

Opioid losses in terms of dosage and value, January 2012 to September 2017: a retrospective analysis of Health Canada data

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Abstract

Background: Canadian health care facilities must report losses or thefts of opioids to Health Canada. To broaden the understanding of opioid loss in Canada, we analyzed data describing these losses to estimate the amount of opioid lost, estimate the wholesale and street value, compare the distribution of loss types between facility types and compare loss trends.

Methods: We analyzed Health Canada records of losses of codeine, fentanyl, hydromorphone, morphine and oxycodone reported by Canadian facilities from January 2012 to September 2017. We conducted descriptive analyses of the opioid losses by calculating milligrams of drug lost, oral morphine equivalents, daily defined doses, approximate wholesale value and approximate street value, and compared loss trends when counted by incidents, dosage units or milligrams.

Results: There were 64 963 reports of loss of codeine, fentanyl, hydromorphone, morphine or oxycodone over the study period. Over 112 kg of opioids were lost, an estimated \$8.7 million in wholesale cost and \$136 million in street value. The dominant loss categories varied by facility type: armed robbery (30.9 kg [31.1%]) for community pharmacies, unexplained losses (6.4 kg [55.8%]) for companies and pilferage (0.8 kg [57.4%]) for hospitals. Loss trends over the study period varied by reporting metric and facility type: community pharmacy losses increased when measured by dosage units and incidents of loss, and remained stable when measured by milligrams; hospital losses increased when measured by milligrams and showed no clear trend when measured by dosage units and incidents of loss. Companies showed no clear loss trend with any reporting metric.

Interpretation: Large quantities of opioids were lost or stolen from community pharmacies, companies and hospitals over the study period, and these losses are valued in millions of dollars. Publishing milligrams of opioids lost annually alongside metrics such as dosage units and incidents of loss would help characterize the economic cost and the magnitude of drug losses.

Drug losses and thefts cost health care facilities in investigations, care for patients with inadequately treated pain or harmed by drug substitution or tampering, and reputation-related damages.¹⁻⁹ Furthermore, losses from health care facilities have the potential to increase illegal supply of opioids via trafficking. In the United States, the Drug Enforcement Agency reports annually on opioid losses from health care institutions (e.g., community pharmacies, hospitals).^{10,11} The Canadian authority that captures data on opioid losses from health care facilities, Health Canada, does not publish an equivalent report. Dating back to at least 1961,¹² any individuals or organizations in Canada licensed to produce, package, assemble, sell or transport opioids are mandated to report losses to Health Canada by fax or email within 10 days¹³ (see reporting form in Appendix 1, section 9, available at www.cmajopen.ca/content/8/1/E113/suppl/DC1). This

group includes, but is not limited to, a wide variety of facilities such as hospitals, community pharmacies, all companies (e.g., drug manufacturers), long-term care homes and veterinary hospitals.

Health Canada conducts random, targeted inspections of community pharmacies to assess compliance with the mandate,¹⁴ but data on hospital inspections are scarce. Local regulatory

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bodies may also conduct inspections (e.g., the Ontario College of Pharmacists inspects both community and hospital pharmacies), but practices in the provinces and territories vary. Police services or insurance companies do not enforce the reporting mandate and may not be alerted to the losses. Pilot work suggests that Health Canada data represent the best source of information on the incidence of Canadian opioid losses (Appendix 1, section 1).

Opioid losses have been reported in “dosage units”^{11,15,16} and “incidents of loss,”¹⁷ both of which have important limitations that may not be widely understood. Dosage units indiscriminately count loss quantities (e.g., the loss of 1 tablet is counted the same as the loss of 1 bottle containing 500 tablets). Incidents of loss ignores the quantity of loss completely and may also be affected by reporting frequency (e.g., hospital A may submit a single report for multiple losses of a drug within a 10-d window, whereas hospital B may submit separate reports after each occurrence).

To broaden the understanding of opioid losses in Canada, we analyzed Health Canada data to estimate milligram losses for 5 common opioids; estimate the wholesale and street value of lost opioids; compare milligrams lost and reason for loss by facility type; and compare opioid loss trends as measured by incidents of loss, dosage units and milligrams.

Methods

Data source

In June 2018, the CBC published Health Canada data from an Access to Information request for all controlled drug losses between Jan. 1, 2012, and Sept. 30, 2017.^{18,19} This is the largest published data set identified and is therefore valuable for assessing trends in Canadian health care sources. The CBC confirmed that the data were uploaded without alteration as they were received from Health Canada (Tara Carman: personal communication, 2019); the data are consistent in format with previous Access to Information requests.

Inclusion criteria and constraints

We limited our analysis to the most commonly dispensed opioids in Canada based on data from the Canadian Institute for Health Information:²⁰ codeine, fentanyl, hydromorphone, morphine and oxycodone. Tramadol is among the 6 most dispensed opioids in Canada²⁰ but is not yet classified as a controlled substance,²¹ so no loss reports were captured for this drug.

Outcomes

The Health Canada data state a numeric quantity lost for each incident of loss, but the unit code (e.g., millilitres, tablets, patches) for each report varies. Two authors (M.F. and D.T.), with the support of pharmacy students, used this information to calculate manually the milligrams lost for every reported drug loss (they updated a single file repeatedly and reviewed it continuously in a collaborative manner). For anomalous reports, M.F., D.T. and M.H. came to consensus on how to proceed. We then used the calculated milligrams lost to deter-

mine oral morphine equivalents and daily defined doses (see Appendix 1, section 3, for conversion factors). Daily defined doses are defined by the World Health Organization as the “assumed average maintenance dose per day for a drug used for its main indication in adults”²² and is used to facilitate international comparisons.

We used the lowest estimate of loss for ambiguous or anomalous reports. For example, 1 report listed the loss of 728 packages of hydromorphone hydrochloride, 50 mg/mL. From the data set, it was unclear whether these containers were 1 mL, 5 mL, 10 mL or 50 mL. In this case, the smallest available package according to the drug product monographs found on Health Canada’s Drug Product Database²³ is a box of ten 1-mL vials. To estimate the impact of a nonconservative approach, we recalculated the losses for the top 40% of anomalous reports most affected by the conservative approach for each of the 5 opioids (additional details are provided in Appendix 1, section 2).

For 2017, the data set contains data only for January to September. We therefore provide a prorated estimate for a full year of 2017 only when data are presented by year. We averaged the milligram losses in the first 3 quarters of 2017 and added this value as the loss for the final quarter (October to December).

The definitions from Health Canada for the various loss categories (e.g., unexplained loss, pilferage) in the data set are included in Appendix 1, Supplemental Table S11. Not all loss categories in the data set are captured in Health Canada’s guidance document, but we left these reports in the analysis for comprehensiveness. We assumed the loss description was accurate in the absence of an alternative strategy.

Wholesale and street drug costing

We calculated approximate wholesale costs from the Ontario Drug Benefit database (2019 data) for the entire data set because most oral morphine equivalent losses came from Ontario. If the cost was not available from the Ontario Drug Benefit database, we searched other provincial formularies (see our analytical dataset, available at <https://github.com/HumanEra/Health-Canada-Drug-Loss-and-Theft-Data-Analysis>, for wholesale pricing information). Although street value fluctuates^{24,25} depending on cycles of supply and demand, geography and drug strength, we used a single point-in-time street value based on information from the Ontario Provincial Police and the literature (Appendix 1, section 4).

Statistical analysis

We conducted descriptive analyses of the opioid losses by calculating milligrams of drug lost, oral morphine equivalents, daily defined doses, approximate wholesale value and approximate street value. We used Microsoft Excel for analyses.

Ethics approval

No personal health information or human participants were involved in the study. No specific institutions are identified, and the data are publicly accessible from Health Canada on request. As a result, ethics board approval was not required.

Results

Restricting our analysis to codeine, fentanyl, hydromorphone, morphine and oxycodone resulted in 64 963 reports, which is 45.6% of the reports in the original data set (142 420). An analysis of the 64 963 reports using a conservative approach when imputing anomalous records showed that the cumulative loss of the 5 opioids between January 2012 and September 2017 was over 112 kg (Table 1). This equates to about \$8.7 million in wholesale costs and \$136 million if all lost drugs were resold on the street. When we used a more liberal approach on a sample of anomalous reports, milligram losses increased by 7.5 kg, the wholesale value increased by \$886 670, and the street value of the losses increased by \$9 695 290 (Appendix 1, Supplemental Table S5).

Community pharmacies, companies and hospitals were responsible for nearly all losses, accounting for 76.8%, 17.1%

and 6.0% of lost oral morphine equivalents, respectively (Table 2). As a result, all subsequent analyses were focused on these 3 facility types.

The dominant reasons for loss (in milligrams) varied by facility type (Table 3). Community pharmacy losses were primarily from armed robberies (31.1%), break and entry (28.1%), unexplained losses (17.6%) and pilferage (15.5%). Company losses were primarily from unexplained losses (55.8%) and losses in transit (30.7%). Hospitals were affected primarily by pilferage (57.4%) and unexplained losses (33.4%).

More detailed breakdowns of loss trends by province or territory for community pharmacies and hospitals showed that there were substantial reductions in community pharmacy losses in British Columbia over the study period, whereas Ontario hospitals reported an increasing amount of pilferage losses in the more recent years of the study period (Appendix 1, sections 5 and 6).

Table 1: Opioid losses reported to Health Canada by facilities such as hospitals, community pharmacies, companies, long-term care homes and veterinary hospitals, January 2012 to September 2017

Drug; route*	Milligrams lost (per 1000)†	Oral morphine milligram equivalent (per 1000)†	Daily defined dose	Estimated wholesale value, \$	Estimated street value, \$
Codeine					
Oral	47 072.3	7060.8	196 135	1 313 140	52 956 369
Injection	3.7	0.9	58	514	4185
Indeterminate	228.7	34.3	953	6369	257 306
Fentanyl‡					
Oral	66.8	8687.6	111 379	3 212 163	26 731
Injection	10.6	1065.5	66 336	302 036	4257
Transdermal	184.0	18 403.2	153 360	199 936	5 111 997
Indeterminate	2.7	349.8	4484	129 346	1077
Hydromorphone					
Oral	12 160.0	60 799.4	607 994	1 447 179	18 239 833
Injection	544.4	9526.8	136 097	199 890	816 581
Rectal	0.5	2.8	117	593	702
Indeterminate	19.2	96.0	960	2288	28 803
Morphine					
Oral	15 154.6	15 154.6	151 546	353 846	12 578 317
Injection	325.6	976.7	10 852	205 417	270 224
Rectal	73.0	87.7	2435	11 318	60 627
Indeterminate	134.7	134.7	1347	3151	111 794
Oxycodone					
Oral	36 537.3	54 805.9	487 164	1 312 734	45 671 623
Rectal	9.6	17.2	319	3229	11 975
Total	112 527.7	177 204.1	1 931 538	8 703 149	136 152 401
**"Oral" refers to tablets, capsules, and sublingual and oral solutions (e.g., syrups); "injection" includes intravenous and subcutaneous formats; "indeterminate" refers to line items in the data set for which the route or format of the drug was ambiguous.					
†Column and row totals may not match the sum of numbers in the table because the table shows only rounded numbers.					
‡Fentanyl is typically dosed in micrograms, but for consistency with other drugs we report in milligrams.					

Table 2: Oral morphine equivalents (per 1000 mg) lost, by facility type

Facility type	Opioid; oral morphine equivalent (per 1000 mg) lost					Total* (% of column total)
	Codeine	Fentanyl	Hydromorphone	Morphine	Oxycodone	
Community pharmacy	6222.4	16 983.0	46 535.1	14 255.2	52 112.9	136 108.5 (76.8)
Company	815.0	10 041.6	15 741.9	1432.7	2298.5	30 329.8 (17.1)
Hospital	42.5	1468.2	8143.4	647.9	395.2	10 697.2 (6.0)
Long-term care facility	11.7	2.0	3.2	0.9	15.5	33.3 (0.0)
Nurse station†	3.7	2.0	0.4	8.6	0.6	15.2 (0.0)
Canadian Forces base	0.8	7.3	1.1	1.2	0.5	10.8 (0.0)
Ambulatory service‡	–	2.0	~0.0	7.2	–	9.2 (0.0)
Total*	7096.1	28 506.1	70 425.0	16 353.7	54 823.2	177 204.1

*Column and row totals may not match the sum of numbers in the table because the table shows only rounded numbers.

†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 or hospital and provide procedures or services on an outpatient basis, or are stand-alone clinics providing similar services.

Table 3: Milligrams lost (per thousand) by dominant reason for loss and facility type

Reason for loss*	Facility type; % of losses (% of column total)			
	Community pharmacy	Company	Hospital	Total†
Armed robbery	30 935.2 (31.1)	10.9 (0.1)	~0 (0.0)	30 946.2
Break and entry	27 978.9 (28.1)	147.5 (1.3)	64.1 (4.5)	28 190.4
Breakage in transit	275.6 (0.3)	58.6 (0.5)	0.3 (0.0)	334.5
Breakage on site	5.9 (0.0)	–	0.6 (0.0)	6.5
Grab theft	1381.3 (1.4)	790.6 (6.9)	34.3 (2.4)	2206.2
Impersonation	74.4 (0.1)	–	–	74.4
Loss in transit	159.2 (0.2)	3540.8 (30.7)	15.2 (1.1)	3715.2
Loss unexplained	17 481.0 (17.6)	6429.2 (55.8)	475.4 (33.4)	24 385.6
Manufacturer's defect (ampoules)	~0 (0.0)	0.1 (0.0)	~0 (0.0)	0.1
Manufacturer's shortage (sealed bottles)	28.6 (0.0)	34.5 (0.3)	1.1 (0.1)	64.2
Overshipment (picking error)	0.4 (0.0)	2.8 (0.0)	–	3.2
Pilferage	15 459.0 (15.5)	260.2 (2.3)	817.6 (57.4)	16 536.8
Spillage	6.1 (0.0)	–	0.2 (0.0)	6.3
Undershipment	4.1 (0.0)	0.4 (0.0)	–	4.4
Other	5659.0 (5.7)	248.3 (2.2)	14.3 (1.0)	5921.6
Total†	99 448.8 (100.0)	11 523.9 (100.0)	1423.2 (100.0)	112 395.6

*Definitions can be found in Appendix 1, Supplemental Table S11 (available at www.cmajopen.ca/content/8/1/E113/suppl/DC1).

†Column and row totals may not exactly match the sum of numbers in the table because the table shows only rounded numbers.

We observed different trends when reporting milligrams of lost opioids than when reporting dosage units or number of incidents of loss (Table 4). Specifically, the incidents of loss and dosage units lost from community pharmacies increased steadily from 2012, but milligram losses did not. Conversely,

hospitals showed increased milligram losses in the more recent years of the study period, whereas the same trend was not seen for incidents of loss and dosage units. Companies did not show discernible trends in any of these metrics. A visual depiction of trends is presented in Appendix 1, section 7.

Table 4: Incidents of loss, dosage units lost and milligrams (per thousand) lost by facility type

Facility type; variable	2012	2013	2014	2015	2016	2017 (up to September only)	2017 (data prorated to full year)
Community pharmacy							
Incidents of loss	4587	3948	5879	7768	13 743	22 517	30 023
Dosage units lost	736 886	596 185	947 010	978 053	1 152 808	1 425 626	1 900 835
Milligrams lost (per 1000)	17 091.0	10 904.4	16 870.6	18 286.1	17 425.6	18 871.1	25 161.5
Company							
Incidents of loss	338	412	524	568	407	252	336
Dosage units lost	90 562	136 032	173 273	111 022	53 296	24 053	32 070
Milligrams lost (per 1000)	1355.7	1974.8	2144.4	1585.6	3682.7	780.8	1041.0
Hospital							
Incidents of loss	650	673	649	625	707	576	768
Dosage units lost	29 692	17 820	47 679	18 379	45 929	16 441	21 921
Milligrams lost (per 1000)	128.6	155.6	88.3	213.1	318.8	518.9	691.8

Interpretation

Our analysis suggests that the lower bound for the average annual loss of 5 common opioids in Canada between January 2012 and September 2017 is 19.6 kg, with a street value of \$23.7 million. Community pharmacies were the largest contributor to the losses, followed by companies and hospitals, which suggests that improving security and accounting of opioids in community pharmacies should be prioritized. However, unexplained losses were a major category of loss in all 3 facility types, which suggests that Canadian facilities as a whole lack adequate capacity to track and secure opioids. Furthermore, each type of facility may benefit from targeted research to address unique vulnerabilities: community pharmacies were most susceptible to armed robbery and break and enter, hospitals faced a high rate of pilferage, and company losses often occurred during drug transit.

The analysis also showed that opioid loss reporting should include the quantity of milligrams lost. Community pharmacy losses remained stable over time when measured in milligrams, but loss rates increased when loss was measured by dosage units or incidents of loss. Hospital losses increased over time when measured in milligrams but not when measured by dosage units or incidents of loss. These findings show that dosage units or incidents of loss alone do not tell the full story; reporting losses in milligrams provides an important complementary means of assessing loss trends over time within and between facility types or provinces.

According to the International Narcotics Control Board, Canada consumed 7747 kg (legally acquired) of the 5 opioids analyzed for 2017.²⁶ The average annual loss in our data set therefore represents 0.25% of Canada's consumption. However, the true quantities of loss are likely higher than what our analysis estimates and suggest that an annual loss of 19.6 kg of opioid from Canadian facilities is not trivial.

Previous literature highlights challenges with detecting or reporting losses; hospitals have been fined for insufficient record-keeping and failing to report drug losses.^{27–29} One endoscopy clinic found that more than \$10 000's worth of propofol was unaccounted for in a single 4-week period.³⁰ These examples suggest that poor traceability obscures detection and reporting of drug losses. Inclusion of nonopioids in future studies would increase the total milligrams lost and the subsequent costs of drug lost.

The 2018 US Drug Enforcement Agency report described an annual average loss of 12.2 million opioid dosage units,¹¹ compared to 1.1 million dosage units in our data. This discrepancy is similar to the population difference between the US and Canada, which suggests that rates of opioid loss and theft are similar in the 2 countries.

Our findings suggest 4 areas of work that may help better understand and potentially mitigate opioid losses and thefts. First, Health Canada and provincial and territorial regulatory bodies may want to assess the impact of their inspection practices against opioid losses moving forward. In 2015, Health Canada began a community pharmacy inspection program.³¹ Data show an upward trend in the incidents and dosage units of opioid lost after this program began but no substantial increase in milligrams lost (Table 4). In contrast, in 2016, the Ontario College of Pharmacists started to inspect and accredit Ontario hospital pharmacies;³² since then, there has been an increase in milligrams lost to pilferage (Appendix 1, section 6). Further research into the differences between these inspection programs might reveal why such differences were observed and support optimal inspection practices that can be used for all Canadian facilities responsible for opioids. Inspection practices for companies could also be reviewed to ensure they are similarly effective, given that they contribute larger opioid milligram losses than hospitals.

Second, analysis of regional differences may provide insight into best practices that could be adopted nationally.

British Columbia showed a notable reduction in community pharmacy losses from armed robberies and break and enter incidents (Appendix 1, Supplemental Table S9), possibly owing to the implementation of time-delay safes.^{33,34} Caution in drawing strong conclusions is warranted given that there were increases in other loss categories (e.g., unexplained losses) in BC. However, armed robbery and break and enter are one of the primary reasons for loss in community pharmacies, and regional differences of this nature may provide regulators and facility managers some indication of potentially helpful practices that may be worth adopting.

Third, the prominence of “unexplained losses” in all facilities suggests that further research is needed to understand why Canadian facilities are unable to track the reasons for loss. The high rate of unexplained losses also raises questions about the misclassification of drug losses. For example, reports of accidental breakage or spillage of a controlled drug may actually be false reports made by hospital staff to obscure diversion, particularly if there are not robust processes in place to verify these losses.

Finally, to support these areas of work, we suggest that Canadian stakeholders would benefit from an annual summary of controlled substance losses reported to Health Canada, similar to that published by the US Drug Enforcement Agency.¹¹ This report would facilitate regular assessment of losses and monitor changes over time. Given our findings, the report should include milligram losses by province and territory. To facilitate analysis of milligram losses, the Health Canada loss and reporting form should capture the number of milligrams lost per drug and the dosage format of the loss, to reduce the number of ambiguous reports captured in its data. The current reporting form is ambiguous, as the reported quantity could refer to the dosage form (e.g., patch, ampoule) or the unit (e.g., micrograms, millilitres).

Limitations

Our analysis has several limitations. First, the Health Canada data may be subject to reporting bias. Jurisdictions with high reported losses may not have experienced a true higher loss rate, but, rather, may have been more diligent at reporting the losses they did experience.

Second, not all drug losses are due to diversion, and diverted drugs may be used personally rather than resold on the street market. Our analysis is not intended to estimate actual revenue from street sales of drug lost but, rather, to contextualize the potential losses and highlight the differences between wholesale costs and street value.

Third, our estimates of wholesale costs and street value are simplified, as we applied single point-in-time estimates (without discounting costs over the data set time span) from selected provincial formularies or police services to the whole data set. Wholesale costs were drawn from 2019 formularies, and police services data reflect average street pricing across geographic areas and the database time frame of 2012–2017.

Finally, 567 reports (0.9% of the data set) were anomalous, which necessitated assumptions to complete our analysis. The anomalous reports were responsible for about 10%

of the milligram losses in the data set and are described further in Appendix 1, Supplemental Table S4.

Conclusion

The drug losses estimated conservatively are large and suggest the need for further research given the other, indirect costs of drug diversion. For example, drugs diverted from the health care system can be resold, channelling taxpayer dollars directly into the hands of drug traffickers while increasing the supply and harms of illicit opioids to surrounding communities, and burdening patients and prescribers who require opioids for legitimate medical use. Our findings suggest that annual reporting of milligram losses by province and territory for use by policy-makers and the public will likely further awareness and research on this topic.

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