Web Scraping Online Newspaper Death Notices for the Estimation of the Local Number of Deaths

Rainer Schnell and Sarah Redlich
University of Duisburg-Essen, Research Methodology Group, Forsthausweg 2, 47057 Duisburg, Germany
rainer.schnell@uni-due.de, sarah.redlich@uni-due.de

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Abstract: Since access to real-world data is often tedious, web scraping has gained popularity. A health research example is the monitoring of mortality rates. We compare the results of local online death notices and print-media obituaries to administrative mortality data. The web scraping process and its problems are being described. The resulting estimates of death rates and demographic characteristics of the deceased are statistically different from known population values. Scaped data resulted in a sample that is more male, older and contains less foreign nationals. Therefore, using web scraped data instead of administrative data cannot be recommended for the estimation of death rates at this time for Germany.

1 INTRODUCTION

Extracting information from websites has become increasingly popular as a data source. For example, web scraping has been used for finding unpublished literature or for efficiently creating lists of contact information (Haddaway 2015; Le and Pishva 2015). However, scraped data is also used for statistical purposes, for example, Barcaroli et al. (2016) updated farm registers using scraped information. Another example is the augmentation of traditional data by scraped data for the estimation of job vacancy statistics (Swier, 2017).

For the estimation of death rates, for example, during a flu epidemic, timely access to mortality data is essential. In countries with decentralized organizational structures such as Germany with about 10.000 independent local death registries and no federal mortality database, getting such data is a lengthy process. In other countries with similar organizational structures, some unconventional data sources have been used.

For example, in Geneva, Switzerland funeral homes have been proved to be a reliable source (Mpinga et al., 2014). They found for a six-year period only a 4.8% discrepancy on average for the number of deaths between funeral homes and official state registries.

Another obvious data source is newspaper death notices. Since online death notices are even easier to access than newspaper publications, online obituaries may provide information on mortality easily. In the US, online newspaper death notices have been used to get information on deceased persons (Boak et al. 2007; Soowamber et al. 2016). A recent study by Sylvestre et al. (2018) compared online obituaries to health records of cancer patients in Rennes, France. They found high overall accuracy (positive predictive values between 98% and 100%, negative predictive value 99%), when linking the two data sets.

To test the feasibility of this approach in a different cultural setting, we obtained research access to the official death registry of one of the largest towns in Germany (about 600.000 citizens) and compared information on the deceased with online newspaper death notices extracted using a web scraper. The databases were matched by record linkage using names, date of birth and date of death. We computed undercoverage and bias in estimates by comparing the scraping results to the death registry.

In section 2, we describe the advantages and problems of web scraping, and discuss the ethical and legal concerns when extracting death notices. We also address some issues encountered during scraping. In section 3 we compare demographic differences of the deceased between scraped and administrative data. Section 4 concludes.

2 WEB SCRAPING

Web scraping is the extraction of data of interest such as text, pictures or links from the world wide web (Chow, 2012). In the literature, it is sometimes referred to as web harvesting, web crawling, and web mining. While web harvesting can be used as a synonym to web scraping, the definitions of web crawling and web mining do not allow for an interchangeable use (Gatterbauer 2009, 3472; Bharanipriya and Kamakshi Prasad 2011, 211; Najork 2009, 3462).

The respective class of programs is referred to as web scrapers (Najork, 2009). They imitate the interaction of a human with a server and perform the same tasks a human would perform to get the information of interest, but in a shorter amount of time. In detail, they access the web page and search the underlying HTML-code using regular expressions. When the information required is found, they extract it and copy it to a pre-defined output file (Glez-Peña et al., 2013, 789 f.). The obtained information usually has to be cleaned and checked after extraction. A web scraper can be a library, a framework or a desktop-based environment (Glez-Peña et al., 2013, 789 f.). The last option enables the use of web scraping without prior knowledge of a programming language (Glez-Peña et al., 2013, 790 f.).

Web scraping has numerous advantages and disadvantages. Advantages are time-efficiency, the possibility of a regular data collection with shorter time intervals, the reduction of costs, avoidance of response burden of survey respondents, no survey response effects such as social desirability bias, and enhancing the quality of statistics resp. the amount of information (Landers et al. 2016, 2; Hoekstra et al. 2010, 6 f., 15).

The disadvantages are the necessity for the skills to write a web scraper, changes of the underlying HTML-code of websites, lack of automatic plausibility checks when extracting data, and ethical and legal concerns (Hoekstra et al., 2010, 7 f.). Furthermore, there is a chance that the web scraper overloads the servers or enhances the costs for the owner of the website for needing a larger bandwidth (Koster 1993b; Thelwall and Stuart 2006, 1776). Given the increasing bandwidth and capacity of web servers, this objection seems to be negligible. The remaining problems are mostly ethical problems.

2.1 Ethical and Legal Concerns

When extracting information from websites using a web scraper, the information is derived without the knowledge and consent of the individuals such as the person whose information is retrieved, the provider of the website and in the case of death notices relatives of the deceased person (van Wel and Royakkers, 2004, 129). Although, the websites `robots.txt`, which regulates the access by robots, can be used to stop web scrapers from accessing the information presented on the website (Koster 1993a; Thelwall and Stuart 2006, 1775), it should be noted, that the `robots.txt` can be bypassed. Ethically and legally the laws for web scraping have to be followed.

Regarding the legal concerns, national laws, as well as European laws, have to be considered (in the case of Europe). For Germany, the copyright law and the European directive 96/9/EG are of interest. Both, as well as different court decisions throughout the years, show that web scraping is legal for scientific purposes if the extracted information is not made publicly available and is not commercialized. Further, the information has to be freely accessible, without the need for registration. Even if the terms and conditions of a website prohibit the use of a web scraper, they only apply if they have been accepted by a registration.

Since personal information is extracted, data protection laws have to be considered as well. In Europe, a deceased person is, by definition, not covered by the data protection law. Nevertheless, postmortem personal rights concerning the dignity of the deceased person still apply. However, for scientific purposes, the extraction of personal information from data sets is permitted, as long as they do not include information about persons alive (Löwer, 2010, 33). In the case of death notices, this refers to the names (and addresses) of relatives mentioned.

2.2 Online Newspaper Death Notices

Since the 18th century, the death of persons was announced publicly. The first death notice in Germany was published in 1753. But not until the 19th century the regular publication of death notices was established (Grümer and Helmrich, 1994, 69). The structure of a death notice is nowadays more or less standardized, as can be seen in figure 1.

Traditionally, death notifications are published in newspapers. Increasingly, in many countries, death notices are also published in online newspaper obituaries. Online death notices have been used as a data source for research purposes in the US. For example, Boak et al. (2007) used death notices from the *Pittsburgh Post-Gazette* to monitor mortality. When comparing their extracted death notices to administrative records, they were able to find death notices for 73.5% of the registered deceased persons, 31.4% could be found in registers of surrounding cities, and 8.96% could not be detected (Boak et al., 2007, 534). Similar results were reported by Soowamber et al. (2016, 167) when using death notices to detect panel mortality. Although they do not report the proportion of detected deaths, they considered death notices as a valid and reliable data source (Soowamber et al., 2016, 167).

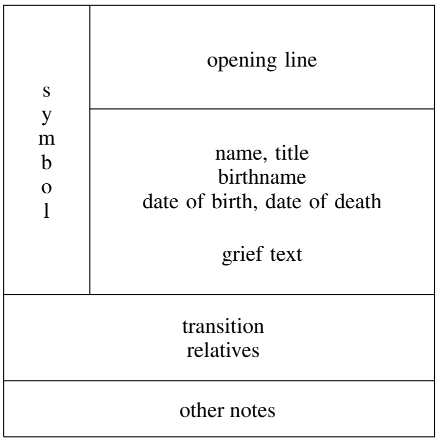


Figure 1: Structure of death notifications (based on Grümer and Helmrich, 1994, 66).

Therefore, we decided to study whether death notifications can be used in Germany. In 2017, our search yielded a total of 152 online newspaper obituaries in Germany. Five of them were unsuitable for web scraping since they required prior registering for access. Since they usually don't cover deaths in our region of interest, we don't consider this exclusion as limiting our conclusions.

The online newspaper obituaries were divided into groups of the same layout. With two web scrapers, we were able to cover 109 of 152 online newspaper obituaries. For the rest, individual programs would be needed. Although we covered only about 72% of the obituaries, we manually verified that none of the online newspaper obituaries which could not be scraped contained death notifications of our test region. Therefore, the undercoverage of the scraped data (to be discussed in section 3) is not due to the exclusion of the remaining 43 obituaries.

The web scraper was written in Python 2.7 using Scrapy 1.3.3 (Kouzis-Loukas, 2016).

The death notices are segmented on the website. There is always the name of the deceased person, sometimes followed by the date of birth and date of death, if available, concluding with a picture of the printed death notice. Sometimes the websites displayed a small image of the printed death notice and next to it the name as well as the first 300 characters of the death notice. All sites offer a filter by names, dates or locations for searching obituaries.

2.3 Problems

Scraping the obituaries encountered different problems (for details, see Redlich 2017).

An unexpected problem was due to multiple death notices per person on the same web page. For some of those, two pictures of death notices were found in the same segment of a death notification beneath each other. Scrapy then concatenated the URLs into one non-existing URL. Therefore, only the URL of the first picture in each segment was considered.

The second problem concerned the resolution of the images. Since only a small preview was shown in the overview of all death notices, a solution for accessing the full-size death notice was needed. The scraper was instructed to search within an URL for the suffixes "small" or "medium" (depending on the size of the picture). Hence, the suffixes "small" and "medium" were replaced by "large" before scraping the picture.

For some websites, the names of the pictures consisted of a letter-number-combination and the larger pictures were embedded into JavaScript. Although scraping data within JavaScript (Mitchell, 2015, 147-159) is possible in principle, we were unable to find a working solution within a reasonable time. However, since those websites provided a medium resolution picture of the death notice, no records were lost.

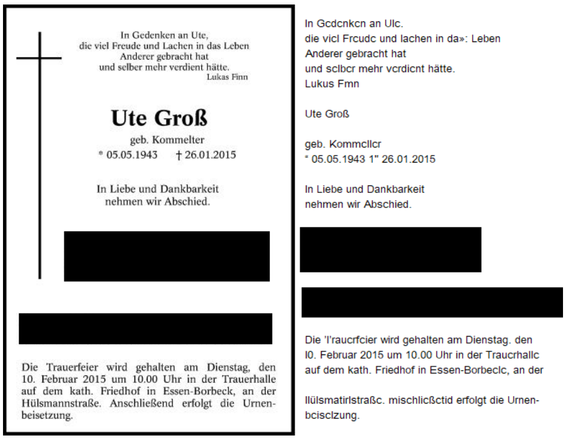
Furthermore, Scrapy was often unable to distinguish between empty pages, the end of the filtered search and the end of the database. Sometimes, a plausible date without death notices was found, because not every day obituaries were published. In those cases, depending on the title of the page, the web scraper was instructed to stop extraction for this notification or try to find information for the day before.

For websites with a 300 letter preview of the death notice, the date of birth and date of death were not explicitly stated in the title or subtitle of the segment. Instead, to extract this information, they had to be part of the first 300 characters to be scraped. In the case of multiple dates, e.g. date of funeral, the first two dates were extracted as the date of birth and date of death.

Two major problems were the modification of the HTML-code of the website or the modification of the `robots.txt` by the webmaster during our collection period of two years. When the `robots.txt` is modified to prevent the extraction of information, web scraping should not be performed. If the HTML-code is modified, the program code has to be adjusted, which can be very time-consuming. We also experienced changes of the `robots.txt` and of the HTML-code. While the first did not impact our results, because the respective online newspaper obituaries did not cover our test region, the latter caused a time-consuming revision of the programmed web scraper.

Moreover, the image of a death notification could contain additional information if dates or locations were missing in the subtitle or within the first 300 characters.

Therefore, we tested the use of optical character recognition and regular expressions to gain this information from the extracted bitmaps of the death notifications. We tested *Tesseract* and *ABBY Fine Reader* (Lawson 2015, 96; Mitchell 2015, 163). Even though we attempted to get the largest resolution possible the resolution was not large enough for Tesseract or ABBY Fine Reader to provide acceptable results (see figures 2 and 3). Especially colored death notices with non-standard fonts lead to useless OCR outputs. Although the attempt was made to still extract as much information as possible from the given OCR using *AWK* (Aho et al., 1988), no working solution could be found. As seen in figure 2 the letter "e" was recognized as a "c" and the cross symbol indicating the date of death was recognized as two characters including a number. Since non-standard layout and color are in some cases more expensive, there might be a systematic difference in socio-economic status of the deceased between OCR recognizable and not OCR recognizable death notifications. However, since only a few death notifications were colored, we don't consider this as a problematic exclusion.



In Gedenken an Ute,
die viel Freude und Lachen in das Leben
Anderer gebracht hat
und selber mehr verdient hätte.
Lukas Finn

Ute Groß
geb. Kommelter
* 05.05.1943 † 26.01.2015

In Liebe und Dankbarkeit
nehmen wir Abschied.

[redacted]

[redacted]

Die Trauerfeier wird gehalten am Dienstag, den 10. Februar 2015 um 10.00 Uhr in der Trauerhalle auf dem kath. Friedhof in Essen-Borbeck, an der Hülsmannstraße. Anschließend erfolgt die Urnenbeisetzung.

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Anderer gebracht hat
und sclbcr mehr vcrdicnt hätte.
Lukus Fmn

Ute Groß

geb. Kommcllcr
" 05.05.1943 1" 26.01.2015

In Liebe und Dankbarkeit
nehmen wir Abschied.

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I0. Februar 2015 um 10.00 Uhr in der Traucrhallc
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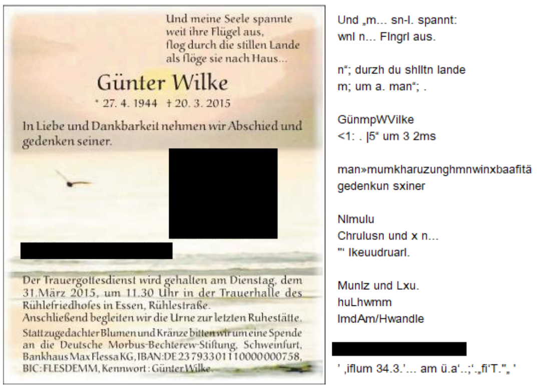
Figure 2: Artefacts by OCR using Tesseract (example 1). Birth name incorrectly identified and cross symbol misclassified as part of numbers. Personal information of relatives are concealed.

Since the websites may nevertheless provide the name, date of birth, date of death, and location this might not necessarily cause biased estimates.

3 RESULTS

We extracted death notices for people in one of the largest German cities for all deaths for every day in 2015 and 2016. For this, all existing six local online newspaper obituaries were used. Since the OCR outputs were not usable, we only used the embedded text in the HTML. After extraction, the data was cleaned and preprocessed using R 3.4.0. For missing data on sex and nationality (German/other), we used a large administrative database to impute sex and nationality based on the first name. The results of the scraped data were compared to the official local death registry. To test for selectivity of the scraped data, we compared age, sex, and nationality between scraped data and administrative data. We conducted two-sample tests of proportions and means using *Stata 15* (StataCorp, 2017).



Und meine Seele spannte
weit ihre Flügel aus,
flog durch die stillen Lande
als flöge sie nach Haus...

Günter Wilke
* 27. 4. 1944 † 20. 3. 2015

In Liebe und Dankbarkeit nehmen wir Abschied und gedenken seiner.

[redacted]

[redacted]

Der Trauergottesdienst wird gehalten am Dienstag, dem 31.März 2015, um 11.30 Uhr in der Trauerhalle des Rühlefriedhofes in Essen, Rühlestraße.
Anschließend begleiten wir die Urne zur letzten Ruhestätte.
Statt zugedachter Blumen und Kränze bitten wir um eine Spende an die Deutsche Morbus-Bechterew-Stiftung, Schweinfurt, Bankhaus Max Flessa KG, IBAN:DE 23793301110000000758, BIC: FLESDEMM, Kennwort: Günter Wilke.

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Figure 3: Artefacts by OCR using Tesseract (example 2). Color, font and low resolution make OCR impossible. Personal information of relatives are concealed.

As shown in table 1, only 3,007 death notices (21.47%) could be scraped, while the administrative database contains 14,003 registered deceased persons.

Table 1: Number of deceased persons in each data set.

	Administrative	Scraped
2015	7,002	1,427
2016	7,001	1,580
$\sum$	14,003	3,007

For sex, the difference between proportions is 3.39% (see table 2) and therefore significant in this setting ($p < 0.01$).

Table 2: Number of deceased persons by sex. The administrative data contains a higher proportion of females.

	Administrative	Scraped
Female	7,399	1,489
	(52.94%)	(49.55%)
Male	6,577	1,516
	(47.06%)	(50.45%)
$\sum$	13,976	3,005

Only 0.77% in the scraped data compared to 2.56% in the administrative data seem to be foreigners (see

table 3). This difference of 1.79% is also significant ($p < 0.01$).

Table 3: Number of deceased persons by nationality. The administrative data contains a higher proportion of foreigners.

	Administrative	Scraped
German	13,606 (97.44%)	2,979 (99.23%)
Other	357 (2.56%)	23 (0.77%)
$\sum$	13,963	3,002

For age at death, we found a higher proportion of people between 75 and 90 in the scraped data (see figure 4 and 5).

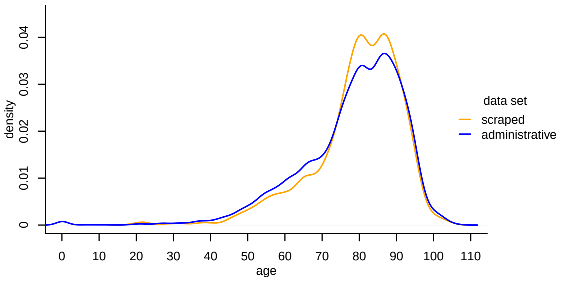

Figure 4: Kernel densities of age at death by data set. Scraped data shows a higher proportion of persons between 75 and 90.

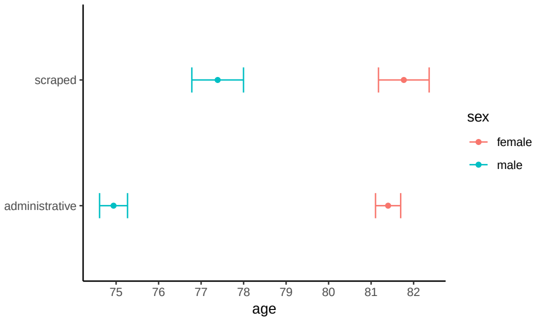

Figure 5: 95%-confidence intervals for age at death conditioned on sex by data set. Mean age for males is higher in scraped data.

As a result of the different distributions, the mean age of death differs significantly between the two data sets (administrative: 78.31; scraped: 79.57; $p < 0.01$). When comparing age between the datasets by sex, we found no significant difference for females (administrative: 81.4; scraped: 81.77; $p = 0.31$), but for males. Here, the mean age differed significantly (administrative: 74.94; scraped: 77.39; $p < 0.01$).

The scraped data does not contain any death notices for deceased persons younger than 18 years. By clerical search, we found that this was because accidentally, for all deaths of people younger than 18, either date of birth, date of death or the location was missing in the database. By inquiry, we made sure that this was not the result of an editorial policy, but merely the result of randomly missing data in a small sample.

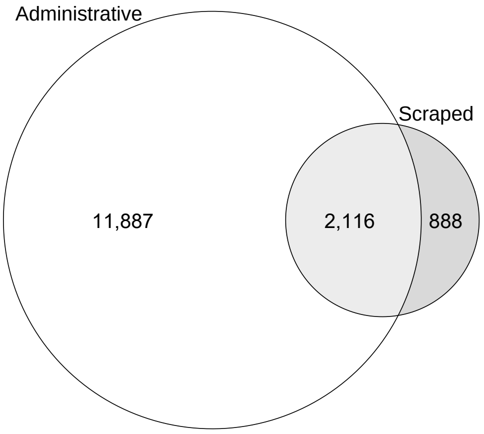

Figure 6: Overlap of scraped death notifications ($n = 3,004$) and administrative data ($n = 14,003$).

All analyses described above compared administrative and scraped datasets as aggregated data. To estimate the probability that a deceased person can be found in an online obituary, both data sets have to be linked individually. Different combinations of matching variables (first name, last name, birth name, date of birth and death) were tested. During the tests, we compared those records where different rules implied different matches. The best combination was defined as the rule which yields the largest amount of true positives while not leading to false positives. Overall, the best linkage result was observed by using the full name, date of birth and date of death, and – if the date of birth was not available – name and date of death.

During the linkage, three cases with duplicates in the scraped data were detected. These were due to multiple death notifications for the same person with different information. In two cases there were death notices with and without the second name, and in one case the prefix of the last name had a typo.

Finally, the overlap of the two datasets ($n = 2116$) was 17.8% of the administrative data and 70.4% of the death notifications (see figure 6).

When comparing matched and not-matched persons of the scraped and administrative dataset, not-matched persons had a significantly higher proportion of females (53.23 % females vs 46.77 %; $p < 0.01$).

For nationality, a higher proportion of non-German persons were among the not-matched cases (2.80% vs 0.57%; $p < 0.01$). This result might indicate a cultural difference of announcing a persons death through death notices. It should be noted that while the administrative dataset contains the factual nationality of a deceased person, the citizenship of the persons in the scraped data was derived from the first name. So we might have misclassified the citizenship of some deceased persons in the scraped data.

The age of the deceased persons differed for about one year between matched and not-matched cases, where the not-matched are younger (78.12 vs 79.77 years); the difference is significant ($p < 0.01$).

A manual check of a sample of not-matched persons ($n = 20$) used additional information resulting from intensive web queries for each case. This check indicated that some problems are due to the location as a filter. Notifications with missing locations were excluded by the obituaries during searches. False positives were prevalent in the scraped data because the name of the town is not a unique identifier and could be a substring of other city names. Additional errors were due to typos in locations, which were missed by searches in the obituaries. In several cases, the first name of a deceased person seemed to be wrong although all other identifiers matched. Since there is no legal requirement that the actual name of the person has to be used in the death notice nicknames and second names were found in the scraped data instead of the first name.

4 CONCLUSION

Real-world research applications of web scraping are more complicated than widely believed. If many different websites have to be scraped over an extended period, the problems resulting from minor changes of HTML-code and the representation of the data of interest within a web page requires continuous efforts on updating the scraper.

Furthermore, for our application, the results indicate that the online information available is not a random sample of the underlying population. Less than 18% of the registered deceased persons could be found in the scraped data. We observed lower proportions of men and foreigners in scraped and administrative data; therefore the estimation of death rates within subgroups by using scraped data will yield biased estimates.

For the estimation of death rates, our conclusions agree with the assessments of scraped data in comparison to administrative data for the estimation of job vacancies (Swier, 2017): Coverage is incomplete and does not yield a random sample. Contrary to Boak et al. (2007) and Soowamber et al. (2016) we conclude that web scraping online death notices is not a suitable alternative for the use of administrative data sets. However, the deviating result may be due to culture-specific differences in the use of online death notifications between the countries studied.

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