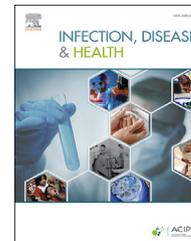


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Research paper

Escherichia coli on the internet: The power of YouTube to educate and influence consumer behavior regarding pathogenic bacteria

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Abstract *Background:* Proper education about food safety and hand hygiene helps to reduce the risk of exposure to *Escherichia coli* associated disease. The purpose of this study was to describe the 100 most widely viewed YouTube videos on the subject of *E. coli* to determine what consumers are viewing related to the hazards of, and reducing risk of exposure to, bacteria such as *E. coli*.

Methods: The search term was conducted using the keywords “*E. coli*.” The 100 videos with the top view counts were included in this study. The sampling frame for this study included only videos that were in English. The source of the upload of each video was determined to be one of the following: (1) consumer, (2) professional (MD, RN)/government, (3) any news (television-based, internet-based, or print/radio). Content categories were created using a fact sheet from the Centers for Disease Control and Prevention.

Results: Videos uploaded by a news source tended to have been uploaded more recently (2015–2018) compared to other sources ($p < 0.001$). Videos uploaded by consumers or news sources tended to have more views than professional/government-uploaded videos ($p = 0.044$). Videos uploaded by news sources were more likely to mention a specific outbreak ($p < 0.001$), statistics ($p = 0.004$), and transmission via raw meat ($p = 0.036$), feces ($p = 0.006$), vegetables or produce ($p = 0.006$), and processing techniques ($p = 0.005$).

Conclusions: YouTube videos on the topic were widely divergent, and varied in content, emphasizing different aspects of concern over hazards associated with *E. coli*. Consumer sources, rather than experts, were the most common source of upload of the most highly viewed videos. Government agencies, which collect and analyze public health data, do not appear to use YouTube effectively to disseminate information. This underscores the need for media to work with government agencies to provide accurate, timely information to the public.

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Highlights

- Videos uploaded by consumers represent more than half of the most popular videos in the sample.
 - Professional/government derived videos accounted for fewer views.
 - These videos vary in terms of content.
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Introduction

Escherichia coli (*E. coli*) are common bacteria that are part of the natural flora in the human digestive system. Although most strains of these bacteria are harmless, living cooperatively in the gut as benign commensals, some strains of *E. coli* can also cause severe illness. The pathogenic strains of *E. coli* can cause diseases such as respiratory illnesses, urinary tract infections, infections of the bloodstream and digestive maladies [1].

E. coli is one of the most widely studied species, “un-surpassed as a model organism in the field of biology” [2]. The importance of *E. coli* to biology research cannot be overstated. The bacteria were used to establish DNA as the genetic material [3], and to demonstrate gene recombination [4]. The first experiments in recombinant DNA technology were done with newly discovered *E. coli* restriction enzymes, and in those pioneering experiments *E. coli* cells served as hosts to the first interspecies recombinant DNA molecules [5,6]. *E. coli* was also the first host used in the artificial production of a biopharmaceutical, Humilin, bacterial-grown human insulin, and among the first organisms to be genetically sequenced [7,8]. Numerous Nobel prizes have been awarded to scientists who made landmark biological discoveries using *E. coli* as their organism of choice.

E. coli resides in the gut of many animals and is excreted in the feces. While most gut *E. coli* is not pathogenic, it is important to avoid exposure to human feces because fecal bacteria can transmit disease [1]. Fecal-oral transmission occurs when food or water contaminated with animal or human fecal matter is ingested. In addition, other bodily apertures can be exposed to the microbe, leading to urinary bladder infections or infections of the female genital tract [1]. Of special concern are strains of *E. coli* that make Shiga toxin, a dangerous protein that can induce severe symptoms typical of food poisoning. Outbreaks of Shiga toxin-producing *E. coli* (STEC) are monitored by public health laboratories across the United States (US) [1]. To help avoid major health crises, local testing and surveillance of STEC assists the Centers for Disease Control (CDC) in tracking sources of contamination. STEC is of particular concern in individuals who are more vulnerable to food poisoning, including children, the elderly, immune-compromised people and pregnant women, all of whom are at higher risks for complications from STEC infections

[1]. The CDC estimates that 265,000 STEC infections occur in the US on an annual basis, resulting in 3600 hospitalizations, and 30 deaths each year [9].

Proper education about food safety and hand hygiene, with emphasis on hand washing after contact with feces or animals and before eating, helps to reduce the risk of exposure to *E. coli* associated disease. For instance, since fruits and vegetables can be contaminated with *E. coli* in fields, or during harvest or transport, produce should be washed under running water before consumption. Hand hygiene is also critical, as *E. coli* is easily transferred from hands to surfaces to hands. Washing hands with soap and water helps to reduce risk of infection after diaper changes, using the bathroom, or handling animals and their wastes. Alcohol-based hand sanitizer also reduces the risk of exposure to *E. coli* and other pathogens [10].

Despite its significant role in biomedical and biotechnology research, *E. coli* was not well known by the public until recent years. Media coverage of food borne illnesses due to *E. coli* has increased as public health studies of such infections became more routine. Media coverage of infectious disease has “resulted in major public interest” and influenced the availability of information on the internet [11]. Videos available on YouTube represent one aspect of online information that people are accessing at a higher rate [12].

Since many consumers now turn to the internet for answers to basic questions on almost every topic, it is important to monitor the information that is readily available on the internet regarding how to reduce the risks of infectious disease. YouTube has an estimated one billion users, and is a provider of information through video sharing [12]. In fact, many people would rather watch a brief video than read an article, and they are more likely to share a video than a print article [13]. Public interest in *E. coli* outbreaks may be of particular concern as it can have economic effects; public knowledge of such outbreaks can influence what people eat, and whether they will patronize particular food establishments [14]. Despite this, there is a gap in the literature regarding information about *E. coli* available on the internet. Therefore, the purpose of this study was to describe the 100 most widely viewed YouTube videos on the subject of *E. coli* to determine what consumers are viewing about the hazards of and reducing risk of exposure to bacteria such as *E. coli*.

Methods

The search of YouTube videos was conducted in the fall of 2018 using the keyword “*E. coli*.” The search was conducted using a cleared browser on Google Chrome, and videos were sorted by number of views. The 100 videos with the top view counts were included in this study. The sampling frame for this study included only videos that were in English. The source of the upload of each video was determined to be one of the following: (1) consumer, (2) professional (MD, RN)/government, and (3) any news (television-based, internet-based, or print/radio). The three categories are described below:

- (1) The source was deemed to be “consumer” if the video was made by any lay person without a professional degree and not associated with any TV or internet-based news station, including that of print and radio. Examples included school projects, vlogs (video blogs), comedy skits, or someone simply providing information.
- (2) In videos categorized as “professional or government” the source of the upload had either licensed credentials (e.g. MD, RN) and was a spokesperson for communicating the health information or was doing so on behalf of a government agency. Credentials were explicitly stated on the video, delivered verbally, or located in the video description box.
- (3) “News” refers to videos uploaded by a known news network or subsidiary brands (e.g. NBC, Fox, CBS, etc.), or an internet-based news following (e.g. BuzzFeed or Vox), or newspaper-based print and/or radio station generated video clips.

The total number of views, year uploaded, and length in minutes were recorded for all videos. Content categories were created using a fact sheet from the CDC [9]. For coding purposes, a binary (Yes/No) response was noted for the presence of each content category in each video. One coder (PG) viewed all videos and a second coder (CHB) viewed a randomly selected 10%. Inter-rater reliability was determined by Cohen’s kappa to be 1.00, which indicates perfect agreement. The following were the content categories used in the study: Science (experiment, do it yourself, time lapse); Transmission (raw meat, feces, raw milk, water, infected animals, processing techniques, vegetables or produce, and other); Health (symptoms, UTI, abdominal, statistics), Treatment, Fear/Anxiety, Prevention (hand wash, food wash, thorough cooking, avoid raw, avoid swallowing swim water); Specific outbreak; Medical; Training Personnel; Government; and Parody.

Statistical tests were performed using SPSS (v23). Fisher’s exact tests were utilized, with the exception of cases where all expected cell counts were greater than 5. When this occurred, Chi-square tests of association were used. Results were considered to be significant if $p < 0.05$. The IRB at William Paterson University does not review studies that do not involve human subjects and considers them to be exempt.

Results

The 100 videos analyzed were uploaded to YouTube between 2006 and 2018 (Table 1). The average video length was 4:15 min with a range of 0:06–52:18 min. The mean number of views was 87,171 with a range of 2687–1,963,541 views. Videos frequently mentioned the symptoms of *E. coli* exposure (29%), information on a specific *E. coli* outbreak (26%), or statistics on *E. coli* exposure (20%). Among the videos that mentioned modes of *E. coli* transmission, it was most common to mention raw meat (26%), feces (20%), or water contamination (19%). For the purposes of data analysis, “professional/government” (21%) and “any news” (25%) were compared with the “consumer” category (54%).

Videos uploaded by a news source tended to have been uploaded more recently (2015–2018) compared to other sources ($p < 0.001$, Table 2). Videos uploaded by consumers or news sources tended to have more views than professional/government-uploaded videos ($p = 0.044$). Videos uploaded by news sources were more likely to mention a specific outbreak ($p < 0.001$), statistics ($p = 0.004$), and transmission via raw meat ($p = 0.036$), feces ($p = 0.006$), vegetables or produce ($p = 0.006$), and processing techniques ($p = 0.005$).

Table 1 Video characteristics (N = 100).

		N
Year of upload	2006–2010	24
	2011–2014	42
	2015–2018	34
Length	<2 min	27
	2–5 min	51
	5–10 min	15
	>10 min	7
Views	<20,000	36
	20,000–50,000	39
	>50,000	25
Source of upload	Consumer	54
	News	25
	Professional or government	21
Mentions...	Symptoms	29
	Specific outbreak	26
	Statistics	20
	Treatment	7
Mentions transmission	Raw meat	26
	Feces	20
	Water	19
	Vegetables or produce	16
	Raw milk	10
	Processing techniques	4
Mentions prevention	Infected animals	3
	Hand wash	14
	Food wash	14
	Thorough cooking	14
	Avoid raw foods	7

Table 2 Comparison of videos by source of upload (Fisher's exact test).

		Video source						P
		Consumer		Any News		Professional or government		
		(n = 54)		(n = 25)		(n = 21)		
		n	(%)	n	(%)	n	(%)	
Year of upload	2006–2010	19	(35)	3	(12)	2	(10)	<0.001^a
	2011–2014	23	(43)	3	(12)	16	(76)	
	2015–2018	12	(22)	19	(76)	3	(14)	
Views	<20,000	15	(28)	14	(56)	7	(33)	0.044^a
	20,000–50,000	24	(44)	4	(16)	11	(52)	
	>50,000	15	(28)	7	(28)	3	(14)	
Video Mention								
Symptoms	Yes	13	(24)	11	(44)	5	(24)	0.162 ^a
	No	41	(76)	14	(56)	16	(76)	
Specific outbreak	Yes	8	(15)	14	(56)	4	(19)	<0.001^a
	No	46	(85)	11	(44)	17	(81)	
Statistics	Yes	6	(11)	11	(44)	3	(14)	0.004
	No	48	(89)	14	(56)	18	(86)	
Treatment	Yes	4	(7)	2	(8)	1	(5)	1.000
	No	50	(93)	23	(92)	20	(95)	
Raw meat	Yes	9	(17)	11	(44)	6	(29)	0.036^a
	No	45	(83)	14	(56)	15	(71)	
Feces	Yes	5	(9)	10	(40)	5	(24)	0.006^a
	No	49	(91)	15	(60)	16	(76)	
Water	Yes	8	(15)	7	(28)	4	(19)	0.363
	No	46	(85)	18	(72)	17	(81)	
Vegetables or produce	Yes	4	(7)	9	(36)	3	(14)	0.006
	No	50	(93)	16	(64)	18	(86)	
Raw milk	Yes	3	(6)	4	(16)	3	(14)	0.260
	No	51	(94)	21	(84)	18	(86)	
Processing techniques	Yes	0	(0)	4	(16)	0	(0)	0.005
	No	54	(100)	21	(84)	21	(100)	
Infected animals	Yes	0	(0)	2	(8)	1	(5)	0.094
	No	54	(100)	23	(92)	20	(95)	
Hand wash	Yes	6	(11)	5	(20)	3	(14)	0.505
	No	48	(89)	20	(80)	18	(86)	
Food wash	Yes	5	(9)	5	(20)	4	(19)	0.294
	No	49	(91)	20	(80)	17	(81)	
Thorough cooking	Yes	5	(9)	6	(24)	3	(14)	0.195
	No	49	(91)	19	(76)	18	(86)	
Avoid raw foods	Yes	3	(6)	3	(12)	1	(5)	0.570
	No	51	(94)	22	(88)	20	(95)	

Bold: $p < 0.05$.^a Chi square.

Discussion

Health information on the internet is widely disseminated and available worldwide, and as such, social media has been noted as a potential tool for health professionals [15]. In this study, only two of the 100 most widely viewed videos included in this study were uploaded by government agencies. We found a similar situation in previous studies of YouTube videos on skin cancer, vaccines, Eastern Equine Encephalitis, and Zika Virus, namely that government videos are not highly represented in the top 100 viewed videos [16–19]. On the other hand, our studies of public

health content on YouTube related to Ebola and HPV videos uploaded by US Public Health Service agencies are among the most widely viewed [20,21]. Further research is needed to determine the factors that drive consumers to specific videos. If trusted sources, such as government agencies and qualified professionals, utilize more video elements that appeal to consumers, this can have a positive influence on the dissemination of reliable information.

Just one generation ago patients were largely passive consumers of healthcare information, relying on physician supplied information [22]. The availability of a wide range of information on the internet, at the fingertips of

healthcare consumers, has changed the landscape, opening up opportunities for tremendous access to information, as well and misinformation, as was the case in a study on Lyme disease [23]. These resources have the potential to reach multitudes of people, and depending on the quality of the information and its presentation, can provide needed education about the dangers of pathogenic bacteria and how to reduce the risk of infectious disease, thereby saving lives. In the worst case scenarios, YouTube videos can provide misinformation, outdated notions, and encourage non-science based actions and responses, which can put lives at risk. For example, social media complicated the Ebola outbreak in 2014 by perpetuating fear and misconceptions via bogus posts and inaccuracies [24]. Youtube videos on immunization also spread misinformation [25]. While some consumers have become aware of a wide spectrum of information on the internet ranging from worthwhile to worthless and as a result practice critical analysis of what is being offered, there are many individuals who are not so discerning. Components of health literacy that are critical include knowledge, ability to access information, understanding the information, and applying the information to promote good health [26] Thus it stands to reason that important features of video information regarding illness are accuracy of the knowledge, currency of medical information, and ability to get the message across by stimulating interest and critical thinking about the information.

This study demonstrated that most of the 100 most widely viewed YouTube videos on *E. coli* are not from the most reliable sources of information, namely qualified health professionals and the government agencies responsible for the health of our citizens. The role and responsibility of the media to work hand-in-hand with experts and disseminate factual information online has become more critical than ever. The huge amount of information on the internet poses a challenge. Information overload can lead to diluting of valuable scientifically grounded information in a sea of less useful material. One initiative called HealthMap aims to classify and integrate reports on disease outbreaks from various news sources [27]. This should be helpful for reporters, healthcare professionals and patients to weed out less useful information.

Our study underscores the need for videos produced by qualified health professionals. Johns Hopkins Medical Center advises consumers to follow specific guidelines to identify trustworthy sites for medical information. Their advice includes checking for currency, credentials, and conflict of interest [28]. YouTube videos should also be scrutinized and screened for value of information based on similar guidelines. Videos made by experts in the field, could help negate potential dissemination of misinformation. The findings that news source videos are commonly viewed on YouTube also suggest that the media plays a critical role in educating the public. These results highlight how critical it is for the media to report accurately, as its influence may be magnified by public access to reports not only on the day they are broadcast, but for an indefinite time after the initial broadcast. In the case where a news video goes "viral" the influence of the media is increased manifold. Thus, media accuracy has taken on a greater level of consequence with regard to public health education.

The limitations of this study include the cross-sectional design, the small sample size, and the inclusion of only English-language videos. In addition, it is important to note that the content on YouTube is changing on a constant basis. Hence, the most widely viewed videos at this time of this study will unlikely remain consistent over time. Despite these limitations, however, this study provides insight on an important topic.

The data in this study indicates that videos on various topics related to specific *E. coli* outbreaks are prevalent on YouTube. Future research could also focus on tracking view counts by date to determine if more views occur during and subsequent to outbreaks. If outbreaks motivate individuals to view YouTube videos on *E. coli*, then health professionals can use this medium and these opportunities to discuss not only treatment, but prevention as well. Given that *E. coli* infections are prevalent, and can be preventable, the use of social media for educational purposes warrants further investigation. In particular, government agencies, which collect and analyze public health data, do not appear to use YouTube effectively to disseminate information. This underscores the need for media to work with government agencies to provide accurate, timely information to the public.

Ethics

The human subjects committee at William Paterson University does not review studies that do not include human subjects.

Authorship statement

CHB conceived and designed the study. PG was the first coder and CHB the second coder. SM did the statistical analysis.. CHB, MZW, SM, PG, wrote and edited the manuscript.

Conflict of interest

The authors have no conflict of interests to declare.

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