Actuarial Considerations When Using Augmented Mortality Models

SECTION 1: Introduction

The purpose of this discussion brief is to provide a source of information to actuaries seeking to better understand the considerations and complexities when using augmented pension mortality assumptions. For purposes of this discussion brief, an augmented pension mortality assumption is a valuation assumption that uses additional predictive information taken from nontraditional data elements (beyond age, sex, collar, etc.) from a source external to that data set, in order to stratify the data and then create a secondary model that attempts to refine the assumption. Examples and discussion provided below further illustrate the concept.

This discussion brief was prepared by select members of the American Academy of Actuaries Pension, Public Plans, and Multiemployer Plans committees for the pension actuary as a user and selector of mortality tables and not as a constructor of tables or mortality models (table construction would require additional information). This discussion brief is intended to assist the actuary in understanding the commonly used approaches as well as the data considerations commonly used to develop a table and help the actuary judge whether the augmented table is or is not a more reliable or predictive basis for mortality. This discussion brief does not cover mortality projection scales.

Multivariate vs. Augmented

When an actuary hears "multivariate," they may likely think of interactions between predictors, not specifically the interaction terms in a regression, but the broader concept of evaluating multiple factors in the presence of each other. Something simple like splitting the population into subpopulations—such as male versus female—is technically multivariate, modeling mortality as a function of age *and* sex. However, the concept of augmented tables is broader, indicating the addition of supplemental information beyond or outside traditional pension census data fields. This discussion brief uses the new and broader term of "augmented tables," which attempt to enhance the predictive power of the assumption. Augmenting a table is not just about adding a new data field (e.g., ZIP code) but having a method behind how that field was used in construction of the table. The source of the data used might fit the definition of "big data," and the reader might want to review the Academy's June 2018 monograph, *Big Data and the Role of the Actuary*.[1] Note: An augmented table is different than taking a standard mortality table and adjusting for a plan's experience using partial credibility. The discussion brief's definition of an augmented table involves the use of supplemental information not related to the plan's experience.

1 See also the Academy's November 2021 monograph, *Big Data and Algorithms in Actuarial Modeling and Consumer Impacts*.

Collar Tables; Examples of Augmented Tables

Collar tables were created because there was an expectation and evidence that blue collar mortality was higher than white collar. Like most pension valuation tables in use today, the focus was on employment factors that affect mortality experience. After collecting and reviewing the experience of pension plans segmented by collar, the Society of Actuaries (SOA) published collar tables showing this result.[2] Some tables are separated further by type of employment (teachers, public safety, general) or amount of pension benefit, but the same basic construction is used.

Consider what would happen if populations were first sorted by location, but without regard to mortality experience. Tables could be developed by first sorting census tracts,[3] of which there are over 60,000 (a distinction not related to employment). The grouping of 60,000 tracts into a manageable partition of the data could be based on correlating various lifestyle and economic factors within each census tract (e.g., prevalence of obesity, cigarette sales, number of hospitals, housing prices, household income). The data would be tested/modeled to see which seem to be correlated to actual experience given the significance of each factor placed on them by the table developer. How the tracts are grouped based on factors other than mortality depends on the developer of the table and the model constructed. This is also a key differentiator in what makes something an augmented table. Some objectives of using an augmented table may include the development of:

- An assumption using more variables that might be a better predictor for an individual participant;
- An assumption that leverages experience among a wider population that shares particular characteristics with plan participants; and
- An assumption that better reflects differences among generations of participants and adapts over time as the population changes.

This discussion brief also covers a short history of mortality tables and how the evolution of augmented tables is another type of change.

2 Care still needs to be taken because, for example, not all blue collar groups are the same.
3 [Census Bureau Glossary](https://www2.census.gov/geo/pdfs/education/CensusTracts.pdf) - https://www2.census.gov/geo/pdfs/education/CensusTracts.pdf

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SECTION 2:
History of Pension Mortality Tables Since the 1970s

Roughly 50 years ago, 1971 Group Annuity Mortality (GAM) was developed and used for many years for pension valuations. It was based on the experience of four deferred annuity contracts and one municipal retirement program. Over time, new tables were developed with the following attributes:

- Unisex rates
- Rates by collar
- Rates by amount vs. headcount
- Based on noninsured data
- Based on mortality improvement scales
- Using larger data sets
- Based on employment sector (e.g., private vs. public sector [governmental] plans including separate tables by occupation [teachers, public safety, general employees])

Widely used tables included UP84, 1994 GAR, UP94, RP, Pri and Pub[4] tables.

While these tables (and some other proprietary ones produced by actuarial firms) are many and varied,[5] it's important to note two facts: (1) While some newer tables replaced older tables, the number of tables an actuary may use has increased—e.g., there are many variations of the Pri and Pub tables; and (2) As actuaries move into the area of more augmented tables, that number may increase at an even faster rate. Augmented tables bring into consideration for the first time the use of non-pension data (e.g., lifestyle or socioeconomic markers) into pension work.

SECTION 3:
Nomenclature

The following are definitions of terms used in this discussion brief:

Study Census—Large participant dataset reflecting a wide variety of participant characteristics used as a benchmark for experience for a wide variety of potential plan census groups. Example: The input census used to create Pri-2012. This data set is comparable to "Relevant Experience" described in ASOP No. 25, *Credibility Procedures*, but this discussion brief specifically does not cover credibility as a subject.

Plan Census—Dataset representing the specific group analyzed in an actuarial pricing or projection (generally unrelated to the study census). Example: XYZ Manufacturing Pension Plan Population at 1/1/2021. Comparable to "Subject Experience" in ASOP No. 25.

4 We have used common abbreviations for the Society of Actuaries tables. Not all tables apply to all pension sectors and many come with variations as described in the prior bullets. In particular, Pub tables are based on public sector experience.
5 Also see the Academy June 2015 practice note on mortality tables, *Selecting and Documenting Mortality Assumptions for Pensions*.

Supplemental Information—Information regarding socioeconomic, demographic, and lifestyle characteristics, such as location or cancer prevalence, associated with participants in the study census and plan census. Could be provided by a government agency or other third party. Example: United States Census Bureau 2020 Census Extracts.

Standard Mortality Assumption—Benchmark mortality table developed using traditional techniques from all, or a subset, of the study census. Example: Pub-2010 Safety, which are graduated rates based on the subset of Pub-2010 data identified as "Public Safety" participants. Note that separate tables for males and females have been standard for decades, but more recent studies have further partitioned data by employee versus annuitant, blue versus white collar, teachers/public safety/general, retiree/survivor, etc. To date, these tables have tended to be mostly separate graduated rates for specific subsets of the study census. Also note that many such tables are created on an "amount-weighted" basis, for example expressing mortality rates as the percentage of accrued benefits that exit due to mortality.

Traditional Actuarial Mortality Model—The actuary uses information about the plan census to select a standard mortality assumption derived from the study census; the actuary may use information included in the plan census or information the actuary has been provided about the plan census to help make a selection.

Examples:

- Plan census is an hourly pension population, the actuary selects Pri-2012 Blue Collar Table.
- Plan census represents firefighters, the actuary selects Pub-2010 Safety.
- Plan census includes only active employees earning over the IRC 401(a)(17) pay cap and inactive participants who had similar characteristics when active, the actuary selects Pri-2012 Top Quartile Male and Female.

Adjusted Actuarial Mortality Model—The actuary selects a traditional actuarial mortality model as a benchmark and applies approximate adjustments to better match the expected experience of the plan census, or portions of it, based on information included in the plan census.

Potential examples of things actuaries could do:

- Credibility-based multipliers: The actuary performs a credibility-based experience study and develops a factor to apply to the standard mortality table to reflect the specific experience of the plan census. For example: Mortality rates for the plan census are assumed to be 94% of the Pri-2012 White Collar Table based on a study of plan experience over the period 2017–2019. A similar approach would be to graduate plan census experience by age and blend the plan table with the standard table according to credibility or other criteria. Establishing full credibility could be difficult unless the plan population is very large.

- Benefit size adjustments: The actuary considers socioeconomic status a key predictor of longevity experience and believes the benefit in payment under an annuity contract or pension plan to be a reasonable indicator of socioeconomic status. The actuary applies a factor to the values from a standard mortality table based on the size of benefit in payment after performing a study. For example:

Monthly benefit in payment	Factor Applied to Table q_x
<=$250	1.10
>$250 & <= $1,000	1.00
>$1,000	0.90

Augmented Mortality Model—This approach involves using models within models. The actuary or researcher uses supplemental information to augment or stratify the study census to refine the modeling of longevity experience. Fields from the supplemental information may be analyzed using statistical techniques or classified by use of a supplemental model to allocate data in the study census to various categories expected to have differing longevity experience, typically correlated with socioeconomic status or other health indictors, and identified using an indicator such as a geospatial identifier (9-digit ZIP code, census tract, or other convenient indicator of location that can be used to classify the members of the study census and ultimately the plan census). Mortality model development is performed taking into account traditional distinctions (e.g., sex, collar, etc.) in conjunction with supplemental information (e.g., socioeconomic indicators). This results in the development of multiple separate tables based on combinations of traditional and supplemental variables that are expected to have similar longevity experience. For each of the members of the plan census, one of the resulting tables is applied based on that member's values for relevant variables.

Examples:[6]

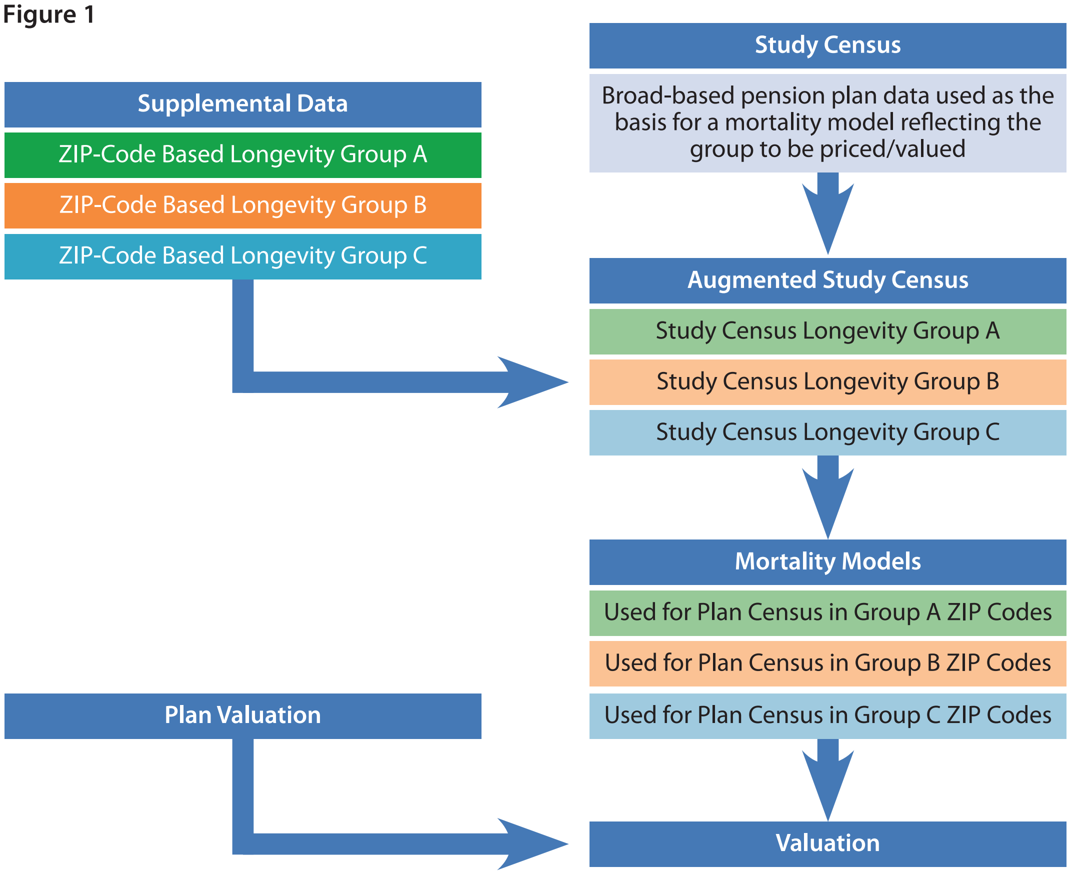
- Median household income of a participant's community may be predictive of longevity experience and represent data outside of the census. The actuary could use identification of community in the study census and the median income in that community from the prior federal Census[7] to stratify data in the study census and develop separate mortality tables for each band of income. Community identification (or individual income level) in the plan census determines the table selected for an individual from the median income banded tables.
- The actuary uses supplemental information to develop a socioeconomic/lifestyle rating for each postal code represented in the study census. (Potential socioeconomic factors might include annual tobacco spend, median home price, health care facilities per capita, etc.) The actuary then groups postal codes with similar characteristics into bands (for example, A thru E) to develop a mortality assumption from the study census for each band (for example, Table A thru Table E). Each participant in the plan census is priced/projected with the table appropriate for their specific postal code (or relevant socioeconomic factors, if known).

6 See notes below about considering the cost-benefit trade-off to determine whether extra effort justifies these potential improvements in an assumption.
7 The U.S. Census Department (www.census.gov) publishes many tables/studies on mortality.

- The actuary uses the Society of Actuaries study on census tract[8] to assign a socioeconomic index (A through Z) to each census tract. The actuary then classifies each participant in the study census by that socioeconomic index and analyzes mortality experience by socioeconomic index value, developing separate tables for each socioeconomic index value (with similar socioeconomic index values grouped as needed to reduce complexity). Each participant in the plan census is assigned the table appropriate for the socioeconomic index value for their census tract.

Figure 1, an illustration of an augmented mortality model approach, presumes that the augmentation is done via a ZIP code classification: There are three different types of census or data shown in this diagram. The supplemental data is a grouping of ZIP code data based on what the actuary believes are indicators of health/wealth. The study census is a traditional collection of data across many plans. A ZIP code field is added to this traditional data to allow it to be mapped to the ZIP code groupings. Finally, the mortality models (tables) are applied to the plan's census, which also includes ZIP code data.

Figure 1



8 See: https://www.soa.org/globalassets/assets/files/resources/research-report/2020/mort-socioeconomic-cat-report.pdf.

SECTION 4:
Considerations on Form of Model

There is considerable flexibility in developing the form of an augmented mortality model. Results of the supplemental data analysis (done by the SOA or another table builder) could be implemented as a set of mortality curves, a set of mortality multipliers, or some other approach that applies separate mortality assumptions to various groups. An actuary contemplating use of such a model would consider:

- What are the strengths and weaknesses of the chosen format?
- How many different versions of the model are available? How is credibility determined for each variant?
- Does the choice of a specific format restrict the value or flexibility of the model for certain purposes? For example, a model that results in a flat multiplier (not age-related) to another table will be straightforward to apply but may not be appropriate at the highest participant ages.

Refinements Achieved Compared to Other Methods

The actuary who opts to use an augmented model might also consider whether the additional refinement sought by introducing supplemental census data elements is materially more predictive given the cost and effort involved.

- What is the additional effort and cost involved?
- How much refinement is achieved?
- What is the expected impact on gains/losses, and does it justify the effort and cost to use a more complex assumption?

Relative Weight of Supplemental Information and Plan Census

Using an augmented mortality model does not eliminate an actuary's responsibility to consider known information about the plan census and reflect that information in any chosen mortality model. A plan census could reflect lives with a high socioeconomic status who live in a region where the population is generally of lower socioeconomic status (example: a plan covering a medical practice or university in a rural area). In such circumstances, depending on the granularity of the geospatial information, location may be less relevant to the experience of and expectations for the plan. The actuary typically considers the relative weight to give the supplemental census information and the plan census information. In addition, the actual historical experience of the plan and its participants is typically considered if partially credible.

SECTION 5: Understanding of Augmented Model and Basis

Credibility/Consistency of the Geospatial Grouping

Selection of a geospatial identifier is often a matter of available data; a 9-digit ZIP code is a generally available indicator of location within the U.S. Additional information can build correlations with these codes to other relevant socioeconomic characteristics, such as income and occupation. The model builder using this approach would first consider the validity/quality of the geospatial identifier as an indicator of socioeconomic status, lifestyle, and (ultimately) longevity.

Related issues could include:

- **Permanence of geospatial identifier:** How does the geographic grouping of the geospatial identifier change over time?
- **Homogeneity within a geospatial identifier:** One would expect that as homogeneity improves in an identifier, the ability of that identifier to predict experience outside the norm improves. All things being equal, using an indicator that looks at a tight band of socioeconomic class is better/more valuable than using one that includes a wide range.
- **Finding best grouping:** One can find lots of data on the average wealth, average smoking incidence, average income, etc. for a 9-digit ZIP code from many sources. But is that the best grouping available? 9-digit ZIP codes are dependent on mail carrier routes that change as the routes are reconfigured. How reliable are they over the long term? Other geographic groupings (like census tract) are specifically designed to create homogenous population cells. Also, what are the size ranges for various groupings?
- **Size and grouping of geospatial identifiers:** There is a potential trade-off between homogeneity and credibility (more experience giving higher credibility).
- **Homogeneity of identifier population size:** Do individual groupings differ significantly in size, with, for example, one representing 100 people and another 10,000 people? While not a flaw in and of itself, this can suggest that the model's value varies geospatially.
- **Relocation effects:** Is using a current geospatial identifier indicative of experience for that participant in a future state, such as when current active participants in a plan retire? (Snowbird or Florida Effect)
- **Neighborhood growth/decline**: How can economic trends in localities be reflected in the model, if at all?
- **Recognition that the ancillary effect of the supplemental data may decline with age:** The impact of factors may change with age no matter what their original characteristics.

SECTION 6: Understanding Underlying Data

Having sufficient data

Including multiple factors in an augmented model should work relatively well if each such subpopulation is large enough to credibly generate its own mortality table (as in RPEC Pub-2010 and Pri-2012 rates). With 9-digit ZIP codes, for example, there clearly isn't enough data to create a separate table for each.

Grouping 9-digit ZIP codes into several (6-12) profiles could produce fully credible tables of rates by age for each profile. The grouping process itself is (of course) a combination of art and science. Using the ZIP-profiles as a regression variable—in the presence of other predictors like age, collar, and sex—makes it possible to generate more customized and arguably more predictive mortality probabilities. This data breakdown process may not even contain significant experience, much less credible experience levels, for every combination of age/collar/sex/ZIP-profile, etc.

Statistics can indicate a very good "fit" of model to data. But a well-fit model can still be suspect for some combinations of indicators with thin data. The model can even generate false directionality for some parameters over certain ranges. The math (statistics) behind parameter estimation and assessments can be formidable.

The developer of an augmented mortality model will likely use relatively standard regression techniques. An actuary unfamiliar with the statistical measures of significance and predictive value can consult with appropriate experts. This should give the builder and other actuaries who might use the model comfort that the proposed augmented model is a reasonable fit to the data. However, an actuary is typically especially sensitive to the amount and quality of data in the study that parallels plan participants. For example, if the plan covers a group of hourly employees with high wage rates, does the augmented model data contain a significant number of like populations? As plan characteristics stray further from the profiles well-represented in the study, the actuary may consider relying less on the study's findings.

Causality

There is also a similar question of correlation versus causation, and how much it matters. As an example, multiple studies have shown that people with more money tend to have lower mortality. Most practitioners believe that having more money buys better education and health care (causation—money directly lowers mortality rates) *and* is associated with healthier lifestyles like not smoking (correlation—to the extent that the behavior is not costly but just habitual). Both of these are probably true. But playing devil's advocate, people with a genetic predisposition to short lifespan may have trouble earning higher pay and accumulating wealth—as individuals and compounded across generations of their family. In that (hypothetical) case the *cause* of higher mortality would not be lack of money—it would be the lack of money that is dependent on inherited genetics (for higher mortality).

Do actuaries need to know the causal mechanism? The statistical models that actuaries use to justify regression analysis posit the outcome (mortality probability) as a function dependent upon the collected indicator variables, with only random noise remaining. A pension actuary's goal is to predict mortality as a function of knowable factors such as age, sex, collar, etc. If these or other factors are not truly causal, this could affect the actuary's confidence in applying regression parameters to a specific plan that is either not in the regression at all or represents only a trivial part of that study. Note this is also an issue even when subpopulations in the study are fully credible and get their own tables.

Reliability of Source Data

Augmented mortality approaches will need to collect data from new sources of information. Actuaries opting to use such models should consider the reliability of the supplemental information used:

- How does an actuary determine whether a source is reliable?
- How recently was the data collected by the source of the supplemental information?
- Can government sources (e.g., Census or the Centers for Disease Control and Prevention [CDC]) be used without review?
- What review process is appropriate for validating a supplemental source?
- If a bias is discovered in source data, what disclosure is needed, and what special treatment is appropriate—or should biased data be thrown out of the model?

Privacy Concerns

When data are analyzed in a data set without addresses or personally identifiable information (PII), individual deaths and ongoing lives present little opportunity for identity theft or other abuse. Once individuals are affiliated with small geographical areas (or other potentially identifying information), data privacy issues become more important. Actuaries must be very careful to protect data privacy and to abide by applicable laws in the appropriate jurisdictions.

SECTION 7:
Testing for Reasonableness

How would an actuary judge (test) whether an augmented mortality table is a reasonable assumption for the plan population? First the actuary should understand the approach and data used to develop the table, as discussed previously. Tables augmented with data not specific to your plan (or any pension plan) may improve the predicted accuracy, but actuaries should understand how tables were built. To the extent some of the augmented tables contain proprietary data and methods not available to the actuary, there may still be ways to examine the data. The use of predictive analytics (which may involve big data) might require a trade-off compared to the traditional mortality table disclosure.

Normally, experience studies are performed to compare historical plan experience to the expected decremental experience for a plan. Mortality is one of the decrements studied. This is typically used as a measure to help actuaries and plan sponsors choose the mortality table that best fits the plan demographic. With respect to augmented mortality tables, this practice would continue and may involve:

1. Comparing different tables to your plan experience; i.e., actual experience versus expected experience.
2. Determining whether the table is within a reasonable range of a standard table (e.g., are some q's in a blue-collar group less than a white-collar table) and investigating any apparent unexpected internal inconsistencies.
3. Ascertaining whether there might be something special about the group (e.g., asbestos-exposed workers) that would suggest the plan assumptions should be an outlier.
4. Asking: If the table is being used for settlement purposes, will using the augmented table give results closer to annuity market prices?

Often mortality is correlated with wealth or income. While a mortality outcome is binary—either a retiree died or did not die—using "amount-weighted" rates may be needed to avoid gains and losses.[9] The amount-weighted concept is not perfect and can generate rates that are 5% to 10% lower than headcount-based. To the extent that an augmented table has more than two curves (males and females) the age-based rates might not be as dependent on "amounts." Augmented tables using multiple factors that correlate with wealth and longevity might provide a better model.

While actuaries can rely on experts, they need to apply their own judgment. Examples include:

- A disability benefit that has an "own occupation" requirement should generally not use a table that was developed using an "any occupation" definition for the study population.
- A blue collar table might be less appropriate for airline pilots than factory workers.

Beyond the issue of using judgment is the question of documenting for others (e.g., auditors) what the table developers did, and what the plan's actuary did, that led to the actuary's judgment.

9 Other post-employment benefits (OPEB) plans and some pension plans may be better served using headcount-based tables.

SECTION 8:
Other Considerations

The above discussion is focused on mortality tables used for an actuarial valuation. Using augmented tables for benefit calculations (i.e., actuarial equivalents) is not likely to be appropriate if assumptions vary by person for reasons such as where someone lives.

In addition, care should be taken when applying an augmented mortality assumption to groups within a plan if the assumption is used to pay benefits or justify an action that may advantage one group versus another. In such situations, care is needed to ensure that the mortality assumption differences between groups do not represent a proxy for a characteristic that if used by itself would inappropriately discriminate between the groups. This could be a legal determination that actuaries cannot make on their own. Based on the use of a table, precepts 1 and 8 of the Code of Professional Conduct can also guide the actuary to help ensure that the actuary's services are not misused. Annotation 1-2 discusses not doing work if the actuary believes it may be used to violate the law or damage the reputation of the profession. Annotation 8-1 discusses steps to be taken to avoid misuse of the actuary's work.

Actuarial firms have used proprietary tables in the past. To the extent that augmented tables are proprietary, there may be some difficulties when (1) another actuary is asked to perform an audit, and (2) when the valuation work is transferred to another actuary.

ASOP No. 25 (credibility) should be considered as well as ASOP No. 23, *Data Quality* (specifically data bias), and ASOP No. 56, *Modeling*.

SECTION 9:
Summary

The creation and use of augmented tables are an evolving practice. Augmented tables can be created using information beyond traditional census elements. As potential users of such tables, actuaries have a need to exercise due diligence in the selection of the tables they use. In order to form their own judgment on the appropriateness of the tables they select, they might consider what went into the model's development (including the data used) and/or what testing they might want to do.

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