

# The burden and determinants of self-reported acute gastrointestinal illness in an Indigenous Batwa Pygmy population in southwestern Uganda

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## SUMMARY

Acute gastrointestinal illness (AGI) is an important public health priority worldwide. Few studies have captured the burden of AGI in developing countries, and even fewer have focused on Indigenous populations. This study aimed to estimate the incidence and determinants of AGI within a Batwa Pygmy Indigenous population in southwestern Uganda. A retrospective cross-sectional survey was conducted in January 2013 via a census of 10 Batwa communities ( $n = 583$  participants). The AGI case definition included any self-reported symptoms of diarrhoea or vomiting in the past 2 weeks. The 14-day prevalence of AGI was 6·17% [95% confidence interval (CI) 4·2–8·1], corresponding to an annual incidence rate of 1·66 (95% CI 1·1–2·2) episodes of AGI per person-year. AGI prevalence was greatest in children aged <3 years (11·3%). A multivariable mixed-effects logistic regression model controlling for clustering at the community level indicated that exposure to goats [odds ratio (OR) 2·6, 95% CI 1·0–6·8], being a child aged <3 years (OR 4·8, 95% CI 1·2–18·9), and being a child, adolescent or senior Batwa in the higher median of wealth (OR 7·0, 95% CI 3·9–9·2) were significantly associated with having AGI. This research represents the first Indigenous community-census level study of AGI in Uganda, and highlights the substantial burden of AGI within this population.

**Key words:** Acute gastrointestinal illness, Batwa, burden of illness, diarrhoea, Indigenous health, risk factors, Uganda.

## INTRODUCTION

Acute gastrointestinal illness (AGI), transmitted by food, water, animals, or person-to-person contact, is a major health concern worldwide [1, 2]. AGI remains

one of the top causes of morbidity and child mortality in developing nations, despite the widespread use of oral rehydration therapies and a greater comprehension of the pathogenesis of diarrhoea [1–3]. Furthermore, poor water supply, sanitation, and personal and domestic hygiene are among the greatest risk factors for death and disability adjusted life years (DALYs) in low-income countries [4]. Research on populations vulnerable to AGI has largely focused on children; studies estimate that 1731 billion cases of diarrhoea occur each year, of which

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half of the total attributed deaths (~700 000) were in sub-Saharan Africa [2, 3]. Yet AGI research is lacking for other vulnerable groups, such as Indigenous or minority populations. Despite an emergent scholarship of systematic and comparable population-based research on AGI in higher-income [5–18] and middle-income countries [19–21], there is limited literature on self-reported AGI for low-income countries [22], especially African countries. In high- and middle-income countries, population-based AGI research focuses primarily on under-reporting, estimating economic burden, and quantifying morbidity in a population [1, 10]. In lower-income regions and in vulnerable populations, where surveillance data are often poor or unavailable, even baseline data on population-based AGI prevalence are generally lacking.

Past and present social disadvantages experienced by some Indigenous populations can negatively impact overall health and can limit access to healthcare [23–25]. In sub-Saharan Africa, Indigenous populations experience some of the highest levels of infectious disease burden, yet negligible consideration is given to Indigenous inequalities in health [23, 26–28]. Standardized methodologies for estimating AGI burden have emerged in the scholarship, facilitating cross-country or regional comparisons [29], and recently, research from high-income regions indicated that Indigenous sub-populations may suffer from higher rates of AGI [30]. However, the use of these standardized methods for AGI burden estimates have not been extended to Indigenous populations in developing regions, and AGI research in Indigenous populations around the world is lacking. Herein, we seek to address this research gap by estimating the prevalence, incidence, and determinants of AGI within an Indigenous population in sub-Saharan Africa, i.e. the Batwa Pygmies of southwestern Uganda. Our research focuses on the Batwa of Kanungu District as a case study to contribute to the development of an evidence base to estimate the magnitude of AGI in highly vulnerable populations globally. To our knowledge, this research is the first published internationally comparable population-based estimate of self-reported AGI prevalence and determinants for Indigenous communities in Africa.

## METHODS

### Study population

The Batwa Pygmies of central sub-Saharan Africa are a highly marginalized population, who in the last century

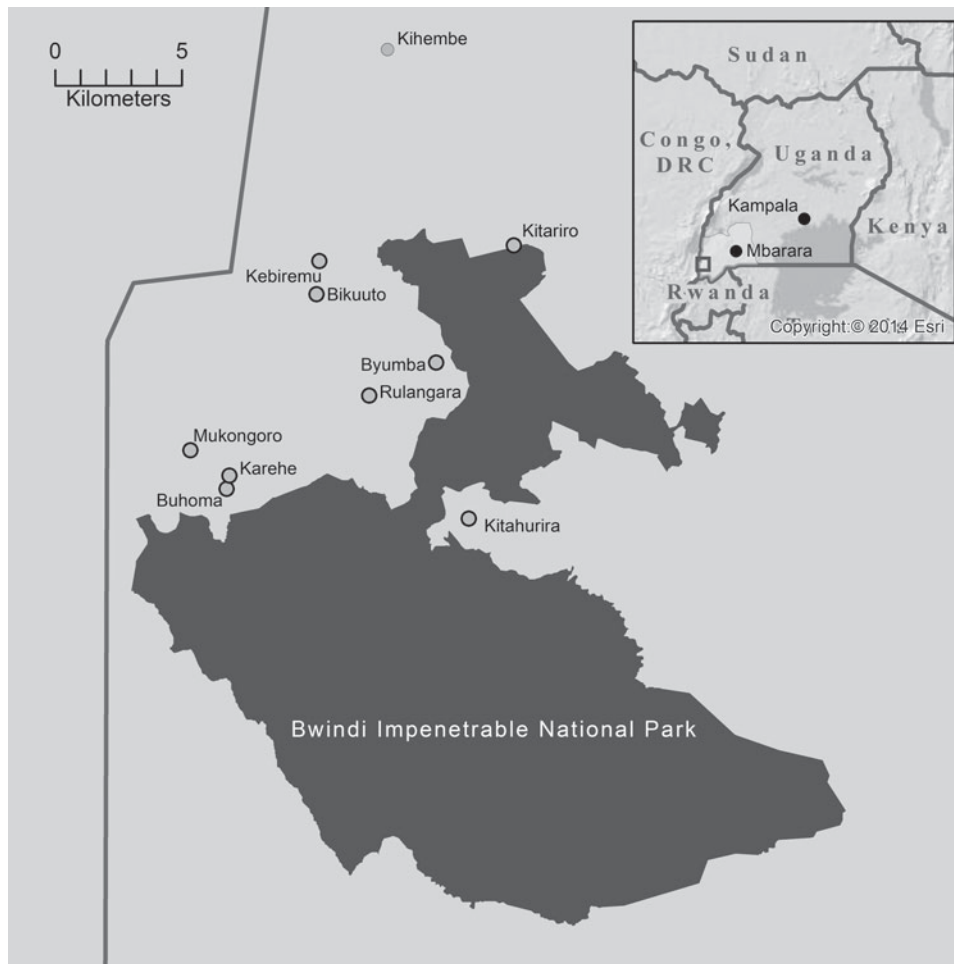
have been evicted from their ancestral forest homes and become landless [24, 27, 31]. The transition of the Batwa from historic hunter-gatherer forest livelihoods to settlement-based and agrarian livelihoods has been relatively unsuccessful, and the Batwa continue to experience substantially poorer health and socioeconomic status than neighbouring non-Indigenous populations in the region [23, 24, 26]. For instance, the average life expectancy at birth for the Batwa was 28 years compared to the Ugandan average of 53 years, and the Batwa under-five child mortality rate has been reported to be higher than the Ugandan average [26, 32, 33]. Furthermore, the Batwa in southwestern Uganda had higher prevalence of intestinal parasitic loads compared to their non-Indigenous neighbours [28, 34] and they reported diarrhoeal and vomiting diseases as a priority health concern within the population [24, 26].

### Study design and sample

A retrospective cross-sectional, face-to-face survey was administered in 10 Batwa settlements in southwestern Uganda in January–February 2013. These 10 settlements represent the formal settlements of Batwa Pygmies in Kanungu District (1274 km<sup>2</sup>) (Fig. 1). Considering the small total population size (estimated at 750), a census was attempted of all Batwa present during the time of the survey and every individual in every household was invited to participate. The sampling frame for the study consisted of 589 people comprising all Batwa available in the settlements during the study period, of which six declined (response rate 99%). The number and composition of households in each community was verified by its respective village chairperson and household heads were asked to identify all of their co-habitants. Individuals not present in the communities at the survey time were either travelling outside the region or unavailable during the survey (e.g. in the fields, at the hospital, working elsewhere, visiting friends or relatives in the Democratic Republic of Congo). Late January in Uganda is classified as a dry to mild rainy season. Children and adolescents who attend boarding schools (primary or secondary) in neighbouring districts were on vacation and thus in their home villages during the survey.

### Data collection

Respondents were interviewed in person in the predominant local language, Rukiga, by trained, local



**Fig. 1.** Map of 10 Batwa communities in Kanungu District, Uganda and Bwindi Impenetrable Park.

surveyors from Kanungu District. There were two questionnaires: (1) an individual-level health questionnaire for all participants of all ages (the AGI section can be viewed in the Supplementary material), and (2) a household questionnaire for the head of the household aged >18 years. The questionnaire design was based on previous international burden of AGI studies [20, 21] and adapted specifically for the cultural and geographical context of this study according to Berrang-Ford *et al.* [26]. Questionnaires were applied, revised, and validated with local research assistants, local partners, and the communities themselves during pilot testing in July and October 2012. The questionnaires captured data on: demographic and personal information, household information, exposure to animals, socioeconomic indicators, water sources, sanitation and hygiene, as well as occurrence of diarrhoea or vomiting in the previous 2 weeks, associated symptoms, and health-seeking behaviour. Parents or guardians answered questionnaires on behalf of children aged

<12 years, while children aged 12–18 years answered questions with parental consent. Data were collected as hard copy and imported into a Microsoft Access database (Microsoft Corp., USA).

### Case definition

The presence of any self-reported symptoms of vomiting or diarrhoea in the previous 14 days was used as a case definition for the outcome measure in this study. An alternative case definition, using stricter criteria proposed by Majowicz *et al.* [29], was used to facilitate international comparisons ( $\geq 3$  loose stools or any vomiting). A 2-week recall period was applied following pilot research and consultation with local partners regarding an appropriate, feasible, and reliable period for recall. Those with vomiting or diarrhoea were considered non-cases if participants reported the symptoms were due to any diagnosed chronic gastrointestinal illness, or diarrhoea caused

by the use of medication, alcohol/drugs, or pregnancy. Since the duration of an episode of acute diarrhoea or vomiting can be short and the recall period was 2 weeks, an assumption was made that each case of acute diarrhoea contributed to only one new episode of acute diarrhoea in the preceding 2 weeks of the interview.

### Statistical analysis

The 14-day prevalence of AGI was calculated as the number of identified cases fitting our case definition divided by the total number of respondents. An annual incidence rate was estimated to facilitate international comparability, as in previous AGI studies [20, 21]. Age groups (0–3, 4–12, 13–34,  $\geq 35$ ) reflect the age distribution of the population – with a low average life expectancy – and natural breaks in the distribution of AGI cases by age. An asset-based index of wealth was calculated using principal component analysis; this method is recognized as a valid proxy for measuring wealth in health studies in rural Africa and elsewhere [35]. Data from participants responding ‘unsure’ or ‘refused to answer’ were excluded from the analysis of that question. We built a multivariable mixed logistic regression model with a random intercept to control for clustering at the community level. First, a series of univariable (i.e. one fixed effect) logistic regression models with a random intercept for community were conducted to explore potential unconditional associations between predictor variables and the outcome variable. Variables with  $P < 0.20$  in univariable tests were considered for inclusion in the multivariable model. Potential collinearity between predictor variables was assessed using a Spearman’s rank correlation coefficient, with a cut-off of 70%. Then, a manual backwards elimination process was used, and the best-fit model was determined by Bayesian Information Criterion (BIC) statistics of model comparison. We tested for potential confounding by removing and inserting plausible variables iteratively to assess for a change of  $\geq 25\%$  in odds ratios and we tested for significant interactions between all final variables in the model. Finally, we graphically assessed the fit of the model by examining Pearson residuals, and assessing the assumptions of normality and homogeneity of variance for the best linear unbiased predictors (BLUPs). Data were analysed using Stata v. 11 (Stata Corp., USA).

### Ethics

This study was approved by the McGill University Research Ethics Board and is consistent with the Canadian Tri-Council’s Policies and requirements for the Ethical Conduct of Research Involving Human Subjects. Informed oral consent was obtained from all participants or the parent/guardian if the participant was a minor. This study is a part of the Indigenous Health Adaptation to Climate Change (IHACC) project, a larger international initiative with parallel field sites in the Canadian Arctic and the Peruvian Amazon ([www.ihacc.ca](http://www.ihacc.ca)).

## RESULTS

### Magnitude

Individual-level surveys were obtained for 583 participants (99% response rate), and a total of 130 household-level surveys were linked to 553 participants (Table 1). Data are limited on the demographics of all Batwa in Kanungu. Based on available estimates, study participants reflect total Batwa population demographics, with study participants somewhat younger (mean age 20 years compared to 23 years in the total population) with more males (48.5% compared to 47% in the total population) [36]. Of the 583 individuals included in the study, 36 individuals reported having symptoms of vomiting or diarrhoea within the previous 14 days, corresponding to a prevalence of 6.17% [95% confidence interval (CI) 4.2–8.1], and an annual incidence rate of 1.66 (95% CI 1.1–2.2) episodes of AGI per person-year (52 new cases per month, 1.2 new cases per day). Using an alternative case definition [29], there were 34 cases of AGI in the previous 14 days, resulting in a prevalence of 5.83% (95% CI 4.0–8.5) and an annual incidence rate of 1.57 (95% CI 1.1–2.6) episodes of AGI per person-year. Children aged  $< 3$  years had a 14-day prevalence of 11.3% (95% CI 5.0–17.7) and the annual incidence rate was 3.13 (95% CI 1.3–5.1) cases per child per year (Fig. 2). Females had a 14-day prevalence of 7.3% (95% CI 4.3–10.2) and males, 4.9% (95% CI 2.4–7.5).

### Description of disease

Of the 36 cases of AGI, about half had symptoms of vomiting (Table 2). The mean duration of vomiting episodes lasted for 2.79 days (95% CI 1.63–3.99) with an average of 2.80 maximum episodes in a 24-h

Table 1. Results of the univariable (i.e. one fixed effect) logistic regression models, using a random intercept to control for community-level clustering for self-reported acute gastrointestinal illness in 10 Batwa settlements in southwestern Uganda, January 2013

Characteristic	January 2013 surveyed participants (%)	No. of non-cases (%)	No. of cases (%)	OR* (95% CI)	P value*	Community-level clustering (P value)†
<b>Social determinants</b>						
Sex	<i>n</i> = 582	<i>n</i> = 546	<i>n</i> = 36			0.04
Male	283 (49)	269 (49)	14 (39)	Ref.	Ref.	
Female	299 (51)	277 (51)	22 (61)	1.52 (0.74–3.02)	0.30	
Age group (years)	<i>n</i> = 581	<i>n</i> = 545	<i>n</i> = 36			0.04
0–3	97 (17)	86 (16)	11 (31)	4.27 (2.14–15.99)	0.03	
4–12	165 (28)	157 (29)	8 (22)	1.70 (0.44–6.7)	0.43	
13–34	211 (36)	197 (36)	14 (39)	2.31 (0.65–8.43)	0.21	
≥35	107 (18)	104 (19)	3 (8)	Ref.	Ref.	
Highest education level in household‡	<i>n</i> = 581	<i>n</i> = 545	<i>n</i> = 36			0.02
No education	192 (33)	182 (33)	10 (28)	Ref.	Ref.	
Primary education	334 (58)	312 (57)	22 (61)	1.20 (0.55–2.63)	0.65	
Beyond primary education	55 (9)	51 (10)	4 (11)	1.92 (0.54–6.86)	0.31	
Wealth (household assets)	<i>n</i> = 549	<i>n</i> = 513	<i>n</i> = 36			0.03
Below median wealth	274 (50)	265 (52)	9 (25)	Ref.	Ref.	
Above median wealth	275 (50)	248 (48)	27 (75)	3.12 (1.47–6.95)	<0.01	
<b>Environmental exposures</b>						
Use soap	<i>n</i> = 580	<i>n</i> = 544	<i>n</i> = 36			0.02
No	429 (74)	398 (73)	31 (84)	Ref.	Ref.	
Yes	151 (26)	146 (27)	5 (14)	0.44 (0.17–1.15)	0.05	
Own animals	<i>n</i> = 553	<i>n</i> = 517	<i>n</i> = 36			0.07
No	415 (75)	394 (77)	21 (58)	Ref.	Ref.	
Yes	133 (25)	118 (23)	15 (42)	2.38 (1.19–4.77)	0.01	
Exposure to goats	<i>n</i> = 553	<i>n</i> = 517	<i>n</i> = 36			0.07
No	493 (90)	466 (90)	27 (75)	Ref.	Ref.	
Yes	58 (10)	49 (10)	9 (25)	3.11 (1.3–6.91)	0.02	
Animals come inside the house	<i>n</i> = 553	<i>n</i> = 517	<i>n</i> = 36			0.06
No	478 (86)	452 (88)	26 (72)	Ref.	Ref.	
Yes	73 (14)	63 (12)	10 (28)	2.73 (1.25–5.91)	0.01	
Main water source	<i>n</i> = 539	<i>n</i> = 505	<i>n</i> = 34			0.13
Standpipe/well	319 (59)	300 (59)	19 (56)	Ref.	Ref.	
Surface or rain water	220 (41)	205 (41)	15 (44)	1.10 (0.53–2.28)	0.78	
Boil water	<i>n</i> = 551	<i>n</i> = 515	<i>n</i> = 36			0.05
No	347 (63)	329 (64)	18 (50)	Ref.	Ref.	
Yes	204 (37)	186 (36)	18 (50)	1.61 (0.83–3.40)	0.15	
Toilet facilities	<i>n</i> = 538	<i>n</i> = 502	<i>n</i> = 36			0.01
Pit latrine covered	395 (73)	369 (74)	26 (72)	Ref.	Ref.	
Pit latrine uncovered	129 (24)	120 (24)	9 (25)	1.10 (0.44–2.27)	0.98	
No facility	14 (3)	13 (2)	1 (3)	1.22 (1.14–10.3)	0.85	

OR, Odds ratio; CI, confidence interval.

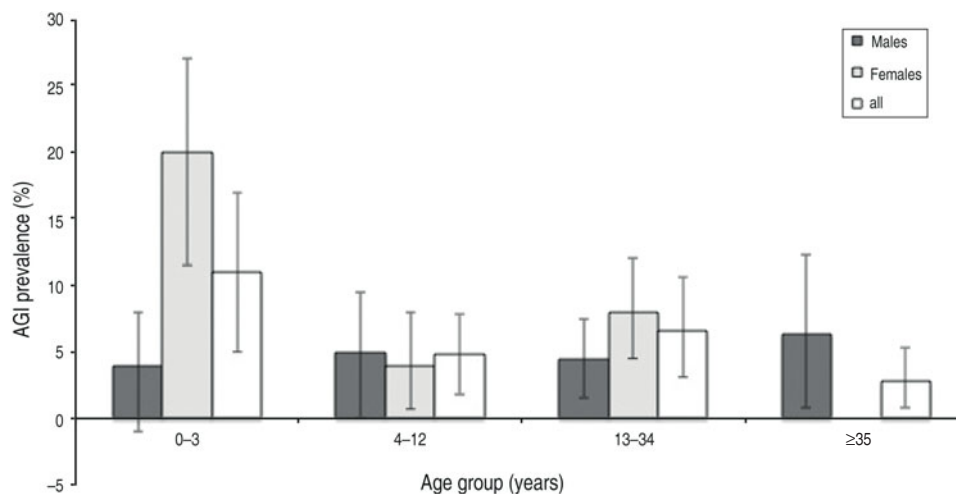
\* Odds ratios and *P* values generated from univariable logistic models.

† *P* values generated from a likelihood ratio test comparing the mixed logistic regression model (using a random intercept for community-level clustering) to logistic regression model.

‡ Highest level of education of someone in the household aged >15 years.

period (95% CI 1.86–3.74). Over three-quarters of the cases had symptoms of diarrhoea, and the mean duration lasted 4.48 days (95% CI 3.37–5.59) with an

average of 4.26 maximum loose stools in a 24-h period (95% CI 3.53–4.98). Of the 28 individuals who experienced diarrhoea, three (12%) had blood in their stool.



**Fig. 2.** Fourteen-day Prevalence of acute gastrointestinal illness (AGI) in age and gender groups, in the 2 weeks prior to interview in 10 Batwa settlements in southwestern Uganda, January 2013 ( $n = 583$ ).

**Table 2.** Severity of primary symptoms, and associated secondary symptoms of acute gastrointestinal illness in 10 Batwa settlements in southwestern Uganda, January 2013

Severity	No. of cases (%)	Average (95% CI)
Total cases ( $n = 36$ )		
Experience any vomiting	17 (49)	
Duration (days) of vomiting episodes		2.79 (1.63–3.99)
Maximum number of vomiting episodes in 24 h		2.80 (1.86–3.74)
Experience any diarrhoea	28 (80)	
Duration (days) of diarrhoea		4.48 (3.37–5.59)
Maximum number of loose stools in 24 h		4.26 (3.53–4.98)
Had blood in stool	3 (12)	
Associated symptoms ( $n = 36$ )		
Nausea	20 (56)	
Stomach cramps	24 (67)	
Fever	13 (36)	
Chills	17 (47)	
Headache	20 (56)	
Fatigue	5 (14)	
Sore throat	5 (14)	
Cough	10 (28)	

CI, Confidence interval.

The most commonly experienced secondary symptoms were stomach cramps, headache, and nausea. Half of the cases reported having to miss their daily activities as a result of their illness, and six cases reported that others had to take time off of their

usual routines to provide care. Over two-thirds of cases reported seeking some form of healthcare, and the most common healthcare provider sought out was a physician or nurse (Table 3). The most recurrent reason for seeking healthcare was that symptoms lasted a long time, or that symptoms included diarrhoea. Thirty-one cases (86%) sought some form of treatment – both traditional and modern – with herbal remedies being the most common, followed by painkillers. For the cases that did not seek medical care, the dominant reasons were financial difficulty and distrust of doctors or nurses (Table 3).

#### Multivariable model

The best-fit model retained respondent age, exposure to goats, and an interaction between wealth and adult ages (13–34 years) (Table 4). The odds of AGI for Batwa aged  $\leq 3$  years were 4.8 times higher [odds ratio (OR) 4.83, 95% CI 1.24–18.95] than for Batwa aged  $\geq 35$  years ( $P = 0.02$ ). The only environmental predictor variable significantly associated with AGI was exposure to goats ( $P = 0.04$ ), with the odds of AGI being 2.6 times greater in those exposed than those not exposed (OR 2.64, 95% CI 1.04–6.76). Interaction between a binary variable (middle-aged adults 13–34 years vs. all other age groups) and wealth indicated that there was a greater odds of AGI for non-middle-aged Batwa (children, adolescents or seniors, aged  $<13$  or  $>34$  years) and in a household with greater assets. Specifically, for children, adolescents or seniors (aged  $<13$  or  $>34$  years), those with greater than median wealth had significantly

Table 3. Number and percent of cases ( $n = 36$ ) that reported health-seeking behaviour, treatment sought, and reasons for no treatment of acute gastrointestinal illness in 10 Batwa settlements in southwestern Uganda, January 2013

Variable	No. of cases (%)
Sought healthcare ( $n = 36$ )	
Yes	25 (69)
No	11 (31)
Healthcare provider visited ( $n = 25$ )	
Physician/nurse	23 (92)
Herbalist	2 (8)
Factors influencing decision to seek healthcare ( $n = 24$ )	
Symptoms lasted a long time	14 (58)
Felt sick enough to go	8 (33)
Had a fever	5 (21)
Had vomiting	8 (33)
Had diarrhoea	10 (42)
Stools were bloody	2 (8)
Wanted medication	2 (8)
Type of medication to treat symptoms ( $n = 36$ )	
Herbal remedies from a garden	17 (47)
Prescription medications	7 (19)
Painkillers (e.g. acetaminophen, ibuprofen)	14 (39)
Antidiarrhoeal	7 (19)
Rehydration therapies	1 (3)
Main reason medical care was not sought ( $n = 11$ )	
Financial difficulty	6 (55)
Physician not available in the area	2 (19)
Did not get around to it	1 (9)
Transportation problems	0 (0)
Dislike or distrust doctors or nurses	3 (27)

( $P = 0.03$ ) higher odds of AGI (OR 7.02, 95% CI 3.95–9.20) than those with lower than median wealth. In the wealthier Batwa, the odds of AGI was significantly ( $P = 0.03$ ) higher for children, adolescents or seniors (aged <13 or >34 years) compared to middle-aged adults (13–34 years) (OR 3.12, 95% CI 1.16–6.85) and the odds of AGI was significantly ( $P = 0.02$ ) higher for wealthier children, adolescents or seniors (<13 or >34 years) compared to non-wealthy middle-aged adults (13–34 years) (OR 4.00, 95% CI 1.26–7.43). Variables relating to soap and sanitation were significantly associated with cases of AGI in univariable tests only, and were not retained in the final multivariable model. None of the variables pertaining to water quality, water source or water treatments were significant in the univariable tests or

multivariable model (Table 1). In the final multivariable model, we found no significant difference between models that did and did not control for community-level clustering (likelihood ratio test:  $P = 0.068$ , variance 0.26, median OR 1.62); however, we forced the random intercept into the model considering the structure of our data, and there was a minimal difference in fit of the model with and without the random intercept (based on BIC values). Post-estimation diagnostics indicated that the model was a good fit for the data.

## DISCUSSION

In the Batwa, the estimated incidence of AGI (1.66) was lower than results from parallel AGI research in Indigenous Inuit in the Canadian Arctic (2.9–3.8) using the same methodology, similar recall period, and case definition [30]. This finding might be explained by surveying during a potentially lower-risk season (dry season) in Uganda, which could also result in underestimates of annual incidence. The estimated incidence of AGI from the dry season is, however, still higher than comparable international estimates. Batwa AGI estimated incidence using an internationally comparable case definition [29] was higher than incidences reported in studies using the same case definition but using a 28- or 30-day recall period in Denmark [12], Italy [11], Ontario [16], United States [10], Chile [20], The Netherlands [8], Australia [10, 13], New Zealand [15], Poland [6], China [14], Argentina [21], Ireland [10], Malta [17], and France [7] (Fig. 3). These higher Batwa AGI rates were expected given the conditions of high poverty among the Batwa and the already high rates of mortality and morbidity due to diarrhoeal diseases in central sub-Saharan Africa [37]. Some AGI studies have observed that longer recall periods can result in underreporting and missed cases [20, 38]. Notably, we used a 14-day recall period for Batwa participants in an attempt to reduce underreporting due to recall bias.

The severity of AGI was greater in the Batwa in terms of the duration of illness, with a mean duration of diarrhoea (4.5 days) and vomiting (2.8 days), compared to the Indigenous Inuit in the Canadian North [30], Cuba [22], China [14], Canadian communities [9, 18], Chile [20], Argentina [21], New Zealand [15], and the United States [5]. The mean maximum number of vomiting and diarrhoea episodes for Batwa within a 24-h period are within range of studies performed in Cuba [22] but greater than reported in the Inuit in the Canadian North [30] and in China [14].

Table 4. Final multivariable mixed-effects logistic regression model using a random intercept to control for community level clustering for risk factors of acute gastrointestinal illness in 10 Batwa settlements in southwestern Uganda, January 2013

Predictor variable	OR	95% CI	P value
<b>Exposure to goats</b>	2.64	1.04–6.76	0.04
<b>Age group (yr)</b>			
0–3	4.83	1.24–18.95	0.02
4–12	1.72	0.43–6.97	0.44
13–34*	–	–	–
≥35	Ref.	Ref.	Ref.
<b>Wealth (households assets) × middle age (13–34 yr)</b>			
Interaction term			
No wealth + child, adolescent or senior (<13 or >34 yr)	Ref.	Ref.	Ref.
Wealth + child, adolescent or senior (<13 or >34 yr)	7.02	3.95–9.20	0.03
Interaction term			
No wealth + middle aged (13–34 yr)	Ref.	Ref.	Ref.
Wealth + child, adolescent or senior (<13 or >34 yr)	4.00	1.26–7.43	0.02
Interaction term			
Wealth + middle aged (13–34 yr)	Ref.	Ref.	Ref.
Wealth + child, adolescent or senior (<13 or >34 yr)	3.12	1.16–6.85	0.03
<b>Clustering at the community level for the model†</b>			0.068
Area level variance (s.e.)	0.26 (0.3)	0.03–2.18	
Median OR‡	1.62		
Interclass correlation coefficient	0.08		

OR, Odds ratio; CI, confidence interval.

\* The middle-aged adult group (13–34 years) cannot be interpreted on its own, as it significantly interacts with the wealth variable.

† Likelihood ratio test comparing the mixed logistic regression model (using a random intercept for community-level clustering) to logistic regression model.

‡ Detailed median OR theory, calculation, and application [46, 47].

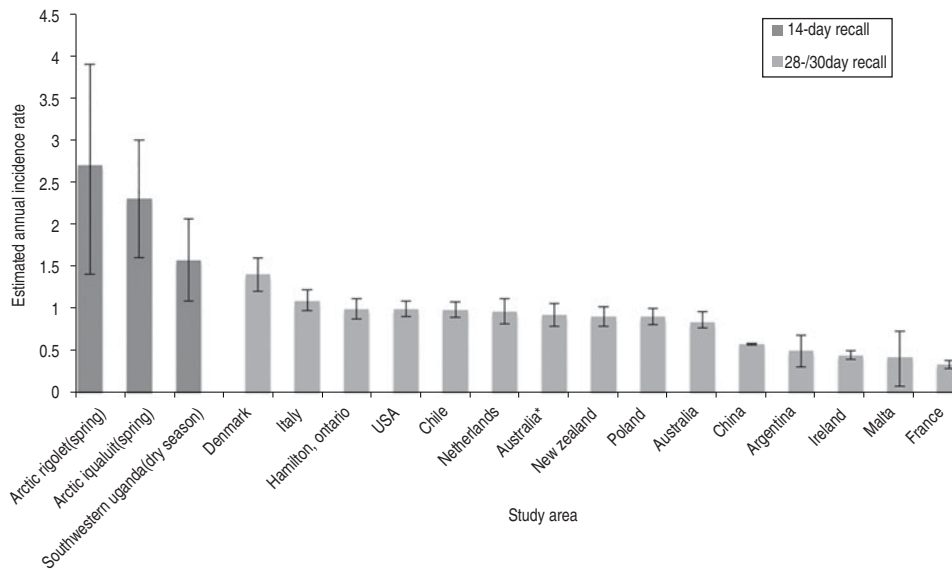
Generally, this greater magnitude in AGI severity in the Batwa could be due to differential exposures to pathogens more or less abundant in different geographical or local environments. While the annual incidence reported in the Indigenous Inuit in the Canadian North was greater than that reported in the Batwa, the Batwa reported a greater severity of AGI symptoms, implying that the consequence of AGI in this population is more serious. Greater debilitating effects of AGI in the Batwa are probable, based on the greater morbidity and mortality of diarrhoea in sub-Saharan Africa compared to higher-income countries [37].

A high proportion of cases reported seeking some form of healthcare; however, sample sizes were low and precluded inferential analysis. The Batwa had a greater proportion of cases seeking care from a physician or nurse compared to cases in the Canadian North [30], Poland [6], Argentina [21], New Zealand [15], Denmark [12], France [7], Italy [11] and China [14]. This can be explained by the recent efforts of

international and local organizations, seeking to improve Batwa access to medical care through subsidized healthcare and outreach programmes [39]. The Batwa more often utilized traditional forms of treatment such as herbal remedies than taking prescription or modern medicines. Past research has documented the prevalent use of herbal diarrhoeal remedies by Indigenous populations in Africa [40]; however, this form of treatment has received negligible attention in the comparable AGI literature [5–17, 20, 21, 30]. Thus, the Batwa maintain traditional Indigenous practices to address AGI episodes in conjunction with utilizing contemporary forms of clinical consultation, with implications for the development of health interventions and strategies.

The gender and age distribution of AGI in the Batwa had the same pattern observed in other studies [7, 9, 10, 12, 14, 15, 17], with a high prevalence in females and in children. Our results are in contrast to studies that observed a higher incidence in young males [21, 22], and it is possible that there are cultural





**Fig. 3.** Graphical representation of 14-day and 28-/30-day recall period estimated annual incidence rates of acute gastrointestinal illness (AGI) per person per year in the Batwa and by comparable retrospective international population-based AGI studies using an international case definition [27] of  $\geq 3$  diarrhoea episodes and/or any vomiting [5–7, 9–16, 18, 19, 28].

differences with respect to gender-related exposures such as food preparation [16–18], water collection [41], and animal rearing, that could put female Batwa at higher risk. This study found a significant association of higher AGI incidence in children aged  $\leq 3$  years (3.13 cases per person-year) which is on a par with the estimated incidence of childhood diarrhoea in Africa (3.3 cases per child per year), confirming studies that indicate AGI is a substantial threat to children globally, and particularly in low-income regions [2]. Children may have a greater vulnerability to AGI due to lower levels of immunological protection when exposed to enteric pathogens [10, 12, 14] and the behaviour of young children may also increase their exposure via person-person contact, environmental transmission, decreased hygiene, and increased hand-to-mouth contact [3, 14].

Of the potential environmental risk factors, exposure to goats significantly increased the odds of AGI (OR 2.64). Similar results of exposure to animals as a risk factor for AGI have been found in studies in the Inuit in the Canadian North [30], Canada [18], Chile [20], and Argentina [21]. AGI symptoms common to humans and animals living in close proximity were noted by previous studies in rural western Uganda [42]. Goats are known to sometimes carry multiple pathogens, including *Escherichia coli*, *Cryptosporidium*, and rotavirus [42], and human contact with animal faeces is often associated with

gastrointestinal illness [42]. Direct transmission of pathogens from animals to humans (or vice versa) can occur through petting, touching or feeding [42]. Pathogens can also survive for long periods of time in the environment and transmission can occur from a contaminated environment long after animals have been removed [43]. Some of the Batwa own or raise animals, and goats are found in or near the communities for both economic and consumption purposes. We did not, however, test animals or the environment for AGI-related pathogens; this warrants further research.

Wealth in the model, derived from household asset scores, significantly interacted with a middle-aged adult category (13–34 years), changing the directionality of odds for Batwa in this age group (13–34 years) or outside of it (<13 or >34 years). Wealth seemed to affect the odds of AGI differently for middle-aged adults (13–34 years) compared to non-middle-aged adults (children, adolescents or seniors, <34 or >34 years), putting children, adolescents or seniors at greater risk of illness. Children, adolescent or seniors (<13 or >34 years) in the higher half of the wealth classification had an increased odds of AGI compared to children, adolescents or seniors in the lower half of the wealth classification. The association between increased wealth and increased odds of AGI was also recorded in studies in Australia [13] and the United States [5] that adopted the hypothesis that higher socioeconomic status could be related to high-risk behaviour regarding health;

however, the opposite relationship was found in a study of children aged <5 years in Uganda [44]. There was low socioeconomic variation in households within the communities in this study and income was an invalid measure of wealth given the predominance of subsistence livelihoods. As such, we used household assets as a proxy for other related socioeconomic risk factors. It is plausible that households with greater assets are more likely to be exposed to animals, making wealth a proxy for increased exposure to potential pathogens. Moreover, larger households with potentially more income earners could also generate more asset-based wealth for the household, but at the same time increase over-crowding. Studies have confirmed the important role that over-crowding and increased human-to-human contact can have in increasing the odds of AGI [6, 14, 45].

The absence of longitudinal and seasonal data, which stems from the cross-sectional design of the survey, is a limitation in this study. Our survey captures cases in the dry season, making the estimated annual incidence rate more conservative than would be expected in the wet season and may underestimate the actual annual incidence of AGI in this population. A low number of observations for health-seeking behaviour estimates hinder the comparability across the literature, and subsequent studies on the burden of disease and access to healthcare systems should be conducted to understand these trends more fully. Another limitation, similar to other studies examining self-reported illness, is that self-reported surveys, by their nature, may result in over- or under-estimates of disease due to potential reporting biases.

In conclusion, this study provides estimates on the magnitude and determinants of AGI within an Indigenous Batwa population in southwestern Uganda. The results highlight the high prevalence of AGI in this population relative to other comparable international studies. Of the potential environmental, socio-demographic, or economic factors that can increase the odds of AGI, we found that being aged <3 years, exposure to goats, and being a child, adolescent or senior with greater wealth were significantly associated with increased odds of AGI. Knowledge of these risk factors is important for resource allocation and public health interventions in these communities. The results of this study support the need for an increase in systematic population or community-based AGI studies to further investigate the differential burden of illness in vulnerable or Indigenous populations.

## APPENDIX

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## SUPPLEMENTARY MATERIAL

For supplementary material accompanying this paper visit <http://dx.doi.org/10.1017/S0950268814003124>.

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## DECLARATION OF INTEREST

None.

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