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A Novel Method Enables General Pathologists to Create Web Dynamic Forms for Synoptic Tumor Reporting

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● *Context.*—Tumor reporting constitutes a significant daily task of pathologists. An efficient tumor-reporting methodology is thus vitally important. The Web dynamic form (WbDF) method offers a multitude of advantages over the prevailing transcription-mediated reporting method based on static-text checklists. However, its adaptation has been severely hampered for 2 decades by its costly needs to maintain a complex back-end system and to change the system for frequent updates of reporting content.

Objective.—To overcome these 2 obstacles with a serverless Web platform that enables users to create, customize, use and download WbDFs as synoptic templates for structured tumor reporting.

Design.—Deploy ReactJS as a Web platform. Create form components in JavaScript Object Notation files. Use JavaScript Object Notation files to make WbDFs on the Web platform. Use the WbDFs to generate final pathology reports.

Results.—Ordinary users (pathologists) can create/customize reporting templates as WbDFs on the Web platform. The WbDF can be used to make a pathology report and stored/shared like ordinary document files. There is no back-end system to change, nor a requirement for computer programming skills.

Conclusions.—This strategy eliminates the need for a complex back-end system and the associated cost when updating tumor-reporting standards, making it possible to adopt the WbDF method without the technological drawbacks associated with content updates. It also opens a new field of how the tumor-reporting system should be organized, updated, and implemented.

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The American College of Surgeons Commission on Cancer mandates that pathology reports of cancer include essential data elements and follow specific formats[1] as a key initiative to promote standardization of diagnostic information with interoperability across health care systems. Cooperative efforts by the College of American Pathologists (CAP) have resulted in a series of cancer reporting protocols or checklists in an attempt to help pathologists comply with the mandates.[2] Similar work has also been contributed by other pathology organizations.[3–5] The benefits of using such structured (or "standard") pathology tumor reports were initially debated, then assessed, and eventually confirmed in the last 2 decades.[6–15] These protocols are available as static text documents. Thus, the prevailing mode to generate final pathology reports is via dictation and/or manual typing of diagnostic data according to the checklists, that is, transcription-mediated reporting (TMR). The disadvantages of this operation model have been well recognized,

including long turnaround time, errors associated with multistep information transactions, and high cost.[13,16] To overcome the drawbacks associated with the TMR method, an online application of a Web dynamic form (WbDF) with data elements in drop-down lists and checkboxes for pathologists to file tumor reports effectively was first introduced by Qu et al.[16] Subsequently, a similar effort was also made by Baskovich and Allan,[17] followed by the CAP[18] with its electronic Cancer Checklists (eCCs). Such dynamic form methods effectively eliminate those drawbacks associated with using the static text–based TMR method.[16,19] However, they face a daunting challenge imposed by back-end system maintenance and frequent updates of tumor reporting standards.
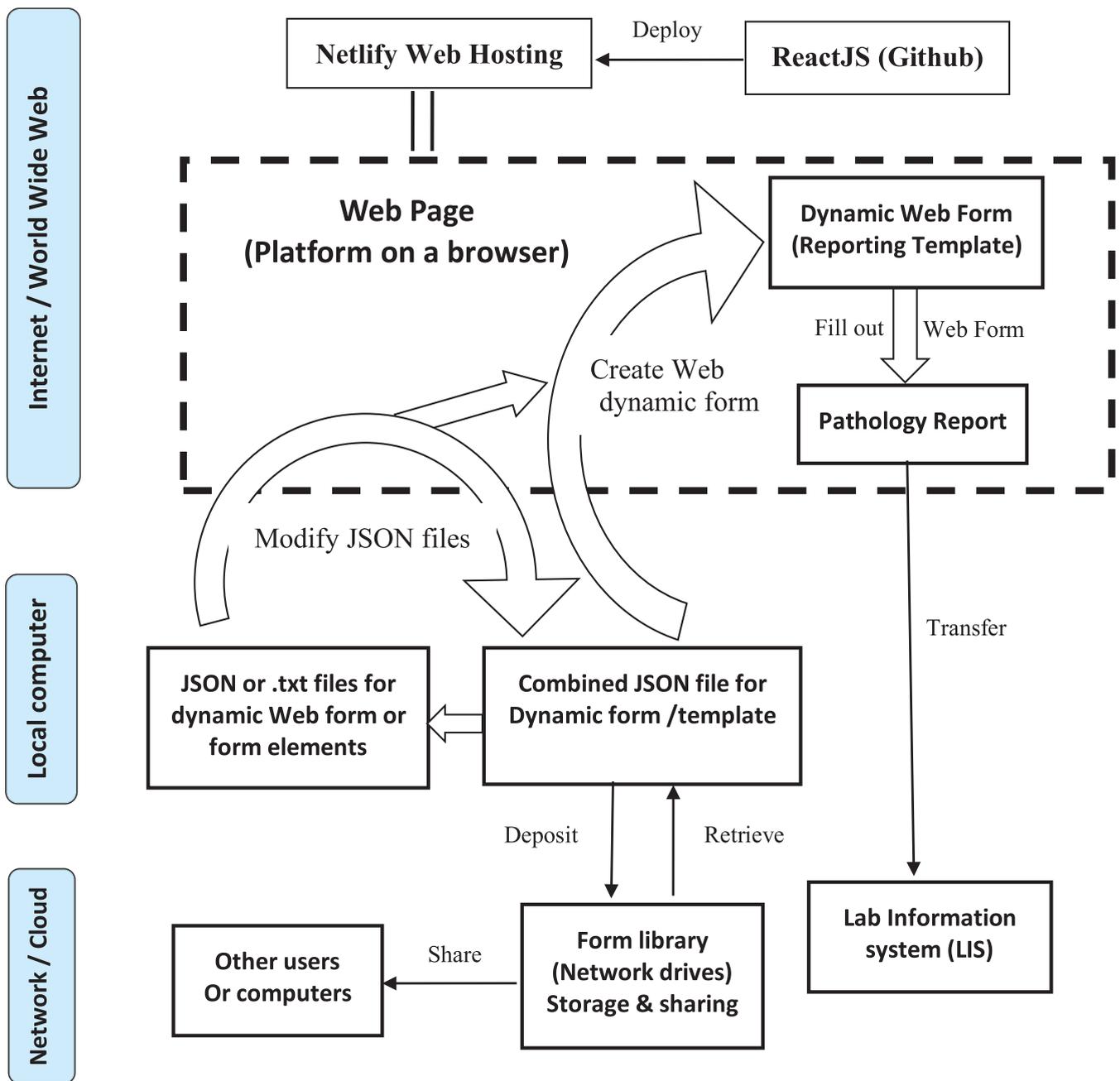
For the dynamic form method, be it on the World Wide Web or intranet, changes to the reporting templates due to frequent updates of the reporting standards require back-end alteration of programming codes and/or databases. Even simple text editing of reporting content can be tedious and time-consuming in this context. In addition, the updates require 2 disparate skill sets to act in concert— pathology and computer technology (especially software programming and database). This is not an easy task in our experience, and it remains the roadblock to keeping the reporting templates up to date in a timely fashion.[16,20] No effective solution has been identified yet to overcome these problems. Here we introduce a new simple do-it-yourself method by which the user can (1) create/update reporting templates as WbDFs on the Web via a simple drag-and-drop operation and (2) use the WbDFs to report pathologic

Workflow diagram: create a web dynamic form/reporting template and pathology report on the World Wide Web. This diagram shows the information flow (arrows) and actions (unblocked labels) in the process of creating a Web dynamic form and final pathology report by ordinary users on the Web page as the operation platform (box with dashed line). Open arrows highlight the 3 key functions: modify/update JavaScript Object Notation (JSON) files, create a dynamic form, and generate the pathology report.

findings. This method effectively eliminates the technical dependence on software skills and back-end systems by enabling ordinary users (pathologists) to create and update WbDFs as templates for routine tumor reporting.

DESIGN AND METHODS

Set Project Goal and Specific Criteria

The goal of this project is to create a Web platform that allows users (pathologists) to create and/or modify (update) WbDFs as tumor-reporting templates that can be used to generate tumor reports. The project design and project workflow are depicted in the Figure and comprise 2 key parts: (1) constructing a Web platform and (2) generating the building blocks (ie, form elements as text files) for the WbDFs. We set out 4 specific aims as the criteria for a successful project. The Web platform should allow the users (pathologists) to (1) create a WbDF when given form elements in correct JavaScript Object Notation (JSON) format[21] (see Table 1 for definition), (2) combine individual JSON files into a single file for more complex WbDFs, (3) create final pathology report in routine practice with the resultant WbDF, and (4) customize the appearance of the WbDF and final pathology report. Several concepts and

Table 1. Abbreviations and Technical Concepts With Definitions	
Abbreviation	**Full Name/Concept Definition**
ACoS-CoC	American College of Surgeons Commission on Cancer
AJCC	American Joint Commission Committee on Cancer
CAP	College of American Pathologists
Data element	The building block of the Web form/template. It labels data types such as histological type, tumor size, etc. In dynamic Web form, data elements are enabled as functional units such as drop-down list, checkbox list, etc
eCC	Electronic Cancer Checklists (eCC) by the College of American Pathologists[18]
ICCR	International Collaboration on Cancer Reporting
CSS	Cascading style sheets. Used to define text styles, table sizes, and other aspects of Web pages written in a markup language
JSON	JavaScript Object Notation: a syntax easy for humans to read and write, for storing and exchanging data. Simply put, it is the form content in a minimal data-interchange format.[31] It uses easily understandable text for data exchange between a server and web application
JSON schema	Specific structure format that makes JSON human- and machine-readable documentation.[21] Their relationship emulates that of the English language and its grammar. JSON schema is a relatively new but widely used method to defines the content and behavior of Web forms
Pathology report	The dynamic (tumor-reporting) form filled out by the pathologist (user) with specific information of a (cancer) case
ReactJS	A popular open-source JavaScript library fully developed by Facebook, Inc (Menlo Park, California), used for building interactive user interfaces (handling view layers for the Web).[22] ReactJS allows us to create the Web platform where JSON can be used to generate WbDFs
Reporting template	This equates to a specific (Web) form created according to specific sets of data component for particular reporting needs (eg, colectomy for adenocarcinoma) that is used repeatedly for data collection. Thus, reporting template may be used interchangeably with Web form sometimes
TMR	Transcription-mediated reporting
WbDF (Web form)	Web dynamic form or Web form—a dynamic form (on the Web) responsive to user inputs to its components or units such as drop-down lists, checklists, etc

specialized terms of computer software technology are inevitably used in this report and are listed along with their definitions in Table 1 for reference.

Set Up ReactJS Framework for Our Web Platform

We first set up a Web platform with the 4 key functions specified above. This platform is the interface where users can create WbDFs, generate the final pathology report, and change report format (on the Web). We selected ReactJS[22] (see Table 1) for this project, installed it on a Dell desktop computer (Dell Technologies. Round Rock, Texas) with the Microsoft Windows 10 operating system (Microsoft Corp, Redmond, Washington), and modified it according to the functional needs of this project to create our ReactJS application, as described by others.[22] The modified ReactJS is uploaded as a project repository to GitHub, a widely used code-hosting platform, at https://github.com/ (accessed on March 12, 2020).

The project is then deployed as a dynamic Web platform in Netlify, a hosting and serverless service. Once the project has been established, no further changes are necessary for the functions related to tumor reporting described in this report.

Determine and Create Functional Units/Modules in JSON for WbDFs

To determine the essential dynamic functionalities to be included in WbDFs, we surveyed more than 100 different tumor synoptic reports, forms/templates, and tumor reporting guidelines by the International Collaboration on Cancer Reporting, including the CAP and the American Joint Committee on Cancer.[2,23,24] Based on our survey results, we created form building blocks, or more plainly Web form components, with these functionalities in JSON Schema (see Table 1 for definition). The JSON files for (complex)

WbDFs can also be created by customizing a preexisting template in JSON off the Internet, if provided, or by assembling different individual JSON files via the drag-and-drop/download feature on the Web platform. The resultant JSON files are used to generate the desired WbDFs. More than 10 such example files with various functional complexity are provided (for download) on the Web site of this platform via the link "Create Templates on the Web" at http://www.essentialpathology.info/ (accessed July 25, 2020).

Create WbDFs as Tumor-Reporting Templates

This is achieved by simply uploading the JSON file or files to the Web platform, which renders all file(s) into a single WbDF. The user can use this WbDF to file a pathology report and/or save it locally as a reporting template for future use. To save the WbDF, the user downloads the WbDF as a single combined JSON file to a desired storage site locally or in the cloud (see Figure). A series of reporting templates/WbDFs can be created in this manner for future use or updates. A step-by-step instruction and video tutorials are available on the Web site of this platform (see Web address above).

Report the Pathologic Findings With the Web Form; Create Final Pathology Report

The system is also designed ultimately as an efficient Web tool for the pathologist to generate the tumor pathology report. Once a WbDF is created by uploading a desired JSON form file as described above, the pathologist can fill out the form based on histologic findings of a tumor and create a final report on the Web as described previously.[16] The process is not different from completing a variety of other Web forms. The final pathology report can be

transferred to the laboratory information system (LIS) by copy and paste.

Compare 2 Methods for Efficacy in Creating Final Pathology Report

To compare the efficacy of this WbDF and TMR methods in filing a final pathology report, 35 pathology reports were first created via WbDF. To standardize, all data elements in a template form were filled out, 1 choice was selected from each drop-down list, 2 choices were checked in each checkbox list, "not applicable" was entered in each free-text field unless other applicable information was entered, and staging notes were included. The final reports were downloaded as a text document and opened in a text editor, and the same data information was manually typed in to simulate TMR by 2 participants with a typing speed at 50 to 70 words/min. The time (in minutes and seconds) required to complete the report via WbDF and the time required to manually transcribe the same reporting information (ie, TMR) were recorded with a mobile phone timer and compared. Ten templates (for commonly encountered tumor types) were used for this test, each of which was used to make a total of 3 or 4 reports (see Table 2) by the participants.

RESULTS

Core Functionalities of Dynamic Form Are Identified and Implemented

Our survey of tumor synoptic reports, forms/templates, and tumor reporting guidelines by different international professional organizations including the International Collaboration on Cancer Reporting and the American Joint Committee on Cancer shows that a small number of frequently used functionalities/features (drop-down list, checkbox, checkbox list, free-text box, table, etc) of WbDFs can meet nearly all functional needs of synoptic tumor reporting. Accordingly, the form elements are written in JSON as drop-down list, checkbox list, free-text box, etc. The element files can be in .json or .txt format. These files determine the content (data elements) and formats of the WbDFs. Changes and necessary modifications can be easily made in the corresponding JSON file (off Internet). At least

15 sample templates for reporting commonly encountered specimen types are provided as JSON files on our Web platform. They cover the vast majority, if not all, of the structural scenarios of pathology reporting. Users can use them for testing and building reusable WbDFs on our Web platform (see next section).

The Web Platform Allows Users to Create and Modify Dynamic Forms in a Web Browser

Uploading the generic form element JSON file(s) to the Web platform gives rise to a WbDF that respond(s) to user input as expected. The result is instantaneous and visual at uploading by drag and drop. The platform and method perform as expected in several common Web browsers, such as Google Chrome (Google LLC, Mountain View, California), Firefox (Mozilla Corporation, San Francisco, California), Microsoft Edge (Microsoft), and Opera (Otello Corporation, Oslo, Norway). The Web platform is accessible via the link "Create Templates on the Web" at http://www.essentialpathology.info/.

As mentioned above, the Web platform allows users to combine 2 or more JSON files into a single executable one. Users can create and upload individual component JSON file(s) (eg, drop-down list, checkbox) via drag and drop to build a desired WbDF in a browser. In other words, a complex WbDF as a reporting template can be constructed with the various individual JSON files modified according to specific tumor specimen type/template. A more practical way to create a form is by modifying an existing JSON file (such as our sample files on the Web page). At least 15 sample forms/templates (in addition to a master template) are provided on the platform to make this do-it-yourself process easier. This is achieved by editing the JSON file in a simple text editor such as Notepad (Microsoft) locally (ie, off Internet). Of pragmatic importance is that Web users (pathologists) can complete all specified functions in a Web browser or offline without having to change the platform system itself.

All Form Files Can Be Stored and Modified Locally for Sharing and Updating

One unique function of this Web platform is that it also allows the user to download the WbDF/JSON file(s) locally.

The downloaded file can be edited as a simple text file for any updates. Thus, users can update any existing template of the WbDF without relying on any computer programming service or Internet hosting server. A complex WbDF with multiple data elements can be downloaded and saved as a single JSON file.

More importantly, these resultant forms/templates in JSON, as other types of electronic files, can be saved/stored locally in .json or .txt formats that can easily be shared/distributed via a shared drive within an institution or on the Internet/cloud. Because they are very small, they can be easily distributed as an email attachment or shared in a network drive. Thus, users can store the template files for different specimen-tumor types as a local template library and reuse them in the future to reproduce the WbDF/template when being uploaded back to the Web platform.

Generate Tumor Reports on the Web

The resultant WbDF (templates) created by this method are dynamic; it responds to selections by the user. Thus, they can be used for online tumor reporting by pathologists on this Web platform in any compatible Web browser. The behavior of the Web forms is similar to that described elsewhere.[16,25] In brief, after uploading JSON file(s) to create a desired WbDF/template with drop-down lists, checkboxes, etc, the user can fill out the form according to tumor features of a case at hand. Upon completion of the form, the platform can generate a final tumor pathology report containing the filled-out data elements at a click on the Submit function button. This final report can be viewed, downloaded, printed, or transferred to the LIS via copy and paste (see Figure). A video tutorial is available on the Web site of this platform (http://www.essentialpathology.info/).

In addition, this WbDF system removes any data element that is not filled out. Users can also easily make the system automatically remove unwanted instructive information (pathologic staging definition, instruction notes, etc) from the final report. Moreover, if a data element is marked as required, the Web form reminds the user by indicating the field to be filled out before the final (pathology) report can be generated.

WbDFs Require Less Time and Effort to Generate Final Pathology Reports

Of the 35 reports created by using a WbDF and TMR in comparison, and assuming that all data elements were filled out, the WbDF required 2 minutes and 17 seconds to 4 minutes and 10 seconds whereas the TMR took 3 minutes and 21 seconds to 6 minutes and 58 seconds, with a ratio of 1.23 to 1.67 (median = 1.51) for the sample reports. Put another way, it took 47% more time to create a pathology report by the TMR method (see Table 2 for results). If the data elements with fields for free-text input were excluded, the time ratio increased to 1.78 to 2.07 (median = 1.86)s meaning that it took 86% more time to complete these data elements by TMR (data not shown).

CONCLUSIONS AND DISCUSSION

Each year, more than 1.7 million new cancer cases are diagnosed in the United States.[26] Pathology provides the definitive diagnosis of most of these cancer cases. In addition, a significant number of recurrent tumors also requires pathology confirmation/reports. Tumor reporting constitutes a main task of pathology and consumes a great

deal of resources. Therefore, choosing a more efficient, less error-prone, user-friendly reporting method is vitally important. The WbDF method has apparent advantages over the TMR method,[16] which has been convincingly confirmed by its universal acceptance by all Web operations for data collection. Because the comparative advantage of WbDF over the prevailing TMR method may be different for our JSON-based WbDF method, we compared the efficacy of these 2 methods even though the advantage of WbDF over TMR in generating pathology reports appears intuitively apparent. Our data show that the dynamic form method saves time by 23% to 72% (see Table 2) with greater consistency and fewer typographical errors than the TMR method. This is consistent with the previous report by Lai et al.[27] Using dynamic forms over static text transcription to collate information has been ubiquitously adapted as an industry standard and overwhelmingly favored by the users on the Internet. These lines of evidence support the superior efficacy of this JSON-based WbDF in generating pathology reports. If the WbDF method is adopted by the pathology community, its impact on reducing opportunity cost, enhancing report quality, and improving patient care would be enormous.

Although this WbDF method enables general users/pathologists to create and update pathology reporting templates as dynamic forms in a do-it-yourself fashion, it is unrealistic to expect pathologists to create the WbDF system. The proposed Web platform has taken over the task of setting up such a system to create/update templates. This means that the system is readily and functionally available, and that pathologists do not need to create it unless they want to clone the system to an offline computer. We also recognize that most pathologists/users may want to avoid creating reporting templates/forms. We therefore have included on the platform at least 15 sample templates for reporting commonly encountered specimen types. They cover the vast majority, if not all, of the structural scenarios of pathology reporting. They make the template creation an easy task of copying and pasting or editing of simple text.

This WbDF method characterized by a serverless Web platform via JSON-powered forms also drastically reduces actual costs by eliminating the complex infrastructures in the hosting server or LIS, an enormous financial benefit not apparent at first glance. The costs and technological demands to maintain the server-backed system constitute the canonical barriers to the wide adaptation of the dynamic form method in tumor reporting. Updating of tumor-reporting content in this setting has remained a formidable technical challenge for nearly 2 decades. Elimination of these barriers can pave the road for wide adaptation of this new serverless WbDF method, and consequently more users/pathologists would embrace and adopt this method because of its advantages over alternative methods. Although no financial assessment has been performed to quantify the potential cost reduction, one can easily make a reasonable estimate based on the essentially negligible expense in setting up and maintaining such a ReactJS-based serverless Web platform. Of course, the application of this serverless WbDF method goes far beyond the field of structured tumor reporting, pathology, or medicine. However, specific examples are beyond the scope of this report.

Perhaps the most potential far-reaching impact of this new method is to change the decade-long model of execution/implementation of structured tumor reporting. When all Web users can easily create, customize, download/

store and share the WbDFs as reporting templates, the change appears inevitable. We envision that the existing operational process/model would be altered at different levels. At the individual institutional/departmental level, commonly used reporting templates can be created according to approved checklists/protocols, customized, and stored by individual users (pathologists or their institution) as a library that can be used for routine tumor reporting. When a new reporting standard or customization is needed, pathologist(s) can update the files locally (see Figure). By enabling pathologists to create, update, and store reporting templates, and then use them to generate WbDFs for tumor reporting instantly without relying on sophisticated software expertise, this method empowers many users outside of the technological field to contribute to this cause. This promotes democratization of technology, a familiar and well-established strategy that has brought many drastic changes to our lives.[28] As a proven natural extension of democratization of technology, user groups/specialty communities will form an ecosystem to improve and perfect the pathology tumor-reporting method via WbDF. As a result, the heavy task burden of creating, customizing, and updating the reporting templates can potentially be reduced/shared by community work or Web user groups. At the national level, a professional organization such as the International Collaboration on Cancer Reporting or the CAP can maintain and make accessible the reporting templates/checklists in the format of this JSON module. By this operational model, all tumor-reporting templates will be distributed as WbDFs as effective reporting modules, and yet users (pathologists) can still customize the WbDFs/templates in JSON files freely. In any case, the update becomes easy, simple, timely, and cost-effective. It offers all advantages of a dynamic form method without its inherent technical drawbacks and cost.

Like most new solutions, this method also has drawbacks. First, manually entering data elements (eg, right breast, colectomy, osteosarcoma) in the JSON file of a report remains as tedious as for other methods, especially when the user is building the initial template from the ground. Despite its simplicity, JSON, by nature, is still loosely a programming language, although highly readable to non-technical users. Misusing or missing a single syntactic symbol (eg, a curly bracket) can render the entire JSON file nonfunctional. To overcome this drawback, we have provided several ready-to-use templates for download as typical examples that can be modified to create new templates with ease. For the most part, when working with an existing template, updating/customization can be achieved by simple copy and paste (of a functional unit such as drop-down list, checkbox, etc) or replacing specific data elements (eg, from "partial mastectomy" for a breast specimen to "segmental colectomy" for a colon specimen) without changing the programming codes. In addition, "How to…" instructions and a detailed protocol and instructive video are included on the Web platform. We are currently also exploring various venues to simplify the production of such JSON files, such as using graphic interfaces. Second, additional step(s) may sometimes be necessary to change the current default report format (eg, text size, font, style) of the template to meet individual user preferences. This can be achieved by manually formatting the final pathology report. A more effective way to overcome this drawback is to use cascading style sheets (see Table 1 for definition), which can control the format of the final report. The process is similar to that for creating the

WbDF described above: users can upload (different) cascading style sheet scripts as they do with the JSON form files to the platform, and the resulting template appears in (different) format(s) as specified by the cascading style sheets. Again, we include 1 sample cascading style sheet on the Web site for interested users to further explore. Third, because this is an independent Web tool, users need to copy the final report from the WbDF and paste it to the routine pathology report in the LIS. Full integration of such a JSON-based system into the LIS requires interface tools/middleware that has not been tested yet. However, such interface tools that feed data content in JSON (schema) to a wide variety of databases, the backbone of LIS, have been well developed (try a search for "JSON data to database" in Google) and can be used to directly link the JSON templates to LIS.

With all these features that effectively counteract the inherent drawbacks of the existing dynamic form method and make updates a simple, easy task, would this new method be a panacea to promote adoption of the WbDF method? The answer is unlikely an optimistic "yes." Adoption may likely meet challenges at both user and organizational levels. Many users may stay with "path dependence"—a result of an inability or a reluctance to commit to change because of the historical momentum. Some users may say, "The static text checklist has been around for many years and seems to work just fine. Why change to a dynamic form method?" However, as the tumor-reporting standards and content continuously evolve, with more tumor-reporting checklists implemented and updated and more detailed and/or new data elements added, it is foreseeable that the TMR method will become increasingly more costly, time-consuming, and cumbersome in coping with revisions. As the result, pathologists/users may likely adopt any method that makes the reporting task easier. Thus, finding and adapting a more efficient method such as this one is very meaningful.

At the organizational level, potential alteration in existing operating mode and/or integration with the LIS in generating and maintaining dynamic reporting forms is another foreseeable challenge(s). Although this WbDF system has all necessary functionalities of the current systems integrated in LIS (eg, creating dynamic forms with reporting function, setting data elements as required [to be filled out by user], controlling format and style of final report, automated removal of selected content), but offers the unique do-it-yourself advantage/freedom and simplicity, its integration with an LIS has not been tested yet. Among these integrated systems, the eCC in extensible markup language (XML) provided by the CAP[18] appears to the one comparable to our WbDF system. Although the adoption of the eCC remains limited compared with its static checklists,[29,30] it appears to be an established implementation model. Given the fact that XML and JSON are both a simple form of data presentation/container, integration of the JSON-based WbDF system with LIS is expected to be similar to that of eCCs. However, an emerging inevitable challenge is posed by the fast-fading XML underlying eCCs. JSON is simpler in syntax, faster for data exchange, and better suited for parsing data to database compared with XML. These features fit better with the intended function of structured tumor reporting than those of XML. In contrast to eCCs, a library of templates in our JSON-based WbDF system is nothing more than a group of regular text documents that could be easily managed. Whether a

pathologist wants to keep and update the templates or let someone else do the job would be a personal preference. However, the change from XML to JSON is not a simple conversion task. Last but not least, this JSON-based do-it-yourself method may likely lead to an alteration of the business model, which could be a significant challenge. At least, this new WbDF method is essentially free to its users.

In summary, this new modular WbDF method allows ordinary users to create and update tumor reporting forms as templates easily in a Web platform without relying on programming skills. The resultant Web forms can be used to file pathology reports for specific tumor cases. All these functions are accomplished in a personal computer with a compatible Web browser. Thus, it effectively overcomes the obstacles to timely update of tumor-reporting standards mandated by the American College of Surgeons Commission on Cancer. It is a simple and essentially cost-free method that solves a complex and costly chronic problem in the standardization of cancer reporting in pathology. It can save pathologists' time creating tumor reports, improve report quality, and enable and empower many pathologists to contribute to structured tumor reporting.

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