PATIENT SAFETY: THE ROLE OF INFORMATION TECHNOLOGY IN REDUCING MEDICAL ERRORS

An IEEE-USA White Paper

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Introduction: The Scope of the Problem

According to the *OECD Health Data 2009 - Statistics and Indicators for 30 countries* report, the United States ranked lower than many industrialized nations in several measures of health care quality for 2006, including childhood immunization for diphtheria, tetanus, and pertussis (DTP), total life expectancy, and infant mortality.[1]

Another study, conducted in 2007 by the Commonwealth Fund, compared the United States with five other industrialized nations -- Australia, Canada, Germany, New Zealand and the United Kingdom -- and put the Unite States in last place in terms of health care access, patient safety, efficiency and equity.[2]

In 2007, total health expenditure for the United States was $2.3 trillion, or 16 percent of the Gross Domestic Product (GDP), up from the previous year by 6.9 percent, more than double the rate of inflation. This represents expenditures of $7,600 per person. This amount is expected to continue to rise for the next decade, reading $4.3 trillion, or 20 percent of the GDP, by 2016.

Yet, persons in countries with higher quality ratings paid less on average for health care, both in terms of individual cost and percentage of GDP spent on health care. Health care spending was 10.9 percent of the GDP in Switzerland, 10.7 percent in Germany, 9.7 percent in Canada, and 9.5 percent in France. Cost/individual in Germany is $3,005 and $3,165 in Canada.[3]

The high cost of health care in the United States is not only a problem for individual payers, but for the economy as a whole. Our system of employer-funded health insurance makes it difficult for businesses to compete in the global market, while providing health care insurance for their employees.

Cost containment and improvement in health care quality should not be seen as separate issues, but rather as problems that are intertwined in complex ways. This white paper proposes the use of information technology to improve patient outcomes, reduce the incidence of medical errors, and restrain the rising cost of providing health care to our citizens.

Scenarios for Health IT

The following five scenarios, based on fictitious, but realistic, patient encounter situations, are intended to illustrate the impact that health care information technology can have on outcomes, and to demonstrate the complex relationship between the cost of health care and the quality of health care. For each scenario, two possible outcomes are described -- one based on use of advanced health information technology, and one in which health IT is not used. The potential impact of health IT on patient safety and cost of treatment is described for each scenario.

Scenario 1: A 911 Call

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1 OECD (2009), *OECD Health Data 2009 – Statistics and Indicators for 30 countries*, online and on CDRom, Paris. See www.oecd.org/health/healthdata.
2 Davis K, Schoen C, Schoenbaum S C, Doty M M, Holmgren A L. Kriss J I, Shea K K, "Mirror, Mirror on the Wall: An International Update on the Comparative Performance of American Health care," Commonwealth Fund, May 2007, vii. http://www.commonwealthfund.org/publications/publications_show.htm?doc_id=482678
3 "Health Insurance Costs," National Coalition on Health care website, http://www.nchc.org/facts/cost.shtml

A 75-year-old female calls 911, complaining of dizziness, and feeling faint. An ambulance is dispatched to her home address. Emergency medical team members find the woman unconscious and unable to respond to questions.

Possible Outcome with Advanced IT: EMTs use a PDA to query the woman's medical history, following their "break the glass" protocol. They find a longitudinal EHR for the woman from another hospital in the same RHIO, which indicates that the woman is diabetic, has poor vision and a history of repeated diabetic coma due to incorrect insulin dosage. With this information, the EMT personnel are able to quickly stabilize the woman's condition. She regains consciousness on the way to the hospital, where she is admitted for a short period for observation.

Possible Outcome without Advanced IT: EMTs have no way of knowing what caused the episode of unconsciousness. The woman is transported to the hospital and enters the emergency department unconscious. She receives an expensive MRI scan to eliminate the possibility of a stroke as the cause of her unconsciousness. Her condition is not correctly diagnosed until laboratory tests reveal that she is suffering from hypoglycemia. She is admitted for an undetermined length of time.

Impact on Patient Safety

Without the ability to access patient records online, it would take longer to obtain diagnosis, possibly worsening the patient's condition. Not having a medical record available to the EMT team would increase the possibility of an incorrect/delayed diagnosis and possible incorrect treatment. No consent form was obtained before she regained consciousness, increasing possibility of legal liability.

Impact on Cost

Additional testing needed to diagnose her condition would add to total cost of hospitalization.

Summary - Scenario 1

Health IT needed to support this scenario would include:

- Electronic Health Records (EHR) made available regionally via RHIO, or globally via NHIN

- Wireless connectivity for PDAs or similar devices available to EMT personnel

- A "break the glass" protocol enabling health care providers to access personal health information in emergency situations

Scenario 2: Patient Hospitalization

While in the hospital, it was noted that the patient was dehydrated. An IV drip was administered to treat this condition.

Possible Outcome with Advanced IT: A checklist procedure was followed during the IV insertion, ensuring that proper hand washing procedure was followed, a sterile field was maintained during the procedure, and that the patient was in the proper posture for IV insertion. Use of the checklist was noted in the electronic medical record. The keyboard used for data entry was of a special pathogen-resistant material, and was properly sanitized on a regular schedule.

Possible Outcome without Advanced IT: No checklist procedure was followed. The patient contracted a hospital-acquired infection, due to failure to follow proper hand washing procedure. The source of the infection may have been a computer keyboard used by many of the floor nurses. The patient required additional aggressive treatment with antibiotics to cure the infection, prolonging her hospital stay.

Impact on Patient Safety

The patient acquired an infection as a result of her hospitalization, endangering her health, and requiring a longer stay.

Impact on Cost

The longer hospital stay, and the need for additional treatment and drugs, increased the cost of her hospitalization.

Summary - Scenario 2

Health IT needed to support this scenario would include:

- Use of checklists documented in the electronic medical record

- Use of health IT hardware (keyboard) designed for use in a clinical environment

Scenario 3: Documenting Diagnosis and Treatment

The patient's diagnosis and treatment are recorded.

Possible Outcome with Advanced IT: Patient orders are entered in a timely fashion by a physician using a Computerized Provider Order Entry (CPOE) system with an easy-to-navigate user interface, and all billable procedures were coded correctly using ICD and CPT codes. The hospital IT network is robust and secure, having implemented industry standards for reliability, availability and security, as well as a well-defined backup schedule and a disaster recovery plan. The patient's preexisting conditions – diabetes and vision difficulties – are correctly coded as "present on admission." Reimbursement proceeds without complication. The physician consults a decision support system, which warns the physician that Orinase (tolbutamide), which the patient has been taking along with insulin, may be contributing to her hypoglycemia. He changes her medication to one of the newer drugs, and recommends regular visits by a home health care nurse to check on her blood sugar levels and insulin dosage, as part of her discharge plan.

Possible Outcome without Advanced IT: The physician, who dislikes the complicated user interface of the online patient charting system, fails to document necessity for tests, resulting in rejected claims. No discharge plan is created, leading to confusion about the patient's discharge date, and she is sent home before her medication is properly reviewed. The patient is discharged with the same medication regimen that led to her hypoglycemic condition. During the course of the patient's treatment, a network failure occurs in the hospital IT system, caused by a virus invading the system, as the result of an employee using the system for unauthorized access to an insecure site. Contributing factors include the failure of the network administrators to upgrade the network to support increased throughput, and failure to install necessary security patches. Backups were performed on an ad-hoc basis, and no disaster recovery plan was in place. When backups are applied, some of the patient's information is lost.

Impact on Patient Safety

Lack of a post-discharge plan and failure to change the patient's medication puts her at high risk of repeated hospitalization.

Impact on Cost

Tests and pharmacy orders lost as a result of the network failure result in missed reimbursement.

Summary - Scenario 3

Health IT needed to support this scenario would include:

- Use of a CPOE system with a user interface specifically designed for clinical use for entering physician orders

- Health IT network design based on industry standards for reliability, availability and security

- Well thought-out plans for backup of critical data and disaster recovery

- Use of a decision support system to correlate drug interactions with patient history

Scenario 4: Patient Discharged and Billed

The patient is discharged and returns home. The costs of her hospitalization and treatment are billed.

Possible Outcome with Advanced IT: Since the patient's identity and medical history were available in the online EHR when the patient was admitted, her admissions record contained her insurance information (Medicare Parts A and B, plus supplemental health care insurance). Her diabetic condition was noted, and Food Service adjusted her diet. Her billing correctly represented only her copayment. Medicare and her supplemental insurance covered the rest. Medicare claims were submitted electronically and promptly paid.

Possible Outcome without Advanced IT: Incomplete information was available when the patient was admitted. The patient's diet was initially incorrect, as the Food Service staff had no way of knowing that this patient was diabetic. The patient was disoriented upon first regaining consciousness, and mistakenly gave a prior address as her current address, so the initial CMS reimbursement claim was denied. Even after the address was corrected, CMS rejected the claim for treatment related to the hospital-acquired infection.

The patient's medical bill was sent to the wrong address and her supplemental insurance was not taken into account. This resulted in delays in obtaining reimbursement, and an excessive charge to the patient.

Impact on Patient Safety

The patient's recovery could have been hindered by an incorrect diet.

Impact on Cost

Initial rejections and delays in processing claims increased the costs of processing the insurance claims for the hospital. CMS no longer pays for treatment for hospital-acquired infections, reducing the hospital's ability to recover the costs of the patient's hospitalization. Failure to note supplemental coverage resulted in an excessive charge to the patient.

Summary - Scenario 4

Health IT needed to support this scenario would include:

- Longitudinal EHR with accurate patient information

- Ability to bill CMS electronically, using the X12n EDI transaction set

Scenario 5: Patient Follow-Up

Possible Outcome with Advanced IT: The patient returns home fully recovered with her diabetes under control. As a result of changes to her medication, she has no further episodes of unconsciousness. A home health care nurse visits periodically to monitor her self-administration of insulin, checks her blood sugar levels, and adds the information to her patient record using a PDA device. She is able to absorb the costs of her hospital stay without difficulty.

Possible Outcome without Advanced IT: The patient has repeated episodes of diabetic coma, due to the adverse effects of her prescribed medications and her difficulty in administering a correct dosage of insulin. As a result of her hospital overcharge, which she did not contest, she has difficulty paying her bills. Her family, concerned that she does not seem to be improving, begins to investigate her treatment at the hospital, and discovers that she acquired an infection while in the hospital. They file a lawsuit, and the hospital is required to pay a large settlement and undergo re-accreditation.

Impact on Patient Safety

Without advanced IT capabilities, the patient's treatment plan was a complete failure. The underlying causes of her hypoglycemia were never discovered, and no attempt was made to follow up on her status. Her initial condition continues to recur, and there is no improvement in her overall health.

Impact on Cost

The consequences of not implementing an advanced health IT system are enormous for the hospital. Costs of treating the patient were excessive, due to lack of proper patient identification at admission, and an extended stay to treat the hospital acquired infection. Since her original condition was not adequately diagnosed and treated, she will continue to require periodic hospitalization. No reimbursement could be obtained for the hospital acquired infection. And the lawsuit filed by the patient's family impacted not only the hospital's bottom line, but its reputation for quality as well.

Summary - Scenario 5

Health IT needed to support this scenario would include:

- Ability to monitor patient progress electronically using home health care nurses with PDAs

Health care IT - What Is Needed

Implementing the advanced IT capabilities mentioned in the previous scenarios would require a nationwide health information network, the adoption of interoperable electronic health records, and ePrescribing (electronic prescriptions); implementation of engineering principles and quality management in health care delivery; and funding for training programs in the medical industry to reduce medical errors.

Implementation of NHIN

Implementing a Nationwide Health Information Network (NHIN) has the potential to reduce the number of medical errors, by providing quick access to patient history and medical guidelines.
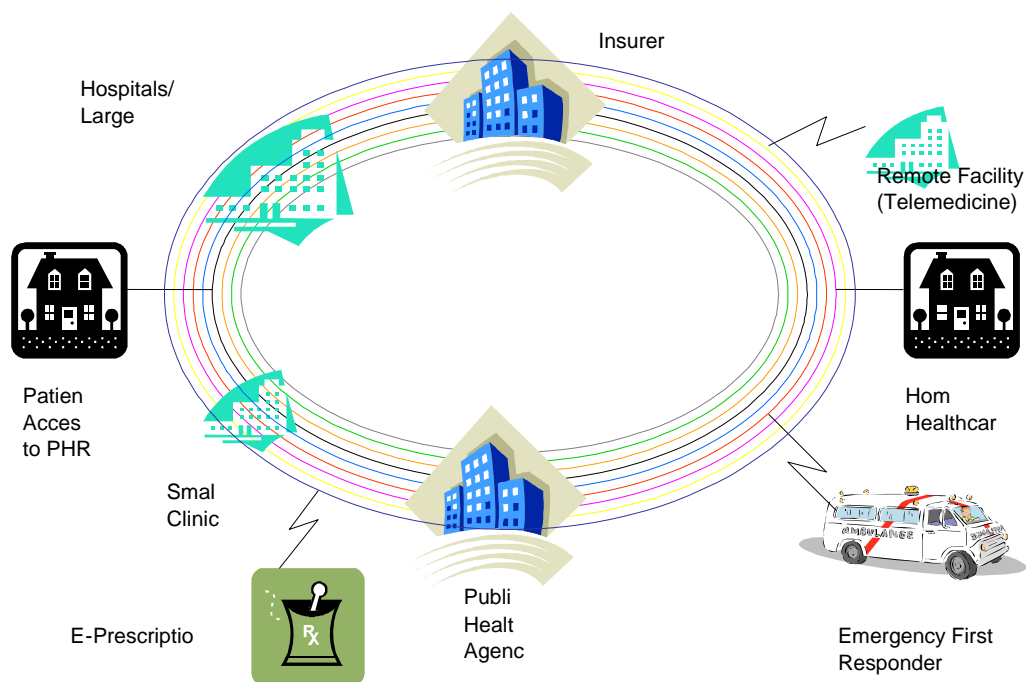
Functions of the NHIN include:

- Fast, ubiquitous access to online Electronic Health Records
- Online claims processing
- Transport of medical images
- Emergency medical response
- Coordination of Health Information Networks
- Telehealth for rural/underserved areas
- Longitudinal EHR
- Home health care
- E-Prescription

Benefits of a Nationwide Health Information Network could include the following:

- *Reducing the number of medical errors --* The fast and ubiquitous access to patient records and other medical information provided by the NHIN could reduce the number of medical errors due to inadequate information regarding a patient's history, prescribed medication and current condition.

- *Restraining the rising cost of providing health care --* Using an electronic network for transmitting health care-related information could reduce the overall cost of providing health care, by eliminating much of the current paper-based processing of patient records and health care insurance claims.

- ***Providing fast access to health care information in emergency situations --*** Implementing an NHIN could enable the sharing of confidential medical record information with enough speed and accuracy to be of value to a physician examining an emergency patient at a remote site.

- ***Coordination of federal Health Information Systems --*** Using an NHIN could expand access to health care information for health care providers and consumers. The Nationwide Health Information Network must interoperate with existing health information systems to make sharing of public health information, and health care delivery, reimbursement and oversight efficient and cost-effective.

- ***Use of Telehealth Systems to provide access to health care services in remote, rural or otherwise underserved areas*** -- An NHIN could make use of information technology to expand services to underserved areas.

Accelerate Standardization of Medical Information and Adoption of Electronic Health Records (EHR)

Standardized medical information transmitted across the NHIN will increase the efficiency of health care providers. It should enhance patient ownership and control of personal health information, especially as individuals transition between care settings. In addition, standardized medical information should facilitate quality assurance and clinical research programs.

According to the RAND Corporation study summary, "Health Information Technology: Can HIT Lower Costs and Improve Quality?" implementation of health care information technology (HIT) could reduce health care costs significantly. HIT includes electronic medical records (EMR/EHR), Picture Archiving Communications Systems (PACS), decision support systems, and Computerized Provider Order Entry (CPOE) systems.[4]

Some specific savings and quality improvements claimed in the summary report for implementation of CPOE include:

- ***Reduced hospital stays.*** Improved scheduling, increased safety, and reduced nursing administrative time, due to implementation of a CPOE system, could reduce hospital stays by 1 million bed-days annually. According to the Agency for Health Care Research and Quality's "National Statistics on All Stays," the average (mean) cost to the hospital per day in 2005 was $1,755/day for a mean stay of 4.6 days. Thus cost savings to the hospital could approach $2 billion annually.[5]

- ***Increased Safety.*** Use of CPOE with adverse medication warnings could prevent 200,000 adverse events per year, with a savings of approximately $1 billion/year.

Implementation of health care information technology has the potential to save as much as $77 billion per year, according to the RAND Corporation study. However, the summary report does not provide specifics about how this figure is obtained. A dissertation available from the RAND site provides some additional detail. It analyses the benefits of implementing PACS and EMR systems separately.

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4 "Health Information Technology: Can HIT Lower Costs and Improve Quality?"
(http://www.rand.org/pubs/research_briefs/2005/RAND_RB9136.pdf)
5 Agency for Health care Research and Quality, "National Statistics on All Stays," http://hcupnet.ahrq.gov/HCUPnet.jsp ,

- ***PACS.*** Capital expenditure for a PACS system is typically around $3.5 million. PACS efficiency savings come from eliminating costs relating to film processing, storage and distribution. A 200-300 bed hospital can typically save around $300,000 annually.
- ***EMR.*** EMR systems increase efficiency by eliminating the need to manage paper documentation. The Fonkych dissertation claims that an EMR system can reduce the costs of medical information management by 50 percent. It may also provide a 10 percent reduction in nurse's time, and a 12 percent reduction in duplicated lab tests.[6]

E-Prescription

Encourage e-Prescription systems, which offer a promising new alternative to reduce errors, such as illegible handwriting. Electronic prescriptions also offer immediate access to possible drug interactions, with closer monitoring of patient use of medications and/or duplicate prescriptions.

Patient Identification

Improve patient identification through interoperable, secure and private lifetime EHRs. In-patient errors due to misidentification can be further reduced through the use of electronic data capture, such as barcoding, RFID and biometric technology.

National Information Database of Medical Errors

Create an integrated national information database of medical errors, incident reports and projects' data that would be used to reduce errors. Also, we recommend providing funding and/or incentives to encourage innovative research efforts using advanced information technology to improve accuracy in patient medical information management, and reducing risk from human error.

Research Funding for Analysis of Errors in Outpatient, Long-Term Care, Home Health Care and Self-Care Settings

Promote research funding for analysis of errors in outpatient, long-term care, home-health agency, and self-care settings. Unlike the hospital setting, very little research has been done in these settings. Research should be undertaken to explore the types, frequency and severity of medical errors in these settings, and the steps that can be taken to reduce the frequency and severity of such errors.

Implement Principles of Engineering and Quality Management in Health care Delivery

Implement the principles of engineering and quality management, including:

- ***Use of standard quality control procedures, such as surgical checklists, to mitigate risk, and to ensure consistent outcomes.*** One such technique is the use of a checklist when performing common ICU procedures, such as inserting or removing a patient's intravenous line, an approach that was suggested by Dr. Peter Pronovost of Johns Hopkins Hospital. Dr. Pronovost's approach of using checklists for these and other procedures in ICUs was adopted by the Michigan Health

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6 K. Fonkych, "Accelerating the Adoption of Clinical IT Among the Health care Providers in US," http://www.rand.org/pubs/rgs_dissertations/2007/RAND_RGSD214.pdf

and Hospital Association as the Keystone Initiative and implemented in numerous ICUs in Michigan in 2004. Results were published in the December 2006 issue of the *New England Journal of Medicine*. In the first three months of the project, infection rates in Michigan ICUs fell by 66%.[7] In the Keystone Initiative's first 18 months, the hospitals saved an estimated hundred and seventy-five million dollars in costs, and more than fifteen hundred lives.[8] Documenting the use of such checklists as part of the EHR would provide verification that correct procedures were followed, and reduce the likelihood of medical errors and resulting malpractice claims.

- *Use of reliability/availability/disaster recovery/capacity planning concepts borrowed from telecommunications and enterprise network engineering.* **Some of these concepts include:**

  o *Capacity Planning -* Health IT systems need to plan for future growth, and take into account the increased performance, bandwidth and storage requirements of advanced IT systems such as PACS, CPOE and EMR/EHR.

  o *Distributed Architecture -* Health IT system design should utilize a distributed architecture with redundancy to eliminate single points of failure.

  o *Storage Architecture -* Backend storage should be designed with characteristics such as performance, access latency, reliability and security in mind.

  o *Backup/Recovery -* Health IT systems need to implement a comprehensive backup/recovery plan, including the ability to do offsite processing as part of disaster recovery. Backups must be performed on a regular basis.

  o *Archiving -* Inactive patient data should be archived on a regular basis, and stored in a secure location. Care should be taken to ensure that system changes and upgrades do not make archive media unreadable.

- *Development of user interfaces for medical devices that reflect the working environment in which clinical procedures are performed.* The following are some specific recommendations:

  o *The design of health IT systems should reflect the clinical environment in which they are used, and support the clinical protocols that they document and record.* Health IT systems should not be seen as an obstacle to efficient health care delivery.

  o *Computers, PDAs, and similar devices should not present a barrier to physician/patient communication.* Such devices must be unobtrusive in a patient/physician encounter.

  o *IT devices intended for use in a clinical environment should be designed to prevent interference from wireless, cell phones, microwave ovens and RFID devices from*

    affecting their operation. Conversely, such devices should not create interference with patient monitoring equipment.

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7 Pronovost et al, "An Intervention to Reduce Catheter-Related Bloodstream Infections in the ICU," New England Journal of Medicine, Vol. 355, Nr. 26, December 28, 2006. http://content.nejm.org/cgi/reprint/355/26/2725.pdf
8 Atul Gawande, "The Checklist," *New Yorker*, December 10, 2007, 94.

o *Health care IT devices intended for use in a clinical environment should be designed to help prevent the transmission of hospital-acquired infections.* For example, it has been shown that keyboards and air filters may serve as incubators of pathogens and sources of hospital-acquired infections. The use of special materials for these and other devices should be taken into consideration.

- *Use of advanced IT technologies, such as clinical decision support systems and data mining, to assist in diagnosis and reduce errors and unintended consequences.* Garg, et al., found in their 2005 study that the use of clinical decision support systems improved practitioner performance.[9] Mahoney, et al., found in 2007 that clinical decision systems were particularly effective in preventing medication errors.[10]

Summary: Can Health Care IT Improve Quality and Restrain the Rising Costs of Health Care?

Considerable evidence exists that implementation of advanced health care IT can result in improvements in patient safety and quality. A study conducted by the Health Care Information Management Systems Society in 2006 showed strong correlation between adoption of advanced health care information technology and improved patient outcomes.[11]

As demonstrated by this paper, implementation of health care IT can not only improve patient outcomes and quality of health care, but also restrain the rising costs of health care by reducing the number of days patients spend in hospitals, eliminating unnecessary laboratory procedures by providing more accurate patient information, and reducing the costs of medical errors that result in additional treatment and litigation. We can not only improve the quality of health care through implementation of advanced IT capabilities, but also make health care more affordable for all.

Additional Reading

Kilbridge P.M., Classen D. C., "Informatics Opportunities at the Intersection of Patient Safety and Clinical Informatics," *Journal of the American Medical Informatics Association*, April 24, 2008. http://www.jamia.org/cgi/content/full/15/4/397#BIB11

Kuperman et al, "Medication-Related Clinical Decision Support in Computerized Provider Order Entry Systems: A Review," *Journal of the American Medical Informatics Association*, 2007:14, 29-40. http://www.jamia.org/cgi/content/full/14/1/29

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9 Garg A.X. et al, "Effects of Computerized Clinical Decision Support Systems on Practitioner Performance and Patient Outcomes." *Journal of the American Medical Association,* Vol. 293 Nr. 10, March 9, 2005. http://jama.ama-assn.org/cgi/content/abstract/293/10/1223

10 Mahoney C. D. et al, "Effects of an Integrated Clinical Information System on Medication Safety in a Multi-Hospital Setting," *American Journal of Health-System Pharmacy*, Vol. 64, Issue 18, 2007. http://www.ajhp.org/cgi/content/abstract/64/18/1969

11 "EMR Sophistication Correlates to Hospital Quality Data," Health Care Information Management and Systems Society, http://www.himss.org/content/files/UHCresearch.pdf .

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