of the research and the general request (e.g., “Reports [e.g., investigative, disciplinary, incident, analysis, incident, loss or other] of controlled-drug diversion or theft by health care workers”). For non–health care organizations (e.g., law enforcement agencies), additional qualifiers (e.g., “opioids”) were added to the request, to help ensure that all relevant reports were considered for retrieval. The databases used different classification systems and keywords; in most cases, discussion with the database custodian resulted in more refined search strategies that allowed capture of appropriate incidents or case examples. For example “diversion” did not exist as a concept in the law enforcement databases; therefore, only “theft” was used as a search term.

In some cases, data holders did not maintain the data in a format that was easily accessible for review, filtering and/or searching. For example, certain data holders, such as regulatory colleges, held and published case incidents and findings for the purposes of disciplinary hearings or for public disclosure, but not necessarily for research or subsequent analysis. As such, search capability was not always available, and a manual review of public data (e.g. published disciplinary cases) was performed in some instances.

Database eligibility criteria

Database holdings that were not related to hospital settings (e.g., community pharmacy reports) were excluded, as they were outside the study scope.

The search timeframes ranged from a minimum of 1 year to no time restrictions; the particular timeframe for each database was determined in consultation with database custodians, to adequately capture the types of information held in the database without retrieving an excessive number of reports. For databases that were expected to hold a smaller number of incidents, the timeframe was typically from database initiation to the present. For databases with no or limited search functionality, manual review was required, and time limits were applied, based on the volume of reports encountered and the availability of past reports.

Results

Data held by 35 Canadian organizations were considered for the database scan. Databases were excluded if they contained only clinical or patient outcome data, drug cost data or non-drug theft data; if the custodian did not

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respond; or if the host organizations had acted as bargaining, advocacy or union organizations. Responses were available from 15 organizations about the incidence of controlled drug diversion in their records, but not all shared data. These databases are described in Table A2, along with the data obtained.

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Table A2

Quantitative findings of database scan

Manner of request	Organization Name and Database Name (if applicable)	Organization Type	Expected holdings	Search terms or request	Time limits	Quantitative data	Comments
Freedom of information or access to information request	Health Canada	Regulator	Loss report forms submitted to Health Canada's Office of Controlled drugs	Reports of diversion or loss or misuse of controlled drugs (including narcotics) in Canada	January 2016 to December 2016	Total number of records reported from hospitals: 991 840 out of the 991 reports were categorized as “Loss Unexplained” By province: <ul style="list-style-type: none"> • Ontario: 556 reports • Alberta: 190 reports • Quebec: 101 reports • British Columbia: 58 reports • Saskatchewan: 39 reports • Manitoba: 29 reports • Newfoundland: 6 reports • Nova Scotia: 5 reports • New Brunswick: 4 reports • Northwest Territories: 3 reports 	Some data available in the loss/theft report forms submitted to Health Canada (including specific drugs and dosages lost, countermeasures taken) were not released by Health Canada, for security reasons.
	York Regional Police	Law enforcement	Investigation reports	“Drug theft from hospitals in York Region investigated by York Regional Police”	January 2012 to December 2016	20 reports, of which 18 (describing 15 separate incidents) were eligible	After discussion with the database custodian, original search timeframe was expanded, to increase the volume of reports available for review.
	Royal Canadian Mounted Police	Law enforcement	Investigation reports	Investigative reports of theft or loss of controlled drugs (opioids, narcotics, stimulants or other controlled drugs) from hospitals in Ontario	January 2015 to December 2016	Response received, but no records found	

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Manner of request	Organization Name and Database Name (if applicable)	Organization Type	Expected holdings	Search terms or request	Time limits	Quantitative data	Comments
	Ontario Provincial Police	Law enforcement	Investigation reports	Investigative reports of theft or loss of controlled drugs (opioids, narcotics, stimulants or other controlled drugs) from hospitals in Northwestern Ontario detachments	January 2015 to June 2017	2 loss reports	On advice from database custodian, scope was reduced from the entire province to a single region; Northwestern region was selected on the recommendation of a project informant.
Direct query	Canadian Medication Incident Reporting Program (CMIRPS): - Individual Practitioner Reporting (IPR), - Consumer reporting program (consumer), - Community Pharmacy Incident Reporting Program (CPhIR)	Error reporting system	Medication incident reports	abuse, misuse, addict*, diver* (for divert, diversion, diverting), steal* (for steal, stealing), stole* (for stole, stolen), hid* (for hide, hidden), cheek*, workaround, access, illicit, forge, theft	Database initiation to June 30, 2017 Initiation date of each database: IPR, August 2000 Consumer, March 2010 CPhIR, April 2010	350 reports reviewed (217 from IPR, 15 from consumer program, 118 from CPhIR) 18 eligible reports of opportunity, tampering, suspected diversion or diversion from IPR No eligible data from consumer or CPhIR reports	Most data in CMIRPS is reported voluntarily; as such, it likely under-represents actual cases of diversion. Search was not limited to controlled drugs because of limitations with database search functionality; reports unrelated to controlled drugs were manually excluded after the search was run.
Manual review of discipline cases	College of Nurses of Ontario	Professional practice regulator	Disciplinary records	Manual review of cases relating to controlled-drug theft or diversion	2005 to 2017	244 disciplinary records, of which 10 were eligible (6 describing diversion from a hospital, 4 describing diversion from unknown facility type, possibly a hospital)	Data collection was limited to 2005 onward to 1) limit the scope of time-consuming manual review and 2) match the timeframe of the scoping review.

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Manner of request	Organization Name and Database Name (if applicable)	Organization Type	Expected holdings	Search terms or request	Time limits	Quantitative data	Comments
	College of Physicians and Surgeons of Ontario (CPSO)	Professional practice regulator	Disciplinary records	Manual review of cases relating to controlled-drug theft or diversion	2013 to 2017	176 disciplinary records reviewed, of which 5 cases were eligible	At the time of the manual review, disciplinary reports mentioned in CPSO news releases were available for 2013 onward.
	Royal College of Dental Surgeons of Ontario	Professional practice regulator	Disciplinary records	Manual review of cases relating to controlled-drug theft or diversion	2004 to 2017	120 disciplinary records reviewed; no relevant cases found	
	College of Dental Hygienists of Ontario	Professional practice regulator	Disciplinary records	Internal review of disciplinary records relating to controlled-drug theft or diversion	No restriction	54 disciplinary records reviewed; no relevant cases found	
Direct inquiry	Ontario College of Pharmacists (OCP)	Professional practice regulator	Disciplinary records	Internal review of disciplinary records relating to controlled-drug theft or diversion	No restriction	Response received, but no records pertained to hospital settings ^a	All pharmacists and community pharmacies are regulated by the OCP; however, hospital pharmacies have only recently (in 2016) fallen under its jurisdiction.
	College of Respiratory Therapists of Ontario	Professional practice regulator	Disciplinary records	Internal review of disciplinary records relating to controlled-drug theft or diversion	No restriction	2 disciplinary records; no relevant cases found	
	Canadian Institute for Health Information: National System for Incident Reporting	Error reporting system	Medication incident report forms	abuse, misuse, addict*, diver* (for divert, diversion, diverting), steal* (for steal, stealing), stole* (for stole, stolen), hid* (for hide, hidden), cheek*, workaround, access, illicit, forge, theft	April 2010 to June 2017	94 reports received, of which 7 were eligible	Search was not limited to controlled drugs because of limitations with the database search functionality; Reports unrelated to controlled drugs were manually excluded after the search was run.

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Manner of request	Organization Name and Database Name (if applicable)	Organization Type	Expected holdings	Search terms or request	Time limits	Quantitative data	Comments
	Canadian Association of Physician Assistants	Association ^b	Disciplinary records	Internal review of disciplinary records relating to controlled-drug theft or diversion	No restriction		Response received, but indicated there was no evidence of diversion in their records
	Hospital #1	Teaching hospital	Incident reports and/or loss reports	Incident reports and/or loss reports related to controlled-drug diversion or theft	No restriction		Response received, but organization declined to release data
	Hospital #2	Community hospital	Incident reports and/or loss reports	Incident reports and/or loss reports related to controlled-drug diversion or theft	No restriction		Response received, but organization declined to release data

Source: Authors' analysis of data from multiple Canadian organizations as described above.

^aReports were available from community pharmacies, but the Ontario College of Pharmacists have only recently begun the process of accrediting hospital pharmacies in 2016; no hospital reports were found during our search.

^bNo regulatory college for this profession exists in Ontario

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Health Canada’s mandatory theft or loss report forms represented the largest repository of data regarding controlled-drug diversion from hospital settings. The Freedom of Information request to Health Canada for 2016 data generated more records than any other database source, revealing 556 reports of controlled-drug loss or theft (some involving multiple products) in Ontario alone. This large number contrasts starkly with the number of reports collected from health professionals’ regulatory colleges, law enforcement agencies and other national insurance organizations, even with multi-year searches. Regulatory colleges for health professionals often pointed to publicly available disciplinary records on their websites, but in some cases, the regulatory college internally searched its own records and provided results. Other organizational databases did not contain a substantial number of reports related to controlled-drug diversion in hospital settings.

Limitations

Manual review of some database reports may not have captured all relevant cases; in addition, it is possible that the same incident was reported in multiple databases, and such duplication might not have been recognized from the report details available to reviewers.

2. Milligram Calculation Procedure used on Health Canada Dataset

This section describes the process used to calculate the quantity of controlled drugs lost from Canadian healthcare sources. We report this quantity in milligrams, oral morphine equivalents, and daily defined doses.

The original dataset is hosted on a web-based service, GitHub: https://github.com/taracarman/drug_losses

The dataset was uploaded by Tara Carman, who also authored a CBC News article on June 28, 2018,^{2,3} where we first became aware of the dataset.

This dataset was acquired from Health Canada following an Access to Information Request, and describes losses of controlled drugs from January 1, 2012 to September 30, 2017.⁴

The original dataset is comprised of 142,421 rows, and 8 columns. The columns include:

- Date of loss (e.g., 12-01-01)
- Province where loss is reported (e.g., Alberta)
- Drug name (e.g., Hydromorph Contin 24mg Cap)
- Generic drug name (e.g., Hydromorphone)
- Quantity of loss (e.g., 2)
- Unit of loss (e.g., Capsule)
- Loss Description (e.g., Loss Unexplained)
- Facility Type (e.g., Hospital)

For the purposes of our analysis, we filtered the ‘Generic drug name’ column to focus on five common opioids:

- Codeine or ‘Codeine & Butalbital’ or ‘Codeine & Phenobarbital’
- Fentanyl
- Hydromorphone or Hydromorphine
- Morphine or ‘Morphine Sulfate’
- Oxycodone

This reduced the dataset to 64,693 rows.

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In the bullets above, we provided an example of a loss from January 1, 2012, where 2 capsules of Hydromorphone Contin were lost from a hospital in Alberta. The following section continues to use this example to show the additional calculations we performed.

One pharmacist (DT), four pharmacy students (DL, LD, EB, and KR worked collaboratively to add several columns to the spreadsheet to further analyze these reports:

1. The year of the loss (as opposed to the full date) (i.e., 2012)
2. The drug route (e.g., oral, oral solution, injectable, patch, suppository, unknown)
3. The quantity of milligrams per ‘unit’ of quantity (i.e., 2mg per capsule lost)
4. The total milligrams lost in that row (quantity column times the milligrams per unit quantity) (i.e., 2 capsules times 2 mg/capsule = 4 milligrams lost in total)
5. The oral morphine equivalent (OMEQ) of the total milligram loss (i.e., the conversion factor from oral hydromorphone to oral morphine is 5, so 4mg times 5 = 20 oral morphine equivalents lost)
6. The daily defined dose (DDD) equivalent of the total milligram loss (i.e., the World Health Organization (WHO) defines 1 daily defined dose of oral hydromorphone as 20mg, so in this case, 1 DDD was lost)
7. A notes column to describe how the row was altered if the original data was ambiguous and required editing. (i.e., in this case, no anomalies were encountered so no note would be written).

We encountered a variety of rows where a straightforward calculation was not possible, or suspect. We made several assumptions, generally seeking to estimate a reasonable lower limit for the drug lost (i.e., we attempted to be more conservative in our estimates of drug loss).

Table A3 summarizes the anomalous reports we encountered, and how we addressed them.

Table A3. Strategy for Anomalous Reports

Description of Anomalous Report	Resolution
The ‘Drug name’ conflicted with the ‘Unit of loss’ (e.g., fentanyl patches were reported with losses of millilitres)	In the majority of cases, we used the drug strength described in the ‘Drug name’ column to calculate the milligrams lost.
Units of loss were reported in ‘packages’ (it was unclear what size of package was lost)	We searched Health Canada’s Drug Product Database (DPD), reviewed relevant product monographs, selected the smallest package size, and used this to calculate the quantity of milligrams lost per package.
Units of loss are high (e.g., kilograms or litres)	We left these reports as is, assuming they were reported accurately. Exceptions are noted in the ‘notes’ column.
Quantities of losses exceed what would typically be held by a facility of that type (e.g., 165,997 tablets of 5mg oxycodone were lost from a pharmacy)	It is possible this report was the discovery of losses over a long period of time. As a result, we generally left these reports untouched.
No concentration was reported in the ‘Drug name’ column (e.g., ‘Oxycodone’ provides no details on the dosage format or strength)	In these cases, we looked to the unit of loss, where some rows provided clues (e.g., unit of loss is reported in Capsules or Tablets, suggesting an oral route). The pharmacy reviewers sought out the drug strength manually, where possible, using the DPD and relevant product monographs. When unclear, we used a

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	1 mg/quantity lost as a conservative measure of loss. Where the pharmacy reviewers felt reasonable, the drug strength was altered and a note is provided in these cases.
Reported concentration in drug name is not available as a drug product	We reduced to the lowest concentration (e.g., Hydromorphone HP 30mg/mL reduced to 10mg/mL).
Quantity of reported loss is zero	Since these rows have no impact on our total, we left them as is.
Unclear what unit of loss is (e.g., MF)	We assumed these rows referred to milligram losses and treated them as such.
Drug route cannot be determined	We treated these rows as oral medications for all analytical purposes (e.g., OMEQ and DDD calculations). They are labelled as ‘unknown’ in the route column of the dataset, and are referred to as ‘indeterminate’ in the article.

Source: Authors’ description of calculation methodology.

Our analytical dataset is available online as a supplemental file and accompanies this article. Interested readers can open the original dataset from CBC, and find the corresponding row in our analytical dataset to see how we altered the row. We believe this maximizes transparency and should allow for further analyses, reviews, or critiques for those who are interested.

3. Conversion Factors for Oral Morphine Equivalents and Daily Defined Doses

We have tabulated conversion factors from existing literature where possible, but please note there are inconsistencies between sources.

The conversion factors provided in this Appendix are not for clinical use. They represent an academic attempt to characterize opioid losses from Canadian facilities and allow policy-makers to approximate and/or benchmark the losses against other values.

We have attempted to use the same conversion factors as the Canadian Institute of Health Information (CIHI) where possible.⁵ However, CIHI focuses primarily on oral and transdermal drug formats, and therefore additional sources were used in the analysis of our dataset (see references associated with each factor below).

Table A4

Oral Morphine Equivalent (OMEQ) Conversion Factors		
Drug and Route ^a (assuming drug in question is being converted from milligrams)	OMEQ Conversion Factor	Notes and References
Codeine		
Oral	0.15	Based on conversion factors published by CIHI and Busse et al. ^{5,6}

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Injectable	0.25	Based on conversion factors published by Nielsen et al. ⁷
Fentanyl		
Oral (sublingual)	130	Based on conversion factors published by CDC. ⁸
Injectable	100	Based on conversion factors published by CDC. ⁸
Patch	100	Based on conversion factors published by CDC. ⁸ Factor of 100 assumes 3 days worth of drug, and uses parenteral conversion factor. For example, 100mcg/h * 72 hours = 7200mcg delivered over 3 days; 7.2 mg x 100 (conversion factor in row above) = 720mg of OMEQ per patch).
Hydromorphone		
Oral	5	Based on conversion factors published by CIHI and Busse et al. ^{5,6}
Injectable	17.5	Based on conversion factors published by Nielsen et al. ⁷
Rectal (suppository)	6	There are no widely accepted conversion factors for rectal hydromorphone to oral morphine. However, for the purposes of this article, we have attempted to estimate using studies investigating morphine.
		Both rectal and oral formulations are technically enteral, and the few studies investigating show close effectiveness in pain relief between oral and rectal routes. ⁹
		Bruera et al. (1995) shows that morphine equivalence between rectal and subcutaneous (injectable) morphine is 2.5 to 1, ¹⁰ and Nielsen et al. (2016) states that injectable morphine is 3 times stronger than oral morphine. ⁷ Therefore, we estimate that 1 mg of rectal morphine is equal to 1.2mg (3/2.5) of oral morphine.
		Mercadante et al. (2005) shows 1mg of rectal tramadol is roughly equivalent to 1.5mg of oral tramadol. ¹¹
		Therefore, we anticipate that rectal routes are slightly more efficient (more powerful) than oral routes.
		Using Bruera et al.’s conversion values for morphine as a benchmark for our calculations, we estimate that 1mg of rectal hydromorphone is equivalent to 1.2 milligrams of oral hydromorphone. Therefore, 1mg of rectal

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hydromorphone is 6mg (5*1.2) of oral morphine.

Morphine		
Oral	1	Based on conversion factors published by CIHI and Busse et al. ^{5,6}
Injectable	3	Based on conversion factors published by Nielsen et al. ⁷
Rectal (suppository)	1.2	Bruera treated rectal to subcutaneous (injectable) morphine at 2.5:1. ¹⁰ Nielsen does injectable to oral morphine at 3 to 1. ⁷ Therefore we consider the conversion factor for rectal to oral is $3/2.5 = 1.2$

Oxycodone		
Oral	1.5	Based on conversion factors published by CIHI and Busse et al. ^{5,6}
Rectal	1.8	This conversion factor is based on the same rationale for rectal hydromorphone. In short, rectal morphine has been estimated to be 1.2 times as strong as oral morphine; this has been extrapolated to oxycodone (i.e., $1.5 * 1.2 = 1.8$).

^aReports where the dosage format was unknown were treated as 'oral' for the purposes of the OMEQ conversion.

Table A5

Daily Defined Dose (DDD) Conversion Factors

Drug and Dosage Format ^a	DDD	Notes and References
Codeine		
Oral	240mg	International narcotics control board has defined the DDD for analgesic use of codeine at 240mg. ¹² This value has also been used by CIHI. ⁵
Injectable	64mg	NO DDD has been defined by the World Health Organization (WHO) for injectable codeine.
Note that in other injectable DDDs, the DDD is 2.5 (oxycodone) to 5 (hydromorphone) times lower than the oral DDD. As an average between hydromorphone and oxycodone, we divided the oral DDD by 3.75 to approximate a reasonable DDD. In this case, parenteral codeine DDD would be $240\text{mg}/3.75 = 64\text{mg}$.		
Fentanyl		
Oral (sublingual)	0.6mg	DDD defined by WHO. ¹³
Injectable	0.16mg	NO DDD has been defined by the WHO for injectable fentanyl.
Using the rationale for codeine above, the injectable		

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fentanyl DDD would be $0.6\text{mg}/3.75 = 0.16\text{mg}$.
 DDD defined by WHO.¹³

Transdermal	1.2mg	
Hydromorphone		
Oral	20mg	DDD defined by WHO. ¹³
Injectable	4mg	DDD defined by WHO. ¹³
Rectal (suppository)	4mg	DDD defined by WHO. ¹³
Morphine		
Oral	100mg	DDD defined by WHO. ¹³
Injectable	30mg	DDD defined by WHO. ¹³
Rectal (suppository)	30mg	DDD defined by WHO. ¹³
Oxycodone		
Oral	75mg	DDD defined by WHO. ¹³
Injectable	30mg	DDD defined by WHO. ¹³
Rectal	30mg	NO DDD has been defined by the WHO for rectal oxycodone. However, WHO has defined a parenteral oxycodone DDD of 30mg. Since DDDs for rectal are the same as the DDD for parenteral in other instances (see morphine and hydromorphone), we have used 30 mg here.

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^aReports where the dosage format was unknown were treated as ‘oral’ for the purposes of the DDD conversion.

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4. Street Pricing Estimates

The street values of pharmaceutical opioids are subject to significant variability (e.g., potency, formulation, bulk purchasing).¹⁴ However, literature suggests that street pricing accurately reflects equianalgesic potency,^{14,15} which supports our contention that reporting losses in terms of dose (e.g., milligrams) or potency (e.g., oral morphine equivalents) is superior to alternative forms of measurement (e.g., dosage units, incidents of loss).

Given the lack of consensus regarding street price per drug per milligram, we used the average price per milligram as provided by a Provincial Policing Service to estimate street value (Table A6). This average price per milligram was used regardless of the dosage format with the exception of fentanyl. The street pricing for fentanyl varied between transdermal and other formats, so Table A6 shows different pricing for these formats.

Previous Canadian literature on street pricing is outdated,¹⁶ and newer articles often describe street pricing in the US (reported in US dollars); it is unclear if street pricing varies considerably between the US and Canada. Pricing is typically reported for oral formats, but it is unclear how accurately this represents other formats (e.g., injectable, transdermal, rectal).

Table A6

Estimates of Street Pricing		
Drug	Price range estimated by Ontario Provincial Police	Additional Notes and References
Codeine	\$1 to 1.25 per milligram (average \$1.125/mg)	Street price not reported in literature.
Fentanyl (oral, injectable)	\$0.3 to 0.5 per milligram (average \$0.4/mg)	The values provided by the Ontario Provincial Police are for powdered fentanyl, which likely underestimates street prices for fentanyl tablets. For example, the US Drug Enforcement Administration has used 1.5 to 1.8mg as possible doses per counterfeit fentanyl tablets, and has provided estimates of sale prices ranging from \$10 to \$20 USD per pill. ¹⁷ Therefore, the actual dose in counterfeit pills could be valued between \$5.5 to \$13.3 USD per milligram. This is ten to thirty times higher than the conservative estimate we have used.
Fentanyl (transdermal)	\$1 to 3 per microgram per hour (average \$2 per mcg/hr)	Fentanyl patch street pricing has been estimated at USD \$1/mcg/hr. ¹⁸
Hydromorphone	\$1 to 2 per milligram (average \$1.5/mg)	Crowdsourced street pricing ranges from \$3.55 to 4.47 USD per milligram. ¹⁵
Morphine	\$0.66 to 1 per milligram	Crowdsourced street pricing ranges from \$0.42 to 0.67

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	(average \$0.83/mg)	USD per milligram. ¹⁵
Oxycodone	\$0.50 to 2 per milligram	Crowdsourced street pricing ranges from \$0.86 to 0.99
	(average \$1.25/mg)	USD per milligram. ¹⁵

Source: Data provided by Ontario Provincial Police and literature as cited.

5. Opioid Milligram Losses for Pharmacies by Canadian Province/Territory (Major Loss Categories only)

This section examines the dominant reasons for loss in pharmacies and hospitals respectively, broken down by province and territory, in descending order of milligrams lost.

Ontario pharmacies show an increasing trend of armed robberies and unexplained losses, but a downward trend in break and enter and pilferage. Alberta pharmacies show a reduction in losses from armed robberies, but a recent upward trend in unexplained losses. BC pharmacies show an astonishing downward trend in losses from armed robbery and break and entry. Newfoundland and Labrador (NL) is ranked fourth in terms of total losses from pharmacies in the dataset, losing over 6kg of the five opioids in our analysis; this is an average of 1.89mg per capita, compared to Ontario, British Columbia and Alberta, which range from 0.5 to 0.7mg per capita.¹⁹ Saskatchewan and Manitoba have seen increasing amounts of unexplained losses in 2016 and 2017.

Table A7

Pharmacy Milligram Losses By Year and by Dominant Loss Description for each Province/Territory in order of Largest to Smallest Milligram Losses (Jan 2012 to Sept 2017)

	2012	2013	2014	2015	2016	2017 (up to Sept. only)
Ontario						
Armed Robbery	2,548,985	2,330,881	2,188,001	2,592,363	1,823,099	4,341,288
Break and Entry	1,669,073	942,251	3,038,883	1,291,617	546,219	618,799
Loss						
Unexplained	536,416	608,142	408,980	666,368	1,824,123	3,002,302
Pilferage	2,816,645	226,533	2,591,775	2,451,156	1,517,376	532,015
Alberta						
Armed Robbery	615,440	899,115	1,204,313	619,595	538,780	123,365
Break and Entry	988,964	460,809	1,158,541	3,471,349	1,505,720	1,089,889
Loss						
Unexplained	163,664	103,481	329,089	238,729	885,076	1,527,698
Pilferage	177,270	453,095	5,840	43,240	10,467	8,324
British Columbia						

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Armed Robbery	2,501,598	1,476,241	1,159,592	1,305,586	8600	72
Break and Entry	752,315	1,236,488	1,200,863	350,460	28,341	14,400
Loss						
Unexplained	159,674	83,621	184,072	110,938	2,141,798	1,073,561
Pilferage	-	24,292	12,750	4,150	12,560	19,629
Newfoundland and Labrador						
Armed Robbery	135,193	68,055	168,541	62,283	838,005	256,595
Break and Entry	44,550	221,791	262,133	936,148	216,153	206,209
Loss						
Unexplained	119,645	861	6,947	14,649	50,592	47,880
Pilferage	-	1,010	-	82,860	2,276,750	-
Quebec						
Armed Robbery	363,585	113,785	296,879	82,213	91,300	12,685
Break and Entry	97,367	98,677	297,084	153,512	192,260	48,381
Loss						
Unexplained	38,664	48,158	70,229	194,565	133,079	152,992
Pilferage	323,370	164,231	26,795	656,670	426,301	124,605
Saskatchewan						
Armed Robbery	19,115	172,774	20,690	179,880	106,769	205,917
Break and Entry	725,734	319,453	361,435	440,172	299,346	338,045
Loss						
Unexplained	67,647	83,247	20,533	113,097	204,236	224,138
Pilferage	478	-	1,960	282,826	1,209	2,415
Manitoba						
Armed Robbery	15,720	-	132,486	61,910	900	15,458
Break and Entry	-	60,229	-	66,578	1,698	6,040
Loss						
Unexplained	30,649	4,510	17,084	15,326	160,383	150,742
Pilferage	-	21,600	3,400	-	-	-
Nova Scotia						
Armed Robbery	428	195	578	180	13	685
Break and Entry	11454	-	4720	-	-	-
Loss						
Unexplained	490	976	1303	2024	782	1095
Pilferage	426	-	4389	-	-	-
New Brunswick						
Armed Robbery	330	-	1398	1218	45	773
Break and Entry	-	687	-	936	22	255
Loss						
Unexplained	311	61	628	126	1741	1395
Pilferage	-	1080	50	-	-	-
Yukon						

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Territories						
Armed Robbery	-	-	-	-	-	560
Break and Entry	-	125,761	-	-	-	-
Loss	-	262	5	-	29,591	68,987
Unexplained	-	-	-	-	-	-
Pilferage	-	-	-	-	-	560
Prince Edward Island						
Armed Robbery	-	-	-	-	-	-
Break and Entry	-	-	69,719	500	-	-
Loss	-	5,400	2,180	2,112	4,078	1,856
Unexplained	-	-	-	-	-	-
Pilferage	-	70	-	-	-	-
Nunavut						
Armed Robbery	-	-	-	-	-	-
Break and Entry	-	-	-	-	-	-
Loss	-	270	6,323	300	8,930	-
Unexplained	-	-	-	-	-	-
Pilferage	-	-	2,888	-	-	-
Northwest Territories						
Armed Robbery	-	-	-	-	-	-
Break and Entry	-	-	-	-	-	-
Loss	148	3,619	8,330	600	664	847
Unexplained	-	-	-	-	-	-
Pilferage	-	-	-	-	-	-

Source: Authors' analysis of data for Jan. 2012 to Sept. 2017 from reports of Controlled Substances Loss or Theft Reports to Health Canada as published by CBC News in June 2018.

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6. Opioid Milligram Losses for Hospitals by Canadian Province/Territory (Major Loss Categories only)

This section examines the dominant reasons for hospitals, broken down by province and territory, in descending order of milligrams lost.

Ontario hospitals show a rapid increase in pilferage losses starting in 2016. Other provinces and territories show no clear trends, but Quebec and Manitoba hospitals show peaks in milligram losses in 2016 and 2015, respectively.

Table A8

Hospital Milligram Losses By Year and by Dominant Loss Description for each Province/Territory in order of Largest to Smallest Milligram Losses (Jan 2012 to Sept 2017)

	2012	2013	2014	2015	2016	2017 (up to Sept. only)
Ontario						
Loss						
Unexplained	10,408	36,746	19,205	26,657	27,576	7,844
Pilferage	24,226	28,952	21,552	12,736	120,645	415,879
Quebec						
Loss						
Unexplained	38,265	14,761	6,760	10,176	7,479	4,920
Pilferage	2,342	2,675	1,532	382	70,287	27,169
Manitoba						
Loss						
Unexplained	1,747	173	144	121,547	508	3,169
Pilferage	1,423	32,533	2,165	-	13,227	100
British Columbia						
Loss						
Unexplained	4,862	1,077	2,899	12,290	2,849	5,882
Pilferage	3,340	16,496	12,318	1,051	1,733	2,112
Alberta						
Loss						
Unexplained	4,368	9,934	6,420	9,239	3,027	4,575
Pilferage	392	20	-	105	205	-
Newfoundland and Labrador						
Loss						
Unexplained	2,901	424	573	160	82	25,038
Pilferage	-	-	-	-	-	-
Saskatchewan						

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Loss						
Unexplained	317	441	4,088	3,208	19,142	217
Pilferage	239	19	1,200	3	-	-
Nova Scotia						
Loss						
Unexplained	2,675	1071	44	331	32	4,060
Pilferage	-	100	-	-	-	-
Nunavut						
Loss						
Unexplained		4	50	2,760		
Pilferage	-	-	-	-	-	-
New Brunswick						
Loss						
Unexplained	187	568	55	47	6	1,132
Pilferage	-	95	-	242	-	80
Northwest Territories						
Loss						
Unexplained	-	-	94	45	12	15
Pilferage	-	-	-	-	-	-
Yukon Territories						
Loss						
Unexplained	130	-	-	-	-	-
Pilferage	-	-	-	-	-	-

Source: Authors’ analysis of data for Jan. 2012 to Sept. 2017 from reports of Controlled Substances Loss or Theft Reports to Health Canada as published by CBC News in June 2018.

7. Line Graphs Comparing Opioid Loss Trends as Measured by Milligrams, Dosage Units, and Incidents of Loss

This section complements Table 4 in the article by providing a visual depiction of the loss trends from community pharmacies, companies, and hospitals. Specifically, loss trends appear to vary depending on the unit of measure. In Figures A1, A2, and A3 below, we show that depending on which measure is reported, readers may be inclined to believe that losses are increasing or decreasing when other measures show differing trends.

****Note,** the units of measure have been scaled so that the y-axis is comparable between the reporting metrics. Specifically the dosage units lost have been reduced by a factor of 100, and milligrams lost has

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been divided by 1000 to provide losses in grams. These figures are primarily to demonstrate differences in trends, rather than a comparison of absolute values between the reporting metrics.

Figure A1.

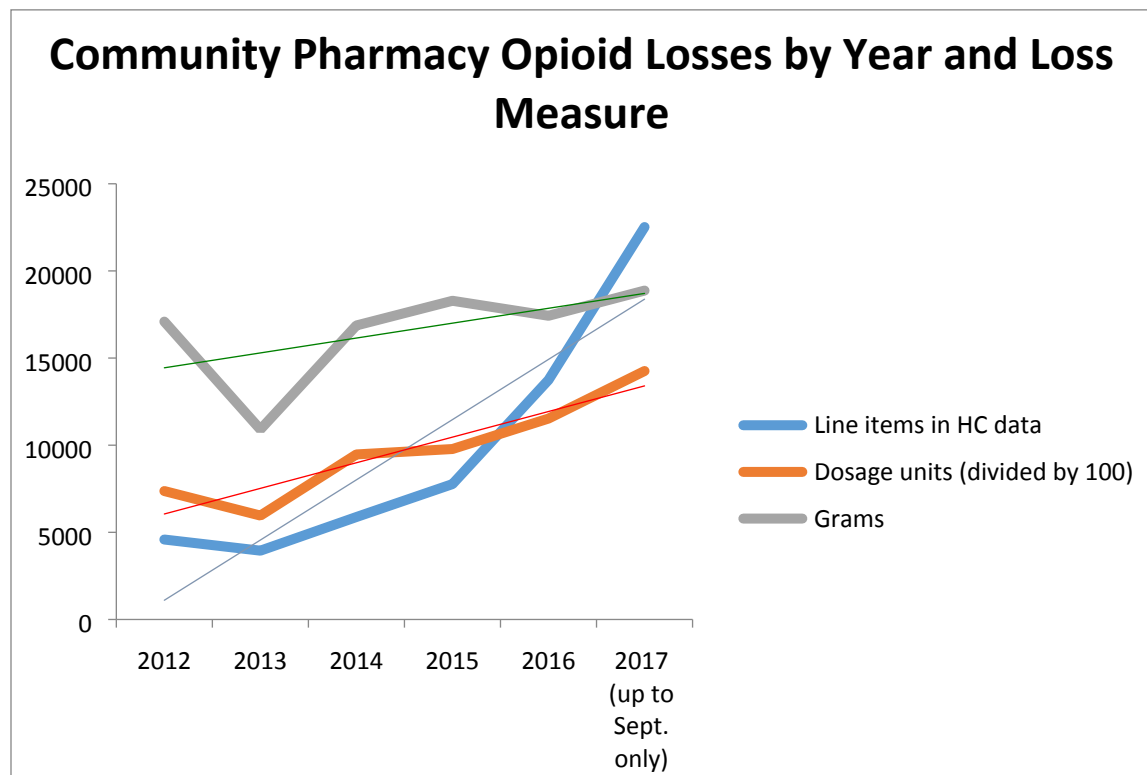
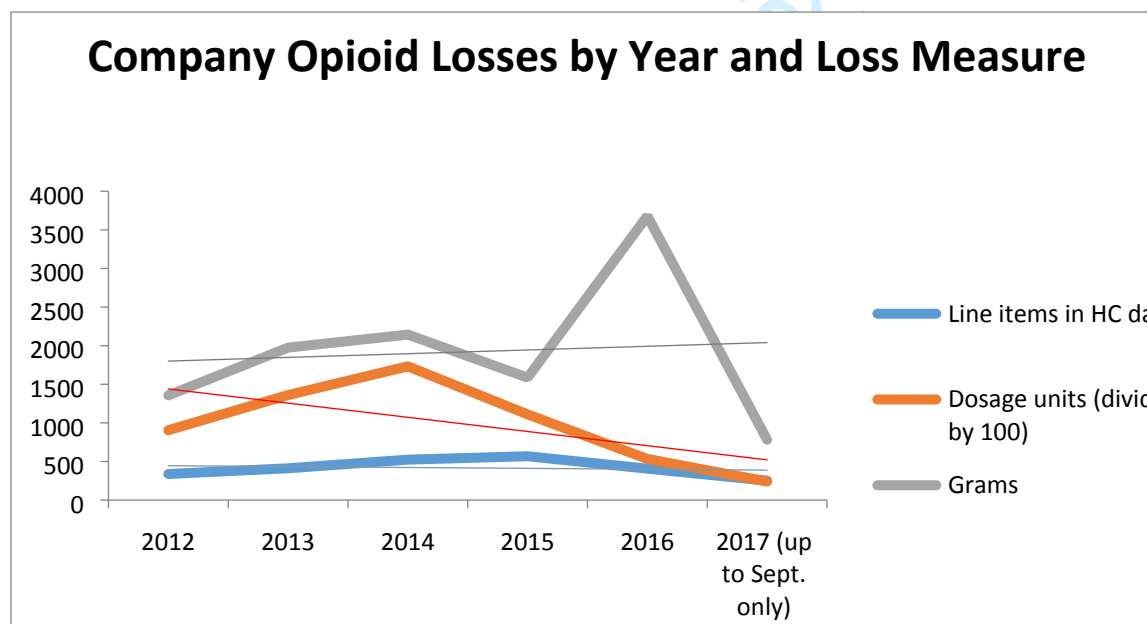
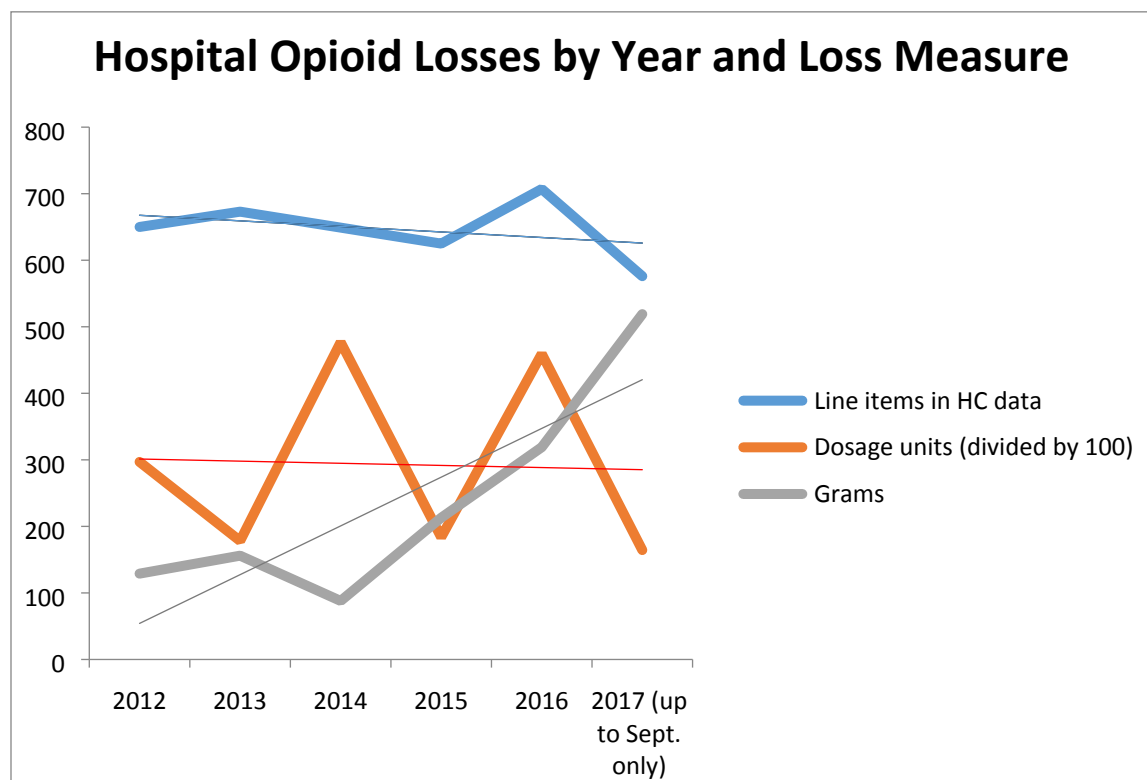


Figure A2.



Appendix for “Opioid losses in terms of dosage and cost: a retrospective analysis of Health Canada data”
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Figure A3.



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