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Digital Food Labels and Healthier Purchasing Decisions

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Abstract

Digital grocery platforms, food-ordering websites, barcode-scanning applications, and mobile shopping interfaces have created new environments in which nutrition information can be presented at the exact moment a purchasing decision is made. Unlike conventional nutrition panels that require consumers to locate and interpret detailed nutrient information, digital labels can highlight nutritional quality through color coding, graded summary scores, warning symbols, comparison prompts, and context-sensitive information. Evidence available through 2021 indicates that front-of-pack nutrition labels can improve consumers' ability to identify healthier products, although effects on actual purchases vary according to label format, product category, consumer attention, socioeconomic context, and study setting.The present study develops a simulation-based framework examining whether digital food-label designs may support healthier purchasing decisions by increasing nutritional comprehension and reducing the cognitive effort required to compare products. Because no original consumer dataset was supplied, 640 synthetic shopping cases were modeled across four digital-label conditions: a standard nutrition panel, a traffic-light label, a summary graded label, and a contextual digital label supplemented with an explicit comparison cue. The numerical findings are hypothetical and are intended for methodological demonstration rather than as population effect estimates.

The study argues that effective digital labeling should not merely make nutrition information visible; it should make nutritionally relevant comparisons cognitively manageable without creating misleading health halos or implying that a single summary score captures the complete dietary value of a product. Digital labels should therefore be evaluated according to objective comprehension, product-selection quality, label attention, equity across literacy and socioeconomic groups, and sustained purchasing behavior. The paper concludes that digital food labels are best understood as decision-support tools whose effectiveness depends on interface design, salience, interpretability, and integration with the wider digital shopping environment.

Keywords: digital food labels; food purchasing; nutrition labeling; front-of-pack labels; Nutri-Score; traffic-light labeling; online grocery shopping; healthier food choice

1. Introduction

Food purchasing decisions increasingly take place in environments where consumers are exposed to large product assortments, price promotions, health claims, advertising cues, recommendations, and detailed nutrient information simultaneously. In conventional retail settings, front-of-pack nutrition

labeling was developed partly to reduce the effort required to interpret nutrient information during rapid purchasing decisions. Digital shopping environments extend this possibility because nutrition information can be displayed beside product images, search results, comparison tools, shopping baskets, or ordering interfaces rather than being confined to physical packaging. Research on front-of-pack labeling indicates that interpretive labels can improve identification of healthier products, although the magnitude of behavioral effects varies across formats and study designs.

The digital environment is particularly relevant because online food shopping allows nutrition information to be manipulated independently of physical package design. Sacks and colleagues examined traffic-light nutrition information within online food purchasing as early as 2011, demonstrating that digital shopping could serve as a meaningful setting for nutrition-label interventions. Later, the Starlight randomized labeling trial used smartphone barcode scanning to display traffic-light, Health Star Rating, or conventional nutrition information; a secondary analysis found that products whose labels were viewed and subsequently purchased were nutritionally healthier than products viewed but not purchased, although labels were viewed for only a minority of purchased products. These results show that nutrition information can influence food selection only when consumers actually notice and use it.

Label format is therefore crucial. Detailed numerical panels provide relatively comprehensive information but require time and nutritional knowledge. Interpretive labels reduce this cognitive burden by converting nutrient profiles into colors, grades, warnings, or summary indicators. Packer and colleagues' 2021 randomized experiment in a representative British sample found that all tested front-of-pack labels improved participants' ability to rank products according to healthfulness relative to no label, with the strongest performance observed for Nutri-Score followed by multiple traffic-light labeling. Fialon and colleagues similarly compared several front-of-pack systems and found that Nutri-Score performed strongly in consumers' ability to classify nutritional quality. These findings suggest that a label's usefulness depends not simply on how much information it contains but on how efficiently that information can be translated into a comparative judgment.

Evidence concerning actual purchasing behavior is more cautious. Croker and colleagues' 2020 systematic review concluded that front-of-pack labeling can encourage healthier purchasing, but An's 2021 systematic review found that intervention results were mixed, with only a subset of purchase studies demonstrating healthier purchasing effects. Dubois and colleagues' large-scale supermarket randomized trial found that Nutri-Score increased purchases of products in the healthiest third of their categories, but the overall improvement in the nutritional quality of labeled baskets was relatively modest compared with effect sizes often observed in laboratory settings. This difference between comprehension and purchasing is essential: consumers can understand a nutritional label correctly and still choose a less healthy product because price, taste, convenience, habit, household preference, brand loyalty, or immediate craving outweigh nutritional considerations.

The present paper consequently examines digital food labeling as a decision-support mechanism rather than a guaranteed behavioral intervention. The proposed model separates label visibility, comprehension, comparison efficiency, and eventual product selection. Digital systems may have advantages over static physical labels because they can present nutrition information consistently, filter or compare products, and potentially reduce the number of cognitive steps required to identify healthier

alternatives. At the same time, digital labels can create new risks if algorithms privilege particular products, labels become visually overwhelming, or summary indicators produce unwarranted health halos. Consumer-effect research has cautioned that front-of-package labels can alter overall health perceptions in ways extending beyond the specific nutrient information provided. The present simulation therefore evaluates healthier purchasing as the final outcome of a multistage process rather than treating exposure to a digital label as evidence of success.

2. Objectives of the Study

2.1 To Examine the Effect of Digital Label Format on Nutritional Comprehension

The first objective is to examine how different digital food-label formats may influence consumers' ability to distinguish relatively healthier from less healthy alternatives. The comparison includes a conventional nutrition panel, a traffic-light format, a summary graded format, and a contextual label that adds an explicit product-comparison cue.

Existing evidence indicates that interpretive front-of-pack systems can make nutritional ranking easier than no-label or less interpretive conditions. Packer and colleagues found improvements in healthfulness ranking across several label designs, while Nutri-Score and multiple traffic-light labels showed particularly strong effects in that study. The present model therefore treats comprehension as an important intermediary between digital exposure and actual selection.

2.2 To Assess Whether Greater Label Interpretability Supports Healthier Purchasing

The second objective is to examine whether the simulated probability of choosing a healthier product increases as labels become easier to interpret and compare. This objective distinguishes hypothetical purchasing behavior from knowledge because a consumer can correctly identify the healthiest option without selecting it.

Experimental and real-world evidence supports this distinction. Egnell and colleagues' 2021 online-supermarket study found better overall nutritional quality of intended shopping baskets with Nutri-Score compared with reference-intake labeling, whereas Dubois and colleagues found statistically meaningful but comparatively small real-world supermarket effects. The study therefore avoids assuming that gains in comprehension translate one-to-one into purchase behavior.

2.3 To Develop an Equity-Sensitive Framework for Digital Nutrition Labeling

The third objective is to examine digital labeling as a potential means of reducing the cognitive demands associated with nutrition information, especially when consumers have limited time or nutritional knowledge. Egnell and colleagues specifically tested Nutri-Score among low-income adults and argued that simplified color-coded grading may reduce the processing burden associated with reference-intake information.

Digital labeling should nevertheless not be assumed to eliminate socioeconomic differences in food choice. Consumers may identify healthier products yet remain constrained by price, availability, household requirements, digital accessibility, or food insecurity. The proposed framework therefore evaluates label effectiveness separately from the affordability and accessibility of healthier foods.

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3. Review of Literature

3.1 From Nutrition Panels to Interpretive Front-of-Pack Labels

Conventional nutrition-information panels provide detailed quantitative information concerning energy and nutrients, but effective use requires consumers to locate the panel, understand numerical units, evaluate serving sizes, and compare values between products. Front-of-pack systems reduce this complexity by positioning selected nutritional information in a more visible and interpretive format. Systematic evidence available before 2022 indicates that these labels can improve healthfulness judgments and, under some conditions, purchasing behavior.

Interpretive systems differ substantially. Multiple traffic-light labels use colors to indicate nutritional levels for individual nutrients, summary graded labels provide an overall assessment, warning labels emphasize excessive levels of undesirable nutrients, and positive logos identify products satisfying selected criteria. Fialon and colleagues' comparative study demonstrated that these formats do not perform equally in nutritional understanding. Packer and colleagues likewise showed that front-of-pack systems differed in how effectively they enabled British participants to rank foods according to nutritional quality.

This literature suggests that label effectiveness depends partly on the cognitive task being supported. A consumer trying to limit sodium may benefit from nutrient-specific information, whereas someone rapidly comparing several products may find an overall graded summary more efficient. Digital systems could potentially combine these functions: a summary cue can support rapid comparison while additional nutrient detail remains available when requested.

3.2 Digital Food Labels and Online Purchasing Environments

Online shopping removes the physical constraint that nutrition labels must fit on packaging. Food retailers can place labels directly beside search results, preserve them during product comparison, or integrate them into shopping-cart interfaces. Sacks and colleagues' online study was among the earlier investigations demonstrating that traffic-light nutrition information could be embedded in a digital purchasing environment. This is important because the online setting allows researchers and retailers to control label position and visibility more precisely than is possible on heterogeneous physical packages.

The Starlight trial extended this principle through smartphone technology. Participants scanned barcodes and received allocated nutrition labels digitally, allowing researchers to record which labels were viewed and which foods were subsequently purchased. Labels were viewed for approximately 23% of purchased products, and label-viewed products that were subsequently bought were nutritionally healthier than viewed products that were not purchased. The study therefore highlights attention as an essential mediator: a theoretically effective label cannot influence a decision if consumers ignore it.

Digital ordering research has also demonstrated the potential of warning labels. Gugliucci and colleagues conducted a randomized experiment on a simulated food-ordering website and found that displaying nutritional warnings reduced the proportion of participants selecting a dish or beverage excessive in at least one targeted nutrient from 76% to 62%. Although such an experimental ordering environment differs from sustained real-world purchasing, the findings show that digitally displayed nutrient warnings can influence immediate choices.

3.3 Purchasing Effects, Decision Friction, and Behavioral Limitations

Evidence concerning actual purchases is more heterogeneous than evidence concerning understanding. Croker and colleagues' systematic review concluded that front-of-pack labeling generally favors healthier purchases, while An's subsequent review described intervention evidence as mixed and inconclusive overall. The apparently conflicting conclusions partly reflect variation in outcomes, labels, populations, food categories, and experimental versus real-world settings.

Dubois and colleagues' supermarket experiment illustrates this issue clearly. Nutri-Score increased purchases of foods in the healthiest third of their categories by 14%, yet improvement in the nutritional quality of the basket of labeled foods was only about 2.5%. This suggests that labeling can shift selected choices while leaving much of the overall basket unchanged. It also reinforces the importance of reporting both relative behavioral shifts and absolute changes in basket quality.

A further limitation is the possibility of halo effects. Ikonen and colleagues' meta-analytic work on front-of-package labeling found that interpretive labels can influence overall product perceptions beyond the narrowly communicated nutrient information. A digital label that designates a product as comparatively healthier may therefore inadvertently encourage consumers to interpret it as healthy in an absolute sense. Effective digital design should maintain a clear distinction between relative nutritional comparison and a general endorsement of unrestricted consumption.

4. Research Methodology

4.1 Research Design

The study adopts a simulation-based explanatory quantitative design. No consumers were recruited, no online supermarket transaction records were accessed, and no actual food products were sold. Simulation was selected because an original dataset was not supplied and because hypothetical purchasing outcomes should not be represented as completed empirical observations.

A synthetic analytical sample of 640 shopping decisions was created. The cases were distributed equally across four label conditions, yielding 160 simulated decisions per condition. The design assumes identical underlying product choice sets so that the principal conceptual difference between conditions is the form of nutrition information presented.

The four conditions were chosen to represent increasing interpretive support rather than to reproduce a particular commercial labeling programme. The contextual comparison condition is especially important because digital platforms can display comparative information dynamically in ways that are difficult to reproduce on static packaging.

4.2 Operationalization of Variables

The primary outcome is healthier product selection, defined conceptually as selection of the product with the more favorable nutrient profile within a matched product set. This does not imply that a selected item is intrinsically “healthy” in every dietary context. The measure represents relative nutritional quality within the simulated choice task.

Table 1: Operational Framework for Digital Food-Label Evaluation

Construct	Proposed Operational Definition	Scale	Analytical Role
Digital Label Format	Nutrition information presented through conventional, color-coded, graded, or contextual digital design	Four conditions	Primary exposure
Label Visibility	Degree to which nutritional information attracts attention during product selection	0–100	Exposure mechanism
Nutritional Comprehension	Ability to identify the nutritionally preferable option accurately	0–100	Primary mediator
Comparison Efficiency	Ease and speed with which two or more products can be evaluated	0–100	Proposed mediator
Healthier Product Selection	Choice of the nutritionally preferable product within the comparison set	Yes/No	Primary outcome
Decision Time	Time required to reach a product-selection decision	Seconds	Secondary outcome
Perceived Complexity	Consumer-perceived difficulty of interpreting the label	0–100	Usability outcome

The framework separates label comprehension from food choice because these outcomes need not correspond perfectly. Price, taste, previous preference, convenience, and brand familiarity could override nutritional information even when a consumer understands the label correctly.

4.3 Simulation and Analytical Procedure

The standard-panel condition was modeled with the greatest interpretation burden. Traffic-light labeling was modeled as reducing nutrient-comparison difficulty, while the summary graded condition provided a faster overall nutritional comparison. The fourth condition added a contextual comparison cue identifying the nutritionally preferable option within the immediate product set without removing detailed information.

Healthier selections were generated at 43%, 57%, 66%, and 72% across the four conditions. These values are deliberately synthetic and were not copied from any empirical trial. The directional ordering was selected because pre-2022 evidence generally suggests improved comprehension with interpretive front-of-pack labeling, while actual purchase effects are more modest and context dependent.

Descriptive analysis was preferred over inferential hypothesis testing because statistical significance calculated from artificially generated observations cannot establish real-world effectiveness.

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A future empirical study could use randomized assignment within an experimental online supermarket and analyze healthier product selection using logistic regression while adjusting for price sensitivity, nutrition knowledge, dietary goals, income, product familiarity, and shopping frequency.

5. Analysis

5.1 Simulated Purchasing Outcomes Across Digital-Label Conditions

The simulation indicates a progressive increase in healthier selections as nutrition labels become more interpretive and comparison-oriented.

Table 2: Simulated Digital Food-Label Outcomes

Digital Label Condition	Simulated Decisions	Correct Nutritional Comprehension	Healthier Product Selection	Mean Comparison Efficiency
Standard Nutrition Panel	160	52%	43%	48
Traffic-Light Label	160	69%	57%	64
Summary Graded Label	160	81%	66%	76
Contextual Label + Comparison Cue	160	88%	72%	84

The gap between comprehension and actual product selection remains visible within every condition. Under the contextual-label condition, for example, 88% of simulated cases correctly identify the nutritionally preferable product, while only 72% ultimately select it. This 16-percentage-point difference represents the influence of competing purchase motives built into the conceptual framework.

The analysis consequently supports a two-stage evaluation strategy: first determine whether a label helps consumers understand nutritional differences; then determine whether that understanding influences purchasing behavior.

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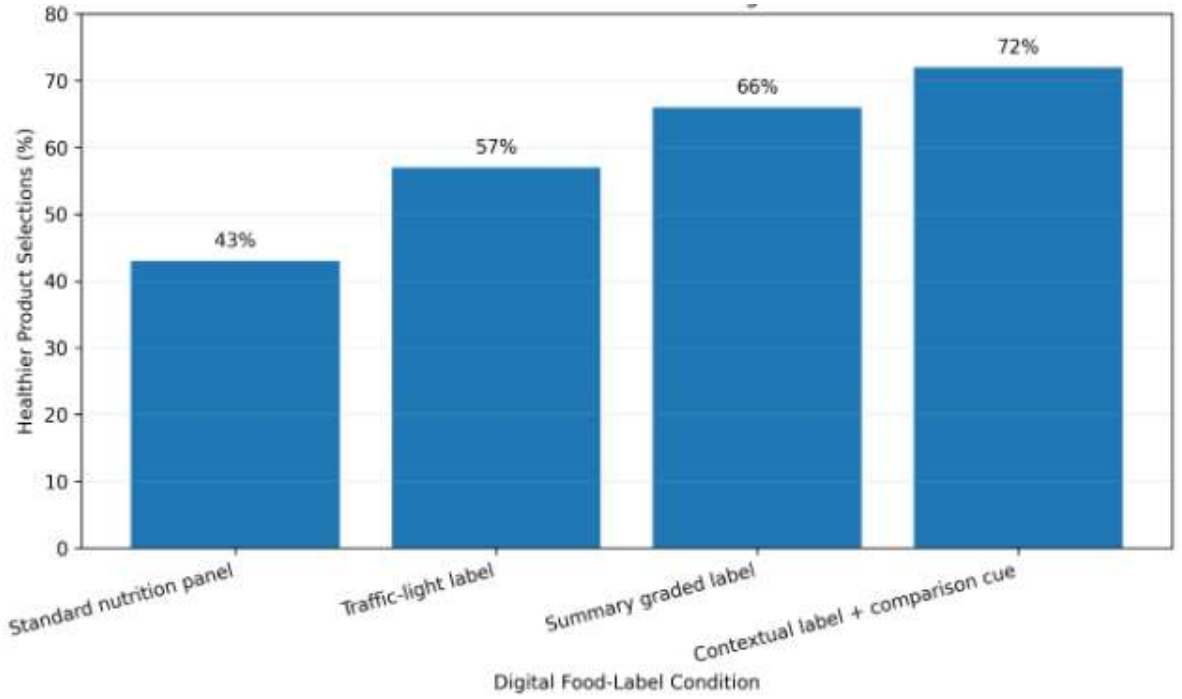
5.2 Healthier Product Selection Across Label Formats

Graph 1: Simulated Healthier Product Selection Across Digital Food-Label Conditions



The column graph shows healthier selections increasing from 43% with a standard nutrition panel to 57% with traffic-light information, 66% with a summary graded label, and 72% under the contextual comparison condition.

Key Finding: Within the simulation, digital labels produce their strongest modeled effect when they reduce the effort required to compare alternatives rather than merely increasing the amount of nutritional information presented.

The pattern is compatible with experimental evidence showing improved product ranking with interpretive labels and with digital-shopping research indicating that nutritional warnings or graded labels can affect intended choices. The numerical effect size itself remains hypothetical.

5.3 Understanding the Comprehension–Purchase Gap

The simulated analysis also demonstrates why nutritional understanding should not be interpreted as equivalent to behavioral change. The standard-panel condition produces only a nine-point difference between comprehension and healthier selection because both measures are relatively low. More interpretive conditions increase comprehension substantially, yet not every informed consumer changes the final choice.

Real-world evidence is consistent with this caution. Dubois and colleagues found measurable improvement in selected healthier purchases but much smaller changes in overall basket nutritional quality than might be expected from laboratory studies. An's systematic review similarly concluded that

front-of-package labeling did not consistently produce healthier purchases across all evaluated interventions.

The behavioral implication is that food-label policy should be evaluated alongside price, availability, default product ordering, promotion, and other characteristics of the purchasing environment. Labels provide information and salience; they do not remove every competing determinant of food choice.

6. Discussion

6.1 Why Digital Interpretive Labels May Improve Decision Clarity

The principal theoretical advantage of digital interpretive labels is the reduction of decision friction. Conventional panels can require several mental operations: identify the relevant nutrient, understand the unit, account for serving size, determine whether the value is comparatively high or low, and repeat the process for competing products. Interpretive systems compress some of these operations into colors, warnings, or grades.

Packer and colleagues' randomized study demonstrates the practical value of this simplification because all evaluated front-of-pack labels improved healthfulness ranking relative to no label, while Nutri-Score and multiple traffic lights performed particularly well. Fialon and colleagues similarly found meaningful differences among label systems in consumers' ability to understand nutritional quality. Digital interfaces can potentially extend these advantages through sorting, comparison, or contextual highlighting.

However, reduction of decision friction should not become reduction of nutritional meaning. A single grade cannot communicate every characteristic relevant to a person's dietary needs. Consumers may require additional information concerning allergens, ingredients, portion size, specific nutrients, or medically relevant dietary restrictions. The most defensible digital architecture is therefore layered: a rapid interpretive cue for initial comparison combined with accessible underlying nutrition information.

6.2 From Comprehension to Actual Purchasing Behavior

The second major implication is that digital labeling should not be judged solely through comprehension experiments. Food purchasing involves goals that extend beyond nutrition, including taste, price, convenience, family preference, availability, and habit. A label can make a healthier option identifiable without making it affordable or desirable.

The empirical literature reflects this difference. Croker and colleagues found evidence overall that front-of-pack labeling can encourage healthier purchasing, but An's 2021 review described results as mixed across interventions. The large-scale trial by Dubois and colleagues further showed that real supermarket effects were much smaller than the effects commonly observed in experimental settings. These findings suggest that policy claims should distinguish improvements in information processing from improvements in entire dietary baskets.

Digital environments may nevertheless permit complementary strategies that physical labels cannot provide easily. A platform can preserve nutrition labels during search, allow side-by-side comparison, or make healthier alternatives easier to identify. Such approaches should be evaluated carefully because the same interface mechanisms can also manipulate commercial visibility. Nutrition-

support features should therefore be transparent and should not secretly privilege products because of retailer or manufacturer incentives.

6.3 Equity, Health Halos, and Responsible Digital Design

Digital labeling has potential equity advantages when simplified formats reduce the nutritional knowledge required for interpretation. Egnell and colleagues' randomized online-supermarket trial among low-income adults found that Nutri-Score produced a shopping basket with better nutritional quality than reference-intake labeling, although differences from the no-label condition were not statistically significant in that trial. The result supports further investigation of simplified labeling among groups facing greater informational or socioeconomic barriers while cautioning against exaggerated claims.

Affordability remains a separate problem. A consumer can receive perfect nutritional information and still purchase a less nutritious product because it costs less or better satisfies household needs. Digital labeling should therefore be viewed as a component of healthier food environments rather than a replacement for affordability, availability, or wider nutrition policy.

Health halos constitute another design concern. Ikonen and colleagues' consumer-effects analysis found that front-of-package labeling can influence general health perceptions beyond specific nutritional attributes. Digital systems should consequently avoid language implying that a favorable score makes unlimited consumption advisable. Labels should communicate comparative nutritional quality rather than transform a graded indicator into an absolute health claim.

7. Conclusion

Digital food labels provide a promising mechanism for supporting healthier purchasing decisions because online and mobile environments allow nutrition information to be presented at the precise point of product comparison. Evidence available through 2021 shows that interpretive front-of-pack labels can improve the ability to classify products by nutritional quality and, under some conditions, can shift purchasing intentions or actual purchases in a healthier direction.

The simulation developed in the present study illustrates this process through four levels of digital nutritional support. Healthier product selection increases from 43% under a conventional nutrition-panel condition to 72% under a contextual digital label containing an explicit comparison cue. Nutritional comprehension rises even more strongly, demonstrating that understanding and purchasing should be treated as related but distinct outcomes. All numerical values in the simulation are hypothetical and should not be cited as measured intervention effects.

The existing evidence also requires restraint. Systematic reviews do not find uniformly positive purchasing outcomes, and real-world effects may be substantially smaller than those observed in controlled experiments. A digital label can improve the informational environment without eliminating the influence of price, preference, convenience, marketing, availability, or socioeconomic constraints.

Future empirical studies should therefore evaluate digital labels through repeated real or experimentally realistic shopping episodes. Outcomes should include label visibility, objective comprehension, healthier product selection, total basket nutritional quality, decision time, expenditure, sustained use, and differential effects by income, nutritional literacy, age, and digital proficiency. Research should also test

whether contextual comparison features provide additional benefit beyond static front-of-pack labels and whether such features create unintended health halos.

The strongest digital food-label system is unlikely to be the one that displays the greatest quantity of nutritional information. It is more likely to be the one that makes relevant differences easy to notice, easy to interpret, easy to compare, and difficult to misunderstand, while preserving consumers' access to complete nutritional information and maintaining transparency about the limitations of simplified scores.

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