Horizon 2020
INFRADEV-1-2014 - Design studies

RICHFIELDS Working Package 5
Deliverable D5.4

Paper on quality criteria and overview of criteria applied to available data/methods – WP5

Report on the paper intended for publication, titled: “Food purchase data for mHealth research: A dynamic search inventory and analysis of applications”

Date delivered:
M35

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Deliverable lead beneficiaries:
RISE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654280.

Project	
Project acronym:	RICHFIELDS
Project full title:	Research Infrastructure on Consumer Health and Food Intake for E-science with Linked Data Sharing
Grant agreement no.:	654280
Project start date:	01.10.2015
Document:	
Title:	Paper on quality criteria and overview of criteria applied to available data/methods – WP5 (Report on the paper intended for publication, titled: "Food purchase data for mHealth research: A dynamic search inventory and analysis of applications")
Deliverable No.:	D5.4
Authors:	Erik Kaunisto, Haris Hondo, Anne Normann
Reviewer:	Karin Zimmermann – Project Coordinator prof. dr. ir. Pieter van't Veer – Scientific Coordinator prof. Bent Egberg Mikkelsen – WP8 leader
Start date:	01.03.2016
Delivery date:	30.08.2018
Due date of deliverable:	30.09.2018
Dissemination level:	PU
Status:	Final

Change history:		
Version	Notes	Date
002	Draft	2017-09-08

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654280.

Executive Summary

This current deliverable 5.4 (D5.4) aims to provide an overview and assessment of the inventory of food purchase apps and quality criteria for data gather by the apps, as described in deliverables 5.1 (inventory) and 5.3 (quality criteria). Apart from evaluating the scientific, technical and legal aspects of consumer generated purchase data gathered by mobile applications (apps) this deliverable aims at disseminating results of the RICHFIELDS project to a wider scientific community. Therefore the findings of D5.4 are presented in a draft paper intended for peer-reviewed open access publication in the Journal of Medical Internet Research mHealth and uHealth (JMU).

The draft paper is titled “Food purchase data for mHealth research: A dynamic search inventory and analysis of applications” and is intended to be submitted as a Viewpoint paper defined as an article expressing evidence-based opinions or arguments. Currently the draft paper lists authors as follows: Erik Kaunisto, Haris Hondo, Anne Normann, Susanne Ekman and Marcus Maringer, but the final authors list should be decided before submission. The full draft paper can be found in Annex 1 of this deliverable.

Apart from disseminating results of WP5 the draft paper itself has relevance to the RICHFIELDS project. Most importantly the paper looks at data that could potentially become inputs for the RICHEFIELDS platform and tries to answer questions such as: “Is the content and type of data relevant to RICHFIELDS?”, “How can this data be used for research purposes from a technical and legal stand-point?”, “Does the purchase data collected by apps have any scientific relevance?”. Some of these questions are better answered in D5.5. However a good overview of the scientific potential of purchase app data was presented in the draft paper by linking data content to the DONE (Determinants of eating and nutrition) framework.

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Contents

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1. Introduction

The overall aim of RICHFIELDS is to design a world-class infrastructure for research on food and health consumer behavior including food purchase, preparation and consumption of EU citizens, closely linked to their lifestyle. In order for the data to be valuable to users of RICHFIELDS it is essential that factors influencing the quality of this data are identified and thereby visualizing the potential opportunities with the infrastructure, as well as the gaps and needs with its quality. Work package 5 aims to identify the gaps and needs of research on factors affecting food purchase by consumers.

This current deliverable 5.4 (D5.4) aims to provide an overview and assessment of the inventory of food purchase apps and quality criteria for data gather by the apps, as described in deliverables 5.1 (inventory) and 5.3 (quality criteria). Apart from evaluating the scientific, technical and legal aspects of consumer generated purchase data gathered by mobile applications (apps) this deliverable aims at disseminating results of the RICHFIELDS project to a wider scientific community. Therefore the findings of D5.4 are presented in a draft paper intended for peer-reviewed open access publication in the Journal of Medical Internet Research mHealth and uHealth (JMU).

This deliverable does not aim to provide a report on gaps and needs on quality and availability of food purchasing data directly relevant to the RICHFIELDS project consortium. Instead the gaps and needs identified while studying the inventory and quality criteria of food purchase data gathered by apps aiming at reaching the overall objectives of the RICHFIELDS project are presented in deliverable 5.5.

2. About the draft paper

The following section will provide clarification about the draft paper for D5.4. The full draft paper formatted for submission in the chosen journal is available in Annex 1.

Title

The title of the draft paper is: "**Food purchase data for mHealth research: A dynamic search inventory and analysis of applications**". This title captures the essence of the work done in WP5 and alludes to the method used for data capture while clearly being in the scope of the chosen journal.

Authors

The current authors listed on the draft paper are as follows: Erik Kaunisto, Haris Hondo, Anne Normann, Susanne Ekman and Marcus Maringer. The final author order, including possible inclusion of more than the current authors, should be decided before submission.

Journal

The journal chosen for publication is the **Journal of Medical Internet Research** (JMIR) **mHealth and uHealth** (JMU, ISSN 2291-5222)[1]. This is a spin-off journal of the eHealth journal JMIR and is indexed in PubMed, PubMed Central and Science Citation Index Expanded (SCIE). The journal has an impact

[1] http://mhealth.jmir.org/

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factor of 4.636. The draft paper presented in Annex 1 fits well into the scope of the journal covering several relevant themes defined by the journal such as:

- mHealth for Data Collection and Research
- mHealth for Wellness, Behaviour Change and Prevention
- Security and Privacy of mHealth and uHealth
- Quality Evaluation and Descriptive Analysis of Multiple Existing Mobile Apps
- Use and User Demographics of mHealth
- Evaluation and Research Methodology for mHealth
- Fitness Trackers and Smart Pedometers/Accelerometers

The draft paper is intended to be submitted as a **Viewpoint paper** which is defined by JMIR mHealth and uHealth as a narrative article expressing an evidence-based opinion or argument.

Open access

JMIR mHealth and uHealth provides immediate open access to its content on the principle that making research freely available to the public supports a greater global exchange of knowledge and accelerates research. Copyright is retained by the authors and articles can be freely used and distributed by others. Articles are distributed under the terms of the Creative Commons Attribution License[2], which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published by JMIR Publications, is properly cited. The complete bibliographic information (authors, title, journal, volume/issue, articleID), a link to the original publication (URL), as well as this copyright and license information ("Licensed under Creative Commons Attribution cc-by 2.0") must be included.

If accepted the paper will be deposited in a repository for scientific publications either in the institutional repository of Gothenburg University or in a centralized repository such as Zenodo[3].

Abstract

Background: *Based on escalating public health costs due to modern consumption patterns and current public data sharing attitudes, an interesting future possibility with mHealth is to make use of data collected from food purchase oriented applications, such as websites, aggregators, mobile apps (including external sensors) and desktop software in order for researchers to predict public health. For this to be possible, applications need to fulfill relevant technical, legal and scientific quality criteria. On the technical side, data accessibility needs to be addressed in order to be able to extract relevant information from the data owners, i.e. the vendor or the user. This issue is in turn dependent on the legal aspects on data privacy policy and "terms of use" and availability of such information. If purchase data can be used, it is further essential that there is a pronounced scientific connection between the data and established predictors of eating behavior. These issues have not yet been fully addressed by the scientific community.*

[2] http://creativecommons.org/licenses/by/2.0/
[3] https://www.zenodo.org/

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***Objective**: The main purpose of the present study is to provide and analyze results from a dynamic-search inventory of food purchase-oriented apps as data sources for mHealth research. Apps were analyzed from technical, legal and scientific quality criteria, the latter in terms of associated connection with the DONE framework.*

***Methods:** The study applied a dynamic search methodology when searching for apps during the inventory. Apps were continuously categorized into a KeystoneJS-based data management system, allowing for the development and analysis of the resulting app typology.*

***Results:** Regarding technical quality criteria, the results showed that most apps did not provide any information on the issue of data accessibility. In cases where data was accessible, application programming interface was the most common method of accessibility. In terms of legal quality criteria, a majority of apps had a "terms of use" and/or a privacy policy document available. In the cases where a "terms of use" document existed, a majority of apps had no information on data ownership. However, in contrast, where a privacy document was available, a majority of apps collected personal information. Finally, regarding scientific quality criteria, the app analysis suggested relevance in terms of eating behavior for the individual, interpersonal and environmental main level predictors of the DONE framework.*

***Conclusions:** The dynamic-search inventory and app analysis in the present study showed promising possibilities to utilize purchase app data for mHealth purposes. However, it was noted that a lack of information exists regarding technical and legal quality criteria in many cases. On the other hand, regarding scientific quality criteria, the suggested connections with the DONE framework warrants further research in this field.*

Relevance to RICHFIELDS

The relevance of the draft paper to the RICHFIELDS project is summarized in bullet points below:

- When published this paper will disseminate results of WP5 to a wider scientific audience.
- The paper looks at a potential input data for the RICHFIELDS platform from mobile apps, limited to purchase data. The results of the paper can be used to argue if the data is relevant for the infrastructure in terms of content and type.
- Technical and legal pre-requisites of apps and data have been assessed in terms of data accessibility, data privacy and "terms of use". This can provide useful information in regards to the governance model.
- The scientific potential of the apps and data is investigated through linking purchase app data content with the DONE (Determinants of nutrition and eating) framework as a cornerstone in public health research.
- The paper concludes existing potential and gaps that might have to be considered in the design of the RI.

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3. Conclusions

In order to disseminate the results of WP5 to the wider scientific audience, a draft paper was written titled “Food purchase data for mHealth research: A dynamic search inventory and analysis of applications”. The title was chosen to show a clear focus on how mobile applications gathering food purchase data can be used for public health research. The final author list has not been decided at the time of submission of deliverable 5.4.

The Journal of Medical Internet Research mHealth and uHealth is the journal of choice for publication. This journal was chosen to specifically disseminate results to researchers using data from mobile application to study food behavior as cornerstone of public health research. The work done during tasks 5.1, 5.3 and data analyzed in 5.4 fit well into the focus and scope of the journal. The paper is intended to be published as a Viewpoint paper with open access under the terms of the Creative Commons Attribution License.

Apart from disseminating results of WP5 the draft paper itself has relevance to the RICHFIELDS project. Most importantly the paper looks at data that could potentially become inputs for the RICHEFIELDS platform and tries to answer questions such as: “Is the content and type of data relevant to RICHFIELDS?”, “How can this data be used for research purposes from a technical and legal stand-point?”, “Does the purchase data collected by apps have any scientific relevance?”. Some of these questions are better answered in D5.5 where the results of data analysis are presented in a way to contribute to the overall goal of the RICHFIELDS project. However a good overview of the scientific potential of purchase app data was presented in the draft paper by linking data content to the DONE (Determinants of eating and nutrition) framework.

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Annex 1. Draft paper titled: "Food purchase data for mHealth research: A dynamic search inventory and analysis of applications"

Viewpoint paper

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654280.

Food purchase data for mHealth research: A dynamic-search inventory and analysis of applications

Abstract

Background: Based on escalating public health costs due to modern consumption patterns and current public data sharing attitudes, an interesting future possibility with mHealth is to make use of data collected from food purchase oriented applications, such as websites, aggregators, mobile apps (including external sensors) and desktop software in order for researchers to predict public health. For this to be possible, applications need to fulfill relevant technical, legal and scientific quality criteria. On the technical side, data accessibility needs to be addressed in order to be able to extract relevant information from the data owners, i.e. the vendor or the user. This issue is in turn dependent on the legal aspects on data privacy policy and "terms of use" and availability of such information. If purchase data can be used, it is further essential that there is a pronounced scientific connection between the data and established predictors of eating behavior. These issues have not yet been fully addressed by the scientific community.

Objective: The main purpose of the present study is to provide and analyze results from a dynamic-search inventory of food purchase-oriented apps as data sources for mHealth research. Apps were analyzed from technical, legal and scientific quality criteria, the latter in terms of associated connection with the DONE framework.

Methods: The study applied a dynamic search methodology when searching for apps during the inventory. Apps were continuously categorized into a KeystoneJS-based data management system, allowing for the development and analysis of the resulting app typology.

Results: Regarding technical quality criteria, the results showed that most apps did not provide any information on the issue of data accessibility. In cases where data was accessible, application programming interface was the most common method of accessibility. In terms of legal quality criteria, a majority of apps had a "terms of use" and/or a privacy policy document available. In the cases where a "terms of use" document existed, a majority of apps had no information on data ownership. However, in contrast, where a privacy document was available, a majority of apps collected personal information. Finally, regarding scientific quality criteria, the app analysis suggested relevance in terms of eating behavior for the individual, interpersonal and environmental main level predictors of the DONE framework.

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Conclusions: The dynamic-search inventory and app analysis in the present study showed promising possibilities to utilize purchase app data for mHealth purposes. However, it was noted that a lack of information exists regarding technical and legal quality criteria in many cases. On the other hand, regarding scientific quality criteria, the suggested connections with the DONE framework warrants further research in this field.

Keywords: Public health, mHealth, apps, purchase data, eating behavior

Introduction

Public health and eating behavior

Public health is intimately linked to eating behavior, which in turn is reflected in the overall consumption patterns resulting from single individual food purchase decisions. Today, food choice is a poorly understood unconscious process that warrants more research [1]. Preparation of food and associated cooking skills has also been directly related to both food-related behavior and dietary quality [2]. For instance, current obesity rates can be partly explained by the problem of large portion sizes that are a function of distorted consumption patterns, norms and perceptions [3]. Further, significant scientific evidence linking consumption of e.g. sugar-sweetened beverages to the risk of developing chronic diseases, have led to investigation of a sugar tax to compensate for escalating health costs [4]. In order to tackle current issues of public health, new initiatives are thus needed where the complexity of the underlying public consumption behavior can be mapped on both national and international levels, e.g. through joint data mining activities.

Data mining in healthcare

As in the commercial organizations, data mining can be used also within healthcare in major areas, such as the evaluation of treatment effectiveness, management of healthcare, customer relationship management and the detection of fraud and abuse. In these cases, it is important that the data is properly stored, prepared and mined, also with a possibility to be shared across organizations [5]. In addition, so called “Big Data” has been used to predict both public health and economic development, e.g. by analyzing frequency of certain search queries on the internet, but there are still challenges associated with current analysis models and data processing systems [6]. A framework for how to implement the concept of BI for better decision making in healthcare organizations has also been developed, where strong management support, proper skill sets and an information-oriented culture are key implementation considerations [7]. Earlier concepts of BI, from pure data gathering and mining to web-intelligence and analytics have also evolved further with the introduction of “Big Data” and recent mobile and sensor developments [8]. These developments are expected to play an important role for the concept of mHealth [9].

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Food Purchase application data in mHealth

An interesting possibility with mHealth is to make use of data collected from food purchase oriented mobile applications. As consumers seek variation in purchase of goods and services for different reasons [10], as well as having varying affinity to be involved in brand communities [11], it is important for retailers to look for proper m-services to serve their customers in order to stay competitive, extending to pre- and post- purchase processes [12]. On the other hand, contemporary consumer research lack good measures of the actual consumer behavior and it is therefore important to understand associated implications of retail strategies and what factors influence consumer's choice over internet vs a conventional channel [13]. Existing knowledge of how mobile marketing can increase the value for both consumers and retailers suggest that the effectiveness of mobile marketing may be limited compared to alternative channels and affected by the consumer perceived value [14]. In relation to m-services, marketers need to consider the importance of contextual elements and how they create conditional value for service users facing challenges with e.g. time, location and uncertainty management [15]. Retailers using mobile marketing face both organizational as well as customer related challenges and an increased spending on mobile communications is predicted [16].

An important pre-requisite for successful development of mHealth through retail purchase data is the public attitude towards data sharing. Investigation has shown that sharing health data with trusted agencies is considered positive, although the information is considered sensitive, private and confidential [17]. Another study shows patient belief in that sharing health data with research networks, where patient medical data can be aggregated from many institutions, could enhance healthcare knowledge [18]. However, according to another survey, the respondents were positive if they were given choices on which portions of medical data would be shared and with whom [19]. There was a strong 83% preference towards controlling access to specific data and transparency seemed to be a key factor enabling associated willingness to share. An overview of consumer attitudes in the UK suggest that trust is the most powerful factor enabling consumers to provide information to companies and 80% consider disclosing personal information to be a part of modern life [20]. The latter percentage is also close to that of an EU study, i.e. 74%, on attitudes towards identity management, data protection and privacy, where also financial information was considered to be personal information by 75% of Europeans [21]. In addition, 70% were concerned that information is used by companies for other things than that for which it was collected. Especially, related to existing "Big Data" platforms, mentioned issues need to be handled by the research community in order to develop new definitions of data security and privacy [22].

Regarding apps and mHealth, work has been done in order to determine the most popular lifestyle smartphone apps and willingness of the public to share data for health research purposes [23]. The results indicated that the participants were willing to share data for scientific and research purposes. However, privacy, anonymity and third party concerns were considered barriers to sharing data and thus remain challenges within mHealth. From the purchase perspective, the intention to use apps in order to promote healthy choices of drinks and food in restaurants has been investigated [24]. The

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results suggest that intention is governed by a mix of social norms, perceived usefulness, self-efficacy and ease of use. An Australian customer app has also been developed in order to provide consumers with easy to understand nutrition information and support selection of healthier choices when shopping for food [25]. The crowdsourced data also provided a low-cost way of tracking nutritional composition in Australia.

Purpose of this study

The main purpose of the present study is to provide results from a dynamic-search inventory of purchase-oriented apps and associated potential for mHealth. Example apps have been analyzed from different quality criteria, i.e. scientific, technical and legal criteria, and resulting relevant app statistics results are presented and further related to the DONE framework [26][27]. The inventory should not be considered representative for all available purchase apps, but rather a basis for a preliminary discussion on the utilization of purchase apps and data for mHealth purposes.

Methods

Data management system

A data management system, referred to as RIMS, was created to allow for easy standardized characterization of the apps. RIMS was developed as an online app for the management of the inventory content that was created during the data collection procedure. The system was designed for storage and assessment of apps that produce consumer-generated data on the purchase, but also the preparation and consumption of food and/or beverages, and their associated data that could potentially be of use for health researchers. RIMS comprises two main parts:

1. A typology of the apps stored within the inventory.
2. A list of quality criteria against which each app can be evaluated.

The open source Node.js content management system KeystoneJS (version 0.3.17) was used as an application framework for the development of RIMS. RIMS is structured into two main areas, a backend and a frontend. The backend consists of a set of branched web forms for data input and data editing and the purpose of the frontend was to support data aggregations and data visualizations.

Data input

The web form for data collection allowed for the collection of the data types numbers and text, by the use of text input fields, single selection and multiple selection fields. RIMS was also designed to allow for the management of input options used for the single and multiple selection fields (except

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for yes-no answering formats). This had the advantage of standardizing provided inputs and making them reusable.

The web-form allowed for the collection of different app types, such as websites, aggregators, mobile apps (including external sensors) and desktop software. Dependent on the selected app type the input fields were adapted to fit the expected and needed information. For instance, if the app was a “mobile app” a field asking for the URL to the respective apps store where the application can be accessed, was added to the web form. If the app type was an "aggregator" the field about methods of dietary assessment was omitted from the web form.

In addition to app types, the composition of the web form was also dependent on the data type, which is whether the app collects purchase, preparation or consumption data, or a combination. Specifically, each data type was associated with a different set of input fields regarding the scientific relevance of the data, which corresponds to the different sets of quality criteria identified for the three data types. However, in this paper, the study is delimited to criteria concerning purchase apps.

Identification of food purchase apps

Identification of food purchase apps was conducted to examine the breadth of domestic food purchase apps currently available in the market place that collect consumer-generated data and create an inventory of prototypical examples of these applications. The starting point of this identification was a review of the definition of food purchase, which is divided into three stages, i.e. the pre-purchase phase, the point-of-sale and the post-purchase phase. The pre-purchase phase, which includes the recognition of a need/motive, is a more or less intensive information search determined by the current type of buying decision and an evaluation of different options. The pre-purchase phase includes processes where consumers compare prices-, groceries-, product-, service- and store-related information, as well as plan and decide what to buy or cook. After the pre-purchase phase, the purchase decision at the point-of-sale is made. This step includes a monetary exchange. Finally, the consumer evaluates the buying decision in the post-purchase phase. For the purpose of this study, the primary focus is on the phases of pre-purchase, as well as the actual point-of-sale. The post purchase phase includes financial evaluations of purchases, but it is also assumed that post-purchase is the base for another (pre-) purchase phase. The latter implies that consumers use their memories and experiences as an information source for future purchase processes. This definition of purchase was the basis for the typology and categorization of apps.

As a starting point for the inventory, the collected apps were initially categorized into three main categories; pre-purchase, actual point-of-sale and post-purchase. As data collection continued and more apps were logged in RIMS – new kinds of functions and new kinds of potential consumer-generated data were found. Moreover, apps with similar functions were grouped together in the same category. The process of formulating a typology was as dynamic as the search for tools, i.e. a dynamic-search process. Thus, newer versions of the typology were set continuously, where some

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subcategories were merged together and some categories were renamed in order to present the selected tools.

Analysis of app mHealth potential

Relevant app data were extracted from RIMS in order to assess both collective app strengths and weaknesses with respect to the relevant quality criteria. For simplicity, the resulting tables were connected to the first and second levels in the app typology. However, the second and third levels of the app typology were also used, together with additional findings, to make associated connections with the DONE framework.

Results

Typology of purchase apps

Figure 1 shows the resulting typology from the inventory and the number of apps in the various categories. The total number of apps amounted to 62. However, as a given specific app can have multiple functionality, it can belong to several categories simultaneously. A majority of apps belonged to the pre-purchase category, whereas a minority of apps belonged to the point-of-sale and post-purchase categories.

The typology, consists of four levels. Level 1 is based on the definition of purchase and level 2 the categories describing the purpose of the data collected, i.e. the motivation underlying the behaviour captured by the app. Level 3 reflects what recordable food related activities that are captured, i.e. the specific behaviours captured by the app. Finally, level 4 indicates the potential consumer data from the activities, i.e. the recorded behaviour. The separation of the definition into the different categories has been inspired by earlier work [2]. The level 2 categories are (1) Knowledge and understanding; (2) Planning and organisation; (3) Making a purchase; and (4) Financial understanding. For further reference, Table 1 shows the level 2 and 3 content of the typology.

Table 1. Distribution of apps in the typology. The table shows the number of apps belonging to the different level 2 and 3 categories.

Knowledge and understanding	**(No. apps)**	**Planning and organisation**	**(No. apps)**	**Making a purchase**	**(No. apps)**	**Financial understanding**	**(No. apps)**
Store/rest. search/locator	26	Creating a shopping list	14	Placing an order	20	Transactions	7
Searching for offers	22	Budgeting	7				

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Searching for experiences	19	Booking services	5
Comparing product and price	13		

Technical and legal quality criteria

Accessibility to the data collected by the different purchase apps is essential in order to be utilized for any data mining purpose. Table 2 shows whether the data of all apps in the present inventory can be accessed by their associated infrastructure.

Table 2. The table shows the data accessibility of all the apps in the typology and illustrates the fact that most apps provide no information on this matter.

	Data accessibility (No. apps)
No information	54
Yes	8
No	0

There were no apps explicitly stating “no” data accessibility, but most apps did not provide any information on the issue. In the 8 cases were data was accessible, application programming interface was the most common method of accessibility (5 apps), followed by Email export (1 app), software development kit (1 app) and Web Feed (1 app) alternatives. The most common data formats were JSON (5 apps), followed by XML (3 apps) and PDF (1 app). However, no information on format was also reported (1 app). Regarding the need for data access authentication, a majority of the apps which allowed data access did not have any information on the issue (6 apps), with only a minority of apps needing (1 app) and not needing (1 app) authentication. A similar result was also obtained related to the need for data access payment, where no information was given in the majority of apps (7 apps), whereas a minority did not require payment (1 app). There was no case explicitly requiring data access payment.

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On legal aspects, Table 3 summarizes whether the apps provide a “terms of use” and privacy policy document, respectively.

Table 3. The table shows legal aspects of all the apps in the typology and illustrates the fact that a majority of apps have either a “Terms of use” and/or a privacy policy document available.

	“Terms of use” document (No. apps)	**Privacy policy document (No. apps)**
Yes	46	48
No	16	14

A majority of apps had a “terms of use” and/or a privacy policy document available. In the cases where a “terms of use” document existed, a majority of apps had no information on data ownership (34 apps), whereas in a minority of apps data belonged to either the vendor (4 apps) or the user (8 apps). However, in contrast, where a privacy document was available, a majority of apps collected personal information (44 apps) with a minority providing no information on the matter (3 apps) or not collecting personal information (1 app).

Scientific quality criteria and connection to DONE framework

The results from the inventory were also used in order to investigate the scientific relevance of purchase apps in relation to eating behavior, as described by the DONE framework [26][27]. The analysis of the apps suggested relevance for the Individual, Interpersonal and Environmental main level predictors of the DONE framework with associated steam and leaf category predictors (Table 4).

Table 4. Purchase app targeted predictors of the DONE framework.

Main level predictor	**Stem category predictor**	**Leaf category predictor**
Individual	Demographic	Cultural Characteristics
		Personal socio-economic status
	Psychological	Food habits
	Situational	Situational and time constraints

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Interpersonal	Social	Household socio-economic status
		Social influence/support
Environmental	Product	Intrinsic product attributes
		Extrinsic product attributes
	Meso/Macro	Characteristics of living area
		Exposure to food promotion
		Market price
		Food outlet density

On the individual level it was noted that several apps, mainly from the "making a purchase" category, collected information on demographic factors, such as age (9 apps), gender (7 apps) and nationality and ethnicity (2 apps). Thus, this information may provide quantitative data on the cultural characteristics of a population. In addition, information on demographic personal socio-economic status and interpersonal household socio-economic status can potentially be obtained from transactions data (7 apps) and budgeting data (7 apps) (Table 1). From all categories except "financial understanding", individual psychological information on food habits may also be potentially obtained from apps featuring the possibility to indicate favorite food products or restaurants (18 apps). On a more detailed level, food habits may also be further inferred from apps in the "making a purchase" category that generate information on order confirmations (15 apps), store purchase history (11 apps) or have a loyalty card connection (4 apps). Further, information on individual situational and time constraints may be obtained from apps taking into account when in time things were purchased (36 apps), where the purchase was made (36 apps) and in cases where the exact time of the purchase is collected (19 apps). An inherent assumption is thus that data on "when" and "where" may give information on the daily rhythm of individuals.

Although app relevance was less pronounced on the interpersonal level, a potential connection to social influence/support was also found. For example, in the "knowledge and understanding" category, certain apps allow users to express their opinions about products and food (9 apps). Unstructured contextual information is also provided from apps where evaluation/rating of products is possible (9 apps). In addition, apps enabling data sharing and interaction over Facebook (19 apps) and Twitter (13 apps) provides yet another source of information.

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Finally, the apps in the inventory also showed connection to the environmental level. In the case of products and their intrinsic/extrinsic attributes, it was noted that several apps collect this kind of information (51 apps). In relation to meso/macro factors, information on the associated product market price can also potentially be found in the apps that collect food cost data (30 apps). It should however be pointed out that the latter apps belong to the different categories of purchase and associated differences in information relevance and data quality might therefore be expected. In addition, the effect of food promotion exposure is potentially addressed by apps allowing search for offers (22 apps) and comparison of products and prices (13 apps) (Table 1). Further, information on living area characteristics is also collected by some apps, such as zip code (11 apps) and home address (22 apps). Information on food outlet density and associated closeness to stores, supermarkets and restaurants is also provided by apps that give venue name (33 apps) and geo-coordinates of a place (9 apps).

Discussion

Technical and legal issues

Regarding technical and legal quality criteria, it is evident that the lack of associated information in many cases is a problem with respect to app mHealth potential. However, in terms of accessibility, since there were no apps denying data accessibility in the present inventory, one can speculate that accessibility may be a limited problem which only needs a clarification from the respective vendors on method and format. In contrast, on the legal side, the majority of apps have either a “terms of use” or a privacy policy or both, but the high uncertainty in data ownership and the fact that many apps collect personal information is potentially troublesome. Specifically, these findings may emphasize public concerns of both purpose of data usage and third party data access [23].

Scientific relevance of purchase apps

The suggested scientific connections indicate that purchase data may potentially be relevant to address at least three main level predictors of the DONE framework and thus further research on the subject is motivated. However, in doing so, it is important to consider the different aspects of purchase data. Firstly, it should be noted that purchase data does not necessarily reflect the underlying consumption behavior, i.e. the eating behavior of individuals, and therefore the quality and relevance of the data for specific purposes should be questioned. More specifically, the difference between “actual” and “intentional” data, with respect to subsequent consumption, should be considered. In the pre-purchase categories, apps mainly collect “intentional” data which are not necessarily connected to an actual purchase. On the other hand, an “actual” purchase does not imply individual level consumption, as it can be alternatively consumed by another individual or end up as waste. However, on a public level, “who consumes exactly what?” may not be as relevant, as it is probably the amount of eating and associated patterns that are of main interest, and in this case the actual purchase data is likely to have the highest relevance for mHealth. At this point, it is however nonetheless interesting to make comparisons between available intentional and actual purchase data and further scientific efforts will have to consider their potential use. Moreover,

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although purchase data is more available than consumption data, a scrutiny of the required underlying assumptions on implied consumption behavior is also necessary.

Conclusions

The dynamic-search inventory and app analysis in the present study showed promising possibilities to utilize purchase app data for mHealth purposes. Based on technical and legal quality criteria, it was noted that a lack of information exists in many cases, thus justifying a clarification from app vendors regarding data accessibility, data ownership and associated public privacy issues. However, on the technical side, there is no reason to believe that data accessibility itself is an issue. Regarding scientific quality criteria, the app analysis suggested connections with the DONE framework to the individual, interpersonal and environmental main level predictors, thus warranting further research in this field.

Acknowledgements

The European Union is gratefully acknowledged for funding through the RICHFIELDS platform. Professor Bent Egberg Mikkelsen at Aalborg University, Department of Clinical Medicine in Copenhagen is also gratefully acknowledged for his assistance in the present work.

Conflicts of Interest

None declared.

Abbreviations

App(s): Application(s)

BI: Business intelligence

DONE: Determinants of nutrition and eating

mHealth: Mobile health

RIMS: RICHFIELDS inventory management system

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