Bar Codes May Have Poorer Error Rates Than Commonly Believed

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By most accounts (1, 2), the development of bar code technology is credited to 2 graduate students at Drexel University. In 1948, Bernard Silver had overheard the president of a local grocery chain asking a dean at the University whether they could develop a system to read product information at checkout. Silver told his colleague Norman Woodland of this request. After one failed idea involving ultraviolet light, Woodland, convinced that he could solve this problem, quit his part-time teaching position at Drexel and moved to Florida to live with his grandfather. While walking on the beach one day and with the inspiration of the Morse code, he used sand to extend the dots and dashes of the codes downward in thin and thick lines. Silver and Woodland filed a US patent application on October 20, 1949, entitled “Classifying Apparatus and Method.” The patent, 2 612 994, was issued on October 7, 1952. It described both a bull’s-eye printing pattern of codes as well as a linear pattern similar to that of the bar codes we know today.

The initial adoption of bar code technology was slow. Attempts to track railroad cars, vehicles with monthly passes crossing a toll bridge, and US Post Office trucks all had limited success. A trial in which Kal Kan used bar codes to track cases of pet food for inventory control sparked the interest of the grocery industry, and a meeting of the National Association of Food Chains in 1966 discussed the use of automated checkout systems. Progress continued to be slow, but in 1974 the first successful scan of a Universal Product Code (UPC) code on a package of chewing gum at a grocery store in Troy, Ohio, ushered in the bar code era (1). Today, more than 2 dozen different linear bar code symbologies are in use, as well as a number of 2-dimensional coding systems. For the most part, these different codes have applications in different industries. In clinical laboratories, the codes most frequently used have been Code 39, Interleaved 2 of 5, and Code 128. CLSI standard AUTO02-A2 has specified Code 128 for sample labels for use in laboratory automation systems (3). Code 128 is also specified by the AABB for use by blood banks in blood component labeling (4).

Most of us working in the clinical laboratory industry understand that bar codes are far more accurate as a means of data entry than human keystrokes and that data are entered into the computer record much more quickly (2). For example, the entry of 12 characters with keystrokes may take 6 s, whereas reading a bar code of the same 12 characters may take <1 s. Furthermore, the error rate for keystroke data entry is generally stated to be 1 substitution per 300 characters, whereas bar codes, depending on the symbology used, have much lower error rates (2, 5). A few examples of error ranges for different bar code symbologies are: UPC, 1:394 000 (worst case) to 1:800 000 (best case); Code 39, 1:1.7 × 10^5 to 1:4.5 × 10^6; Code 128, 1:2.8 × 10^6 to 1:37 × 10^9 (5).

In this issue of Clinical Chemistry, Snyder and colleagues (6) report an unexpectedly high error rate of 1:84 000 with Code 128 on patient wristbands scanned with several bar code readers in point-of-care devices. The bar-coded patient identifiers were each 12 digits. Over the course of a full year, the authors observed a total of 10 substitutions of one or more characters for the correct characters out of 840 000 scanned wristbands. This rate is 15 times higher than the poorest error rate described for Code 128 and 440 times higher than the best-case error rate for that symbology (5).

The authors describe the rates of the observed incidences, in which various bar code readers substituted incorrect digits, “converted” Code 128 symbology to a different symbology (leading to completely incorrect identifiers that were rejected), or simply failed to read the encoded identifier on the patient wristband, again causing rejections. The rejections did not pose a potential for patient harm because the error was immediately noticed and the correct identifier was entered into the record; however, the substitution errors in which one or more incorrect characters replaced correct characters produced identifiers that appeared correct in format but that had the potential to cause patient harm if not caught and corrected.

In their investigation into the problem, Snyder and colleagues compared “pristine” bar codes printed by the printer vendors to bar codes printed on different models of these printers used in their facility.
research identified that one of the major causes for these errors was failure in the print heads on the label printers. The printers in use in clinical laboratories today are generally thermal transfer printers that use a combination of heat and a waxed ribbon. The labels are quite permanent and have high-resolution bar codes; however, thermal transfer print heads can become dirty or clogged from the label media or the ribbon so that they fail to transfer heat uniformly. These failures can lead to white streaks that obliterate part of one or more of the black bars that constitute the bar code. The resulting code (with a narrow bar instead of wide bar or perhaps no bar at all instead of a narrow bar) may be rejected, but it also could have a substitution error.

In their report, the authors also describe the corrective actions they took as a result of their investigation. The foremost was to turn the label stock by 90° in the printing systems so that any white streaks that might be caused by a defective print head would be perpendicular to rather than parallel with the bars in the bar code. Thus, even if a bar code had a white streak transversing the code, there would be sufficient high-quality bars above or below the streak so that most bar code readers would give a correct read. The authors also initiated printing a thick black line across all wristbands to reveal any defects with the printer in use. Finally, depending on the model of bar code reader used, one can often select the symbology printed on the labels as the only symbology that can be read by the reader, which eliminates the possibility of poor bar code quality causing the reader to interpret the code as a different symbology.

This report by Snyder et al. provides a valuable lesson to the clinical laboratory community. Perhaps we all take for granted that bar code technology has extremely low error rates, such as the 1 per 37 × 10^6 described as the “best case” for Code 128 (5). Thus, the possibility that a bar code error could lead to one patient’s result being associated with another patient’s medical record does not even occur to us. It is expected that bar codes on patient wristbands may have higher error rates than bar codes on sample labels or other labels because of the curvature of wristband labels and the increased opportunities for such labels to become soiled. It would be inappropriate, however, for laboratorians to assume that the error rates on samples being tested in their random access analyzers, for example, are zero or that bar code errors might be nonexistent in other laboratory operations apart from the point-of-care example described in this report.

Laboratorians are strongly advised to develop programs that can verify the quality of the bar code labels printed in their laboratory. Such programs may include regular schedules for the cleaning of print heads and the purchase and use of a bar code verifier. Only bar codes determined with such a device to be of grade A, B, or C are considered to be of acceptable quality. The recommendations and corrective actions described by Snyder et al. are a good starting point for a laboratory’s bar code quality-assurance program.

In the future, 2-dimensional bar codes and/or radio-frequency identification may enter the clinical laboratory field. In addition to using less space on labels, the higher-density 2-dimensional codes have much lower error rates than linear bar codes, owing to more rigorous error checking, higher tolerances for printer malfunctions, and the ability to embed more than one patient identifier in the same code. Adoption of 2-dimensional codes, however, will require a serious effort by a standards organization such as CLSI to drive it, as well as the cooperation of dozens of diagnostics vendors to incorporate more advanced readers into their systems. Radio-frequency identification technology overcomes many of the problems associated with bar codes and label printers. At present, however, radio-frequency identification is still in its infancy, and the chips are too expensive ($0.10–$0.30 per chip) to be affordable for labeling all routine clinical laboratory samples.

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