

## Trends in Medical Use of Opioids in the U.S., 2006–2016

Brian J. Piper, PhD, MS,<sup>1</sup> Dipam T. Shah, BS,<sup>1</sup> Olapeju M. Simoyan, MD, MPH,<sup>2</sup>  
Kenneth L. McCall, PharmD, BCGP,<sup>3</sup> Stephanie D. Nichols, PharmD, BCPS, BCPP<sup>4,5</sup>

**Introduction:** The U.S. is experiencing an opioid epidemic which is at least partially iatrogenic and fueled by both prescription and illicit misuse. This study provides a nationwide examination of opioid distribution patterns during the last decade.

**Methods:** Data were obtained from the U.S. Drug Enforcement Administration's Automation of Reports and Consolidated Orders System for 2006–2016. Analyses include quantities of ten opioids legally dispensed nationwide by weight and converted to Morphine Milligram Equivalents. Geospatial and state-level analyses were also completed in 2017.

**Results:** The total for ten opioids peaked in 2011 (389.5 metric tons Morphine Milligram Equivalents) relative to both 2006 (286.1) and 2016 (364.6). Changes in the volume of opioids by weight over the decade were agent specific. Since 2011, there were decreases in hydrocodone (–28.4%); oxycodone (–28.0%); fentanyl (–21.4%); morphine (–18.9%); oxycodone (–13.8%); and meperidine (–58.0%) and an increase in buprenorphine (75.2%) in 2016. There were substantial inter-state variations in rates with a fivefold difference between the highest Morphine Milligram Equivalents in 2016 (Rhode Island=2,623.7 mg/person) relative to the lowest (North Dakota=484.7 mg/person). An association was identified between state median age and per capita Morphine Milligram Equivalents ( $r = 0.49$ ,  $p < 0.0005$ ).

**Conclusions:** With the exception of buprenorphine, used to treat an opioid use disorder, prescription opioid use has been decreasing over the past 5 years in the U.S. Further efforts are needed to continue to optimize the balance between appropriate opioid access for acute pain while minimizing diversion and treating opioid addiction.

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### INTRODUCTION

Misuse of prescription opioids has exerted a tremendous toll on the U.S. over the last decade<sup>1,2</sup> but the opioid epidemic may be evolving. More than 33,000 drug overdoses involving an opioid occurred in 2015.<sup>3</sup> Further, the peak age for drug overdoses was between ages 45 and 54 years.<sup>3</sup> According to pharmacy records, analysis of opioid prescriptions revealed an 18% decrease from 2010 to 2015 in the Morphine Milligram Equivalent (MME) per capita but an increase in the average days' supply.<sup>4</sup> The MME was highest in many counties throughout Tennessee and Delaware.<sup>4</sup> Substance use treatment admissions involving a prescription opioid were more than threefold

elevated in 2011 relative to 2004. Furthermore, although oral use is the primary nonmedical route, inhalation, smoking and injection have become more prevalent

From the <sup>1</sup>Department of Basic Sciences, Geisinger Commonwealth School of Medicine, Scranton, Pennsylvania; <sup>2</sup>Department of Clinical Sciences, Geisinger Commonwealth School of Medicine, Scranton, Pennsylvania; <sup>3</sup>Department of Pharmacy Practice, University of New England, Portland, Maine; <sup>4</sup>Department of Pharmacy Practice, Husson University School of Pharmacy, Bangor, Maine; and <sup>5</sup>Department of Psychiatry, Tufts University School of Medicine, Boston, Massachusetts

Address correspondence to: Brian J. Piper, PhD, MS, Department of Basic Sciences, Geisinger Commonwealth School of Medicine, 525 Pine Street, Scranton PA 18509. E-mail: psy391@gmail.com and bpiper@som.geisinger.edu.

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and accounted for 41.1% of prescription opioid administration routes.<sup>5</sup> These non-oral routes, and injectable routes in particular, substantially increase the risk for HIV<sup>6</sup> and hepatitis C.<sup>7</sup> Perhaps encouragingly, self-reported nonmedical use of non-heroin narcotics decreased from 13.4% in 2006 to 7.8% in 2016 among high school seniors.<sup>8</sup> However, past-year heroin use at older ages (18 years and older) has increased.<sup>9</sup>

The Automation of Reports and Consolidated Orders System (ARCOS) is a publicly available data set of controlled substances that are reported to the U.S. Drug Enforcement Administration. Relative to more restricted sources of prescription opioid information,<sup>4,10,11</sup> the advantages of ARCOS are that data reporting is mandatory and much more comprehensive to include not only pharmacies but also hospitals; federal institutions (Veterans Affairs, Indian Health Services); long-term care facilities; palliative care; veterinarians; and Narcotic Treatment Programs (NTPs). ARCOS analyses identified pronounced changes in opioids, including a 20% decrease in the volume of codeine but increases in fentanyl (35%); methadone (37%); morphine (64%); hydrocodone (73%); oxycodone (117%); hydromorphone (140%); and buprenorphine (2,318%) between 2004 and 2011.<sup>12</sup> An analysis of ARCOS would provide more recent data from a complementary source<sup>4</sup> at the level of individual agents and geographically to inform public policy. Therefore, the objectives of this report are to provide (1) an update on medical use of prescription opioids in the U.S. over the past decade; (2) examine changes in opioids for the treatment of pain versus an opioid use disorder (OUD) at a state level; and (3) determine if state demographics (i.e., median age) were associated with the opioid quantities.

## METHODS

### Study Sample and Measures

ARCOS is a federal program mandated by the 1970 Controlled Substances Act that reports on narcotics in Schedules I to III from pharmacies, hospitals, and NTPs and was used previously.<sup>2,12-18</sup> Ten opioids were selected based on prior reports<sup>12,14,15,17,18</sup> including eight primarily used for pain (oxycodone, hydrocodone, morphine, codeine, hydromorphone, oxymorphone, meperidine, and fentanyl) and two for opioid addiction (methadone and buprenorphine). Results were compared to a Prescription Drug Monitoring Program (PDMP) to validate ARCOS. The correlation between ARCOS and the Maine PDMP for oxycodone by weight over 5 years was high ( $r_{[3]} = 0.985$ ,  $p \leq 0.002$ ) but the PDMP was only 78.5% of ARCOS (ARCOS=329.7 kg, PDMP=258.9 kg,  $t_{[4]} = 19.83$ ,  $p < 0.0005$ ; Appendix Figure 1, available online). Prior ARCOS publications have covered the U.S. from 1997 to 2003,<sup>15</sup> 1999 to 2008,<sup>13</sup> 1999 to 2015,<sup>16</sup> 2000 to 2010<sup>14</sup>, or 2002,<sup>18</sup> Puerto Rico from 1999 to 2013,<sup>16</sup> and North Carolina from 1997 to 2010.<sup>2</sup> Although recent (2011–2016) data was the primary emphasis,

earlier information was included for comparative purposes. This study was deemed exempt from review by the University of New England's IRB.

### Statistical Analysis

Five main analyses were completed between July 2017 and October 2017: (1) the total MME for all ten opioids, and also excluding methadone and buprenorphine, was calculated (in metric tons) for each year and expressed as the difference relative to the peak year (2011); (2) total raw weight (in kg) for each opioid per year; (3) weight per jurisdiction (state and territory) reported to ARCOS; (4) total MME per jurisdiction corrected for population (MME per person) using the Census; and (5) the Pearson correlation between median age per state as reported by the U.S. Census and MME. These analyses were completed to potentially identify patterns in agents or regions that could inform opioid policy. In order to correct for the relative potency of each opioid, oral MME conversions were completed using the following multipliers: buprenorphine 10, codeine 0.15, fentanyl 75, hydrocodone 1, hydromorphone 4, meperidine 0.1, morphine 1, oxycodone 1.5, and oxymorphone 3.<sup>2,13,16,19</sup> For methadone, an MME conversion factor of 12 was used for NTP and 8 for all other sources.<sup>20</sup> Data analysis was completed with Systat, version 13.1. Heat maps were prepared with Carto, version 2.1, and other figures with GraphPad Prism, version 6.07.

## RESULTS

The total weight for all ten opioids over the past decade peaked in 2011 at 389.5 MME metric tons. Figure 1A shows opioids expressed as a percentage of the peak year. Opioids in 2006 were 26.5% lower than 2011 levels. However, opioids in 2016 were 6.4% lower in 2016 compared with 2011. The rate of decrease escalated in the more recent period with 0.7% reduction from 2011 to 2012 vs 4.3% from 2015 to 2016. Methadone accounted for 40.5% (methadone from NTPs=27.2%; Appendix Figure 2, available online) whereas buprenorphine was responsible for 4.4% of the total MME in 2011. With methadone and buprenorphine excluded, the same general pattern was evident with the maximum MME of 214.6 MME metric tons in 2011. Figure 1A also expresses the MME as the percentage of the peak year for eight opioids. These opioids decreased by 2.7% from 2011 to 2012, but by 5.9% from 2015 to 2016.

Figure 1B depicts the total volume of each agent from 2006 to 2016. For five drugs (oxycodone, hydrocodone, morphine, oxymorphone, fentanyl) volume was highest in the middle of the study period and had an appreciable (>10%) reduction since 2011. Meperidine exhibited a pronounced decrease of 79.1% from 2006 to 2016. By contrast, buprenorphine in 2006 accounted for 10.3% of current levels in that year. Figure 1C demonstrates relatively small (<5%), but statistically significant, declines in methadone and oxycodone; intermediate

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