



# **Patient Safety Visual Analytics Reporting System**

**Emerging and Innovative Technologies**  
NASCIO 2016 State IT Recognition Awards

Patient Safety Authority  
Commonwealth of Pennsylvania

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Project Initiation: February 10, 2014 (Proof of Concept)  
Project End: January 29, 2015 (Production Launch)

## Executive Summary

Since its inception in 2003, the Pennsylvania Patient Safety Authority (PSA) has developed one of the nation's largest databases of medical error event reports through its Patient Safety Reporting System (PA-PSRS). The PA-PSRS database contains over 2.5 million reports from Pennsylvania health care facilities, with each report containing over 200 data and text fields detailing both patient harm and near-miss errors. PSA analysts and patient safety liaisons (PSLs) use this data in their research, to author journal articles, and in working directly with health care facility staff to improve patient safety and reduce medical errors in Pennsylvania.

Through PSA's first decade, custom data requests from PSA management, staff analysts, and PSLs were routed through a single data analyst responsible for constructing complex SQL queries to extract the requested information. This process frequently progressed through multiple iterations, with queries often generating progressive follow-on requests resulting in substantial queuing and workflow delays.

In 2013, PSA conducted a study of data warehouse design and analytic solutions to enhance PA-PSRS data structure and performance. While the initial focus of this initiative was on data warehouse design, the appearance of a new generation of business intelligence (BI) products, as well as very powerful and suddenly affordable commodity hardware, refocused PSA's efforts on exploring the availability of advanced query engine, business intelligence, and data visualization capabilities.

In January 2015, PSA launched the Visual Analytics Reporting System (PSA VA) utilizing a custom build of SAS Institute's Visual Analytics (SAS VA) business intelligence and data integration product as an advanced query engine and web-based reporting tool for the PA-PSRS database. This decision saved hundreds of thousands of dollars in database redesign and development.

A substantial benefit gained from the implementation of PSA VA afforded the PSA staff, almost none of whom have IT backgrounds, the ability to build customized, web-based data queries and analytic reports. Now, many of PSA's field and analytic staff develop their own BI tools in PSA VA, applying a variety of visual objects, statistical measures, and data sources to create novel reports accessed over the web and shared remotely with co-workers. Furthermore, SAS VA is capable of ingesting data sets from outside sources, further expanding the scope and utility of the PA-PSRS database. In so doing, PSA has merged staff expertise with system development, yielding multiple efficiencies.

PSA-VA has allowed staff to gain new insights from the PA-PSRS data, demonstrating the effectiveness of PSA's programs and creating new opportunities to further assist Pennsylvania health care facilities to improve patient safety and reduce medical errors.

# Project Narrative

## Concept

On March 8, 2016, the Department of Health and Human Services (HHS) issued its Final Rule on the Patient Protection and Affordable Care Act's (ACA) Benefit and Payment Parameters. In the Final Rule comments, Pennsylvania's mandatory Patient Safety Reporting System was noted as one of only two examples (along with Maine) of "robust, evidence-based, effective patient safety programs that have delivered high value and improved patient safety across their regions." The Final Rule Response then concludes, "We acknowledge that there could be local, State, or national patient safety reporting programs that meet or exceed the patient safety standards for ... the QHP [Qualified Health Plan] issuer patient safety requirements...."

It is one thing to have developed the nation's largest and most recognized statewide patient safety database, but quite another to turn that data into usable information, mining powerful insights and even life-saving information from 2.5 million medical error reports, containing over 500 million data fields, and billions of text field characters.

Having spent ten years designing and enhancing the PA-PSRS database and data intake systems, the PSA now receives a quarter million reports each year from over 1,200 licensed Pennsylvania health care facilities. In 2013, PSA's Board identified a strategic initiative directing development of a more efficient data design, capable of providing not just the best answers, but of inspiring innovative questions from PSA's analysts, researchers, and PSL's working directly with health care facility staff to improve patient safety and reduce medical errors. While the initial focus of this initiative was on data warehouse design, the appearance of a new generation of business intelligence (BI) and data integration products, as well as very powerful and suddenly affordable commodity hardware, refocused PSA's efforts on exploring the availability of advanced query engine, BI, and data visualization systems and capabilities.

After much research and engaging in vendor and product demonstrations, PSA leveraged its recent database mapping and design work to participate in a proof of concept (POC) build of SAS Institute's Visual Analytics system. The POC was completed during a blizzard shortened week in February 2014 by a small team of PSA staff working with a SAS software architect. In three days, the team installed the SAS application on a networked server built just days before the POC, then linked, transformed, and loaded PSA's complete core acute care data tables, designed and built several detailed reports and explorations, and concluded with a live system test and analytic presentation to PSA management, analysts, and IT staff. By July 2014, PSA had negotiated and executed a bundled licensing, consulting, and training package, retaining the same SAS architect for the production build and design of the

initial library of PSA VA reports. Training and development were completed by December 2014, and the production system went live on January 29, 2015. Over a similar timeline and with spectacular results, PSA saved hundreds of thousands of dollars or about half the original data warehouse budget.

## **Significance**

The effect of this project has been transformational throughout the Patient Safety Authority. PSA VA has been key in identifying and measuring PSA's success in fulfilling its mandate under Pennsylvania's Medical Care Availability and Reduction of Error (MCARE) Act of 2002. It is the declared policy of the MCARE Act "... to reduce and eliminate medical errors by identifying problems and implementing solutions that promote patient safety." Under the Act, PSA is responsible for the collection, analysis and evaluation of medical error reports submitted by licensed health care facilities. These reports include Serious Events, in which actual physical harm has reached the patient, and Incidents or "near misses", in which a medical error occurred but did not reach or harm the patient. PSA is an independent, non-regulatory governmental agency of the Commonwealth of Pennsylvania. The confidential reports and data PSA receives through PA-PSRS are strictly confidential and not subject to discovery or Public Records laws. However, PSA can disclose its data in statewide aggregate totals, which it does in its [Annual Reports](#), while not identifying any specific facilities or individual events.

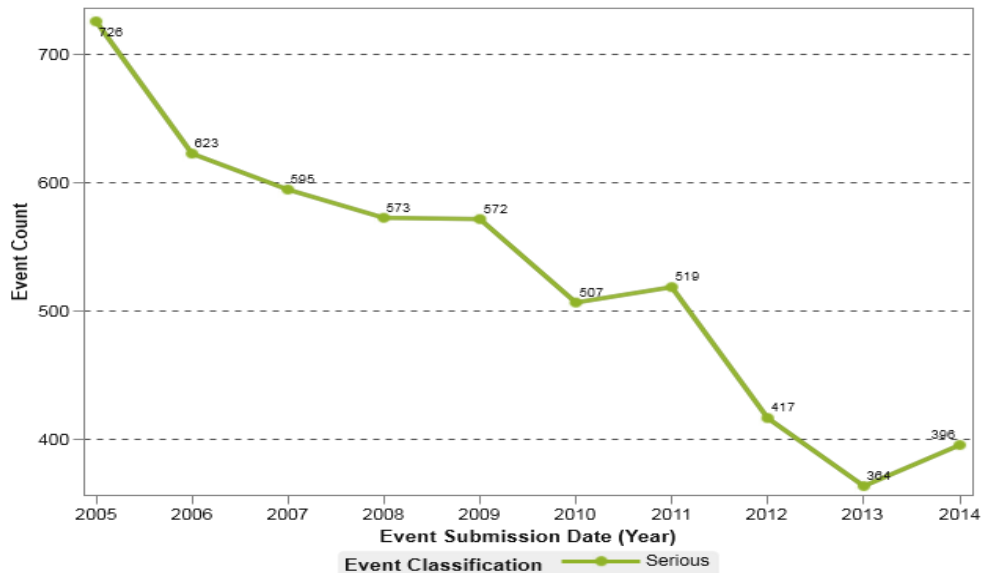
The PSA is also responsible for advising health care facilities on changes that can be made to avoid or eliminate such errors. This advice is given in a number of ways including the publication of the [Pennsylvania Patient Safety Advisory](#), PSA's quarterly scholarly journal, at no charge to subscribers. Also, PSA's Patient Safety Liaison (PSL) program directly advises individual facilities on specific trends and improvements, and conducts educational programs on a wide variety of patient safety topics.

Because of its mission and role in government, the PSA works to continually improve measurement indicators both programmatically and in relation to the goal of reducing and eliminating medical errors. While the number of reports that PSA receives are not an absolute measure of the number of medical errors in Pennsylvania health care facilities, the PA-PSRS reports are considered to be an accurate measure of trends and improvements in Pennsylvania patient safety.

With the implementation of PSA VA, the ability to access these measurements and identify trends has vastly improved. One of the first reports produced through PSA VA was the analysis of "High Harm" event reporting through PA-PSRS. Both Incidents and Serious Events are defined through a harm score taxonomy which designates harm scores A through D as Incidents, and E through I as Serious Events. The High Harm

events are scored as G (permanent harm), H (a near-death event), and I (an event that contributed to or resulted in death). The following figure is the graphed results of the High Harm Event Count analysis run on PSA VA shortly after the system went into production:

Annual High Harm Event (G,H,I) Report Count by Submission Date (2005-2014)



Over the 10-year period from 2005 through 2014, High Harm events reported in Pennsylvania declined from 726 reports in 2005 to 396 reports in 2014, a 45% decline. This trend can be viewed as indicative of an actual decline in High Harm events in Pennsylvania during this period. This outcome not only supports the work of PSA and the intent of the MCARE Act, but these results also suggest a very positive effect on people’s lives, alleviating suffering, and in fact preventing death in many cases. The monetary savings associated with this decline are measured in tens of millions of dollars, if not more. While this data already existed in the PA-PSRS database, the implementation of PSA VA facilitated both the asking of these important questions and the extraction of accurate answers, turning PA-PSRS data into usable and highly significant information.

## Impact

The use of PSA VA has also been very successful in identifying data relationships that had previously been unexplored or unrecognized. Often PSA VA analysis begins with the most fundamental questions. For instance, an initial test of a correlation visualization led to fascinating research into how gender may influence specific types of medical errors. It first appeared that several medical error event types were skewed either to male or female patient populations. Men appeared to experience more Falls and Skin Integrity events, while women had significantly more Adverse Drug Reactions (not related to a medication error). The PSA VA system provided the ability to filter PA-PSRS data, removing factors that could

skew reported data, such as age range (women live longer), gender specific care areas, or reports that contained language in event detail fields indicating gender specific conditions or procedures.

Upon activating these filters, the remaining reports contained data that was significantly more gender neutral, with differences in gender frequency relating more specifically to the type of error, rather than a generalized effect of gender bias in the original data distribution. The following table captures Serious Event data since 2010 by gender, filtered by age range (18-65), and excludes gender based care areas and gender related procedures and infirmities. One can see that certain primary medical error event types are still influenced by gender, particularly Adverse Drug Reaction (skewed female), and Skin Integrity (skewed male):

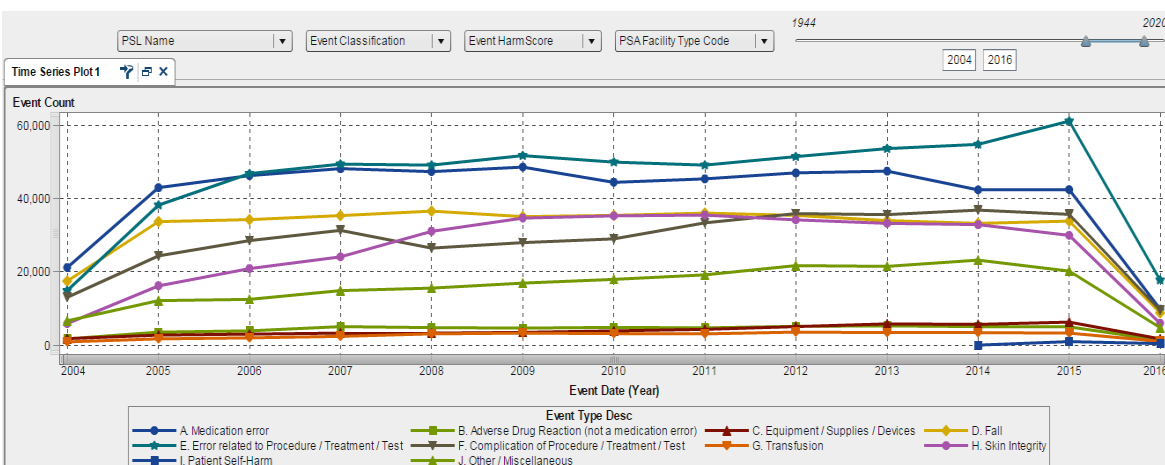
Patient Gender Analysis 2010-Present	Female	Male
Event Types (filtered for age and procedure bias)	Frequency	Frequency
A. Medication error	309	262
B. Adverse Drug Reaction (not a medication error)	491	296
C. Equipment / Supplies / Devices	73	78
D. Fall	968	1,047
E. Error related to Procedure / Treatment / Test	896	712
F. Complication of Procedure / Treatment / Test	3,521	3,285
G. Transfusion	29	20
H. Skin Integrity	491	774
I. Patient Self-Harm	47	52

PSA VA gives each user the ability to drill down into customized, user controlled event hierarchies to determine which sub-events are driving these results. The following is the drill down to the next hierarchical level of Adverse Drug Reaction events, applying all the same filters. One can observe that the frequency of certain Adverse Drug Reaction sub-events appears strongly influenced by patient gender:

All Event Type Drill Down > B. Adverse Drug Reaction (not a medication error)		
Patient Gender Analysis (2010-Present)	Female	Male
Adv Drug Rx (Filtered for Age and Procedure Bias)	Frequency	Frequency
1. Skin reaction (rash, blistering, itching, hives)	217	121
2. Hypotension	15	11
3. Arrhythmia	3	1
4. Hematologic problem	8	5
5. Nephrotoxicity	5	4
6. Dizziness	5	1
7. Mental status change	59	34
8. Other (specify)	179	119

Such findings will continually raise more questions for the PSA VA researcher. The next step might be to drill down further through the hierarchy to differentiate another level of event sub-types, or to examine data at individual facilities or by unit type, or to analyze the underlying text fields describing these events. These procedures should eventually lead to a better understanding of factors influencing patient safety events and may ultimately result in changes to procedures, policies or cultures reducing medical errors and patient harm in Pennsylvania and nationally.

A substantial benefit gained in the implementation of the PSA-VA resulted in PSA's research and PSL staff building their own original, customized, web-based reports and explorations. Because PA-PSRS data is strictly confidential (except in aggregate form), end-users only comprise PSA's patient safety analysts, patient safety liaisons, and infection control professionals, almost none of whom have IT backgrounds. At the January 2015 production release, PSA VA users could already generate their own data queries, set multiple filters, and build drill-down hierarchies in dynamic report designs. Here is a report showing all reported Incidents and Serious Events by year. The report contains pull-down filters (across the top) for PSL Name, Event Classification, Harm Score, Facility Type and a Date Range slider. Often data is also filtered for specific facilities to support direct PSL consultations with facility staff. Each of the Event Type lines and data points can be clicked-on to drill down the defined hierarchy to gain access to underlying data.



Within months after the PSA-VA production release, many PSLs and staff analysts began designing their own web-based reports and explorations, applying visual objects, statistical measures, and new data sources to create novel reports that could be shared remotely with co-workers. Each new report design became a template for further development in users' Personal Folders within PSA VA. Successful designs are then moved into Shared Areas for staff access. In doing so, PSA has hybridized its health care expertise with innovative system development skills, producing a paradigm shift in professional performance and efficiencies.

### Technical Specifications

PSA VA is designed with a highly secure web interface and user authentication, approved for production through a comprehensive application security certification process conducted by the Commonwealth's CISO office. The production system runs on a physical 16-core, 256 GB RAM, Windows 2012 64-bit Server, 1TB SAN, running SAS Visual Analytics 7.1 (soon to be upgraded to VA 7.3) on a SAS LASR Server. PSA-VA also runs on a corresponding test/backup server with SAS VA 7.3.